INSTITUTIONALIZING SOLAR THERMAL TECHNOLOGIES IN THE HOMEBUILDING INDUSTRY

by

BARBARA S. PARKER

A.B., Barnard College
(1975)

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER IN CITY PLANNING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

March 1980

Signature of Author...
Department of Urban Studies and Planning
March 12, 1980

Certified by...
Richard D. Tabors
Thesis Supervisor

Accepted by...
Bernard J. Frieden
Chairman, Department Committee on Graduate Studies

ABSTRACT

INSTITUTIONALIZING SOLAR THERMAL TECHNOLOGIES IN THE HOMEBUILDING INDUSTRY

Barbara S. Parker

Submitted to the Department of Urban Studies and Planning on March 12, 1980 in partial fulfillment of the requirements for the Degree of Master of City Planning.

Each year, nearly 20 percent of the national energy budget is used for home space and water heating. Solar thermal technologies could meet a large fraction of these needs and thereby help to mitigate the current U.S. energy dilemna. But they are far from the point of widespread diffusion in the homebuilding industry.

Drawing on the theoretical literature on innovation, this thesis aims to broaden the traditional perspective on innovation acceptance, and to suggest additional means for facilitating acceptance of the technology. Central to the analysis is the view that innovations are not likely to be accepted on the basis of their intrinsic characteristics alone. Rather, innovation acceptance is a more complex process, set in the context of a larger "institutional" environment. How an innovation is seen is partly a function of the "process" in which it is encountered in terms of the existing institutional environment.

To investigate this proposition and identify the forces contributing to innovation acceptance, the thesis examines three cases in which solar thermal was used in housing. (All are projects in the HUD Solar Heating and Cooling Demonstration Program, a program which provides grants to homebuilders to encourage use of the technology). Three different developer types are presented: the speculative builder, the housing cooperative, and the non-profit developer.

The study concludes that institutional forces significantly effect the rate and extent of acceptance of solar thermal technologies. All three builders were induced to use solar thermal not only because of the availability of HUD funding, but also, because the technology was introduced and associated with a range of facilitating institutional forces. This included a variety of supporting institutional entities, i.e., individuals and/or groups, who, because of their "institutionalized," roles and functions were able to "mediate" the uncertainties of the technology and generally "legitimate" its use. Similar mediating and legitimating effects were achieved by introducing solar thermal in supportive institutional contexts, i.e., contexts in keeping with the builders' institutional routines.

On the basis of these and related forces common to the solar thermal acceptance process, the thesis makes recommendations for the design of future programs aiming to facilitate acceptance of solar thermal technologies in the homebuilding industry. Though the thesis focuses exclusively on solar thermal technologies, it is believed that the conclusions have validity for the introduction of other new energy technologies in the homebuilding industry, and innovation in the homebuilding industry in general.

Thesis Supervisor

Richard D. Tabors
Department of Urban Studies and Planning

ACKNOWLEDGEMENTS

This thesis would not have been possible without the support and assistance of many people. Thanks are due to Richard Tabors who provided many useful comments on the many drafts presented and encouraged me to approach the thesis in a more "practical" manner. Thanks are due to Bernard Frieden for his suggestions regarding the homebuilding industry and his assistance in administrative matters. Finally, very special thanks are due to Tom Nutt-Powell (the "behind-the-scenes" thesis advisor), who helped in conceptualizing many of the ideas presented and so generously provided direction and encouragement throughout the preparation of the thesis.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

INTRODUCTION

In the face of continuing political and economic unrest in the oil-exporting countries of the Middle East, rising energy prices and spiraling inflation, coupled with concerns about the environmental consequences of coal and nuclear powered plants, alternative energy sources like solar energy are being looked upon from a wholly new perspective. Currently, the solar energy field is itself marked by turbulence and uncertainty, with attitudes differing widely as to the potentials of different solar approaches and systems. Nevertheless, it is clear that solar energy has become a serious alternative energy source for the long-term future. As one recent study notes, the issue is now a matter of "how much solar energy, what kind--and when." [1]

A particularly compelling case can be made for the use of solar thermal technologies in buildings, specifically in the residential sector. Of all solar technologies, those small-scale technologies for space and hot water heating are the most technically advanced and easily adapted. And buildings play a significant role in energy consumption; each year, home energy use accounts for roughly 20 percent of the national energy budget. Judgements differ as to the precise contribution solar thermal can make. But whether a solar thermal system can supply only 50 percent of the energy used in the home, as projected in the most conservative forecasts, or 100 percent, as suggested in the most

---

[1] Robert Stobaugh and Daniel Yergin, eds., Energy Future: Report of the Energy Project at the Harvard Business School, New York: Random House, 1979. p. 183.

optimistic, the potentials for mitigating the current U.S. energy dilemma are, by all means, considerable.

This thesis aims to explore new means for facilitating more rapid acceptance and widespread use of solar thermal technologies in the homebuilding industry. For as compelling as the case may appear, solar thermal is far from the stage of widespread diffusion in the industry. Since the time of the oil embargo, the idea of solar thermal has gained in appeal, and use of the technology has increased. But solar thermal is not yet considered a serious alternative by actors in the mainstay of the homebuilding industry, the homebuilder, in particular.

Many different explanations have been offered to account for this predicament, as might be expected in a field so new and dynamic. Most analyses, however, conceptualize the problem in terms of a "mismatch" or incompatibility between the intrinsic characteristics of the technology, in its present state of development, and major industry dispositions and routines. Solar thermal, for example, involves a high capital cost, while industry members are characteristically "first cost sensitive." Solar thermal is at odds with industry design and aesthetic standards: a solar house looks and "feels" different from the traditional home characteristically sought by the homebuyer. Further, solar thermal currently involves many uncertainties, uncertainties regarding key activities in the housing production process (e.g., product procurement, distribution, installation and service) in addition to basic technological uncertainties. Members of the homebuilding industry, however, are characteristically conservative, and often avoid things perceived to be uncertain and/or risky.

In turn, on the basis of these related instances of "mismatch," a host of policies and programs have been proposed to facilitate more rapid acceptance of the technology. This includes a variety of financial incentives, e.g., federal and state loans, grants, and tax abatements; programs to upgrade solar thermal systems and components in technological areas; programs to develop product standards, warranties, performance criteria, procedures for product certification and labeling--in all, measures to alter the characteristics of the technology such that solar thermal is "intrinsically" more compatible with existing industry dispositions and routines.

By contrast, a review of the theoretical literature on innovation suggests a view of the innovation acceptance process that is at once more dynamic and more complex. Innovations are not simply bundles of intrinsic characteristics, and the process of innovation acceptance is not likely to be as "objective" or rationally based as conventional analyses imply. Rather, innovation acceptance is a process taking place in the context of a larger "institutional" environment, that is, an environment of regularized relationships, shared assumptions and expections about different individuals and groups, appropriate behavior in different contexts, and the like. In this context, the attributes of an innovation like solar thermal are not entirely fixed, intrinsic to the innovation, but instead, the product of the interchange between the innovation and forces in the institutional environment. In other words, the process of innovation acceptance is likely to be both objective and subjective, depending on the intrinsic characteristics of the innovation as well as the "process" in which it is encountered in the existing institutional environment.

In this study, the process of innovation acceptance is explored to more fully understand the current resistance to solar thermal and to assess the potentials suggested in the latter approach. Specifically, the thesis examines three cases in which solar thermal was used in housing, at the initiation of the homebuilder. [2] Three different builder types are presented: the small to medium-sized speculative builder, the housing cooperative, and the non-profit developer. By considering each builder's likely predisposition toward solar thermal on the basis of the technology's intrinsic compatibility with the builder's disposition and routines, in addition to the process in which the innovation was encountered and used in the context of the institutional environment, the thesis attempts to identify the diverse forces contributing to the acceptance of the innovation. In particular, the thesis aims to assess the extent to which institutional forces played a part in facilitating acceptance, and to identify those forces common to the solar thermal acceptance process that may be of use in future programs attempting to facilitate acceptance of the technology.

The thesis is divided into five major sections, organized as follows. In the first section, Chapter 1, the theoretical framework is

---

[2] All three case studies are projects in the HUD Solar Heating and Cooling Demonstration Program. This Program, the first federal intervention in the housing market to encourage the use of solar thermal technologies, provides grants to builders to cover the incremental costs due to the use of solar thermal.

presented; institutions, and the institutional context in which innovation acceptance take place, are defined and described; factors believed critical to the process of innovation acceptance are discussed. In the following two chapters, Chapter 2 and 3, this framework is used to assess the likely response of the homebuilding industry to an innovation like solar thermal and to suggest the means by which the innovation acceptance process might be helped along. Chapter 4 then presents the case studies of solar thermal use in housing, and describes and analyzes the forces contributing to acceptance of the technology. Finally, Chapter 5 summarizes the findings of the case studies and presents implications of the study for the design of future programs aiming to facilitate the acceptance of solar thermal technologies in the homebuilding industry.

CHAPTER 1: INSTITUTIONS, INNOVATION AND DIFFUSION

Introduction

This chapter presents the analytic framework used in this thesis to study the process of change, i.e., "innovation," in the homebuilding industry. The framework is divided into three sections. First, "institutions" are defined and described as the key analytic construct by which to study innovation and the context in which innovation takes place. Briefly, institutions are the major elements in society's normative structure, in other words, the meanings we collectively develop and use to define both society and ourselves. As such, they provide a sense of order and stability to the social world, making life in society both "comprehensible" and "routine."

"Innovations," defined and described in Section 2, stand in direct contrast to institutions as "new" things which have yet to acquire social meaning, i.e., shared assumptions and expectations. Innovation acceptance is explained as a naming/integrating/routinizing process, in short, the process of institutionalization.

Building on this framework, Section 3 describes some of the critical factors in the process of innovation acceptance focusing on those factors likely to contribute to the acceptance of an innovation. Briefly, in so far as innovations can only be understood in terms of what is already known, i.e., existing institutions, the probability of innovation acceptance is hypothesized to be higher if, in its introduction, the innovation is connected or in some way associated with the existing institutional structure, in particular, through personal sources of information.

Institutions Defined

To understand the context in which innovation takes place and the concept of innovation itself, it is necessary to begin with the more fundamental social construct, the institution. Traditionally, this term has been used to denote one of two things: formal social groups and organizations, for example, the US Senate or the Exxon Corporation, or less formal societal dispositions, such as customs and folklore. In this study a broader view encompassing both definitions is taken. Institutions are defined as the repositories or carriers of social meaning; they are manifestations of society's normative formulations, i.e., society's notions of good/bad, appropriate/inappropriate, worthy/undeserving--in short, the meanings we develop and use to define both society and ourselves [1].

Anthropology and sociology, the disciplines traditionally concerned with human social order, provide the context for understanding institutions. In brief, "man" is said to occupy a peculiar position in the animal kingdom because in contrast to other higher mammals, human nature is not fixed to any large degree by biological drives. Thus "man" can have no "species specific" environment, that is, no environment naturally structured by instinctual organization [2]. Both human nature and the human social world must largely be constructed. In other words,

---

[1] Thomas E. Nutt-Powell et al., "Towards a Theory of Institutional Analysis," Cambridge, MA: MIT Energy Laboratory, 1978, p. 3.

[2] Peter L. Berger and Thomas Luckmann, The Social Construction of Reality, Garden City, New York: Doubleday and Co. (Anchor Books), 1967, p. 46.

our identities as individuals as well as the human social world must be humanly produced. Neither is "given" or "pre-defined" in the way things are in the physical world. Thus neither has meaning in and of itself. Our identities are real only to the extent that they are routinely recognized by society. One cannot assume and/or maintain a position of power if others are unwilling to confer and agree to such status; I cannot think of myself as reliable or trustworthy all by myself. In a similar vein, society requires our confirmation to exist. Social phenomena, for example, social mores, marriage, divorce, our legal sanctions, and so on, are "real" only because we as individuals agree to them and routinely confirm their existence through our actions [3]. Although as we shall see, there is little likelihood of such occurence, if individuals were to all of a sudden begin acting in ways to contradict these parts of the social world, they would, quite simply, no longer exist.

In sum, both society and human nature exist, to a very large extent, by virtue of definition. Institutions, then, can be understood as the constructs or meanings by which we define them; they are our shared assumptions about social reality, the common frame of reference we use to organize our individual activities and our interactions with others, to carry out life in human society. Thus, we can speak of religion, of class or of the economy as institutions. Similarly, the various customs,

---

[3]This phenomenological perspective toward social reality is more fully explained in Berger and Luckmann; David Silverman, The Theory of Organizations, New York: Basic Books, 1971, Chapter 6; and in a series of working papers by Filmer et al., in New Directions in Sociological Theory, London, England: MIT Press, 1972.

practices, mores, and so on, dealing with the delegation and regulation of power can be seen as political institutions, those dealing with the administration, legal institutions, and those dealing with adjudication, judicial institutions. In a similar vein, that wide range of customs, practices, traditions and beliefs relating to the transmittal or learning about society and social behavior, both the informal approaches found in the home and the formal approaches found in schools, are examples of the institutions of socialization.

Though institutions are characteristically either "prescriptive" or "proscriptive," always carrying some one of the many qualitatively different kinds of "shoulds" or "oughts," there is an enormous range in the extent of such normative emphasis [4]. Obviously, there is a significant difference between fashion and fads, and religious precepts. Further, institutions exhibit enormous variability on such related issues as enforcement modes, enforcing agencies, consistency of enforcement, sources of authority for enforcement, penalties/rewards associated with non-compliance, and so on [5]. For example, some institutions are enforced entirely through informal means, e.g., gossip or ridicule, while others are enforced through more formal and institutionalized mechanisms, e.g., law enforcement agencies and the courts. Still other institutions have no explicit means of enforcement at all. They may be internalized in individual personalities such that individuals simply consider it to

---

[4] Robin Williams Jr., American Society: A Sociological Interpretation, New York: Alfred A. Knopf, 1970 (3rd edition), p. 29.

[5] Ibid., p. 30.

"be their duty," or "their right," and act in a manner consistent with this view.

Another important aspect on which institutions vary considerably is in their distribution, in other words, the extent to which they are known and accepted and the extent to which they are actually deemed appropriate and used [6]. Some institutions, for example, are widely known, and agreed upon and also widely used, while others are known and used by only a select group. There are other institutions that are known and acknowledged by a broad public but considered relevant or applicable for use by a much smaller class of individuals. Thus many may know and agree on the appropriate roles for high school students and teachers, but these roles are applicable only to these groups. In regard to the variations in the prevalence of the actual application and use, institutions can be viewed relative to a continuum ranging from the personal to the societal. It is also important to recognize that between these extremes institutions are manifest in many different forms. In addition to such entities as individuals, formal organizations, or informal groups, institutions are manifest in more amorphous entities such as social orders (for example, the traditions of law) or collectives (such as alternative energy advocates) [7].

In spite of these many variations, institutions have certain basic features in common. One approach to identifying these features is to consider the manner in which institutions develop and the manner in

---

[6] Ibid.

[7] Nutt-Powell, p. 21.

which they are used. Here institutions are often visualized as the core or critical elements in a social dialetic. "Man" defines society, i.e., through the creation of institutions. In turn, society, i.e., institutions define "man." Though the process is continual, for analytic purposes, it is useful to discuss these two aspects of institutions and the institutionalization process separately.

On the one hand, in the construction of the social world (i.e., "man" defines society) institutions always have their origins in action, in general, habitualized action. As explained in the anthropological literature, all human activity is subject to habitualization. Actions that are frequently repeated become "cast into patterns"--in a word, "typified"; in this form, they can be repeated at will in the future, with the same economy of effort and with recognition by their performers as "those patterns" [8]. Most importantly, the actions retain their meanings for their performers. Because they will serve the same function, in other words, have the same meaning in future usage, future activities can, in fact, be anticipated and alternative actions considered.

This process of habitualization and recall is central to the process of institutionalization. Institutionalization, however, has one further requirement. It must involve more than one person; in other words, the typifying experience must be shared. As Berger and Luckmann explain: ". . . institutionalization occurs whenever there is a 'reciprocal typification' of habitualized actions by types of actors . . .

----

[8] Berger and Luckmann, p. 53.

put differently, any such typification is an institution..." [9]. Berger and Luckmann aim to stress two points in this account: first, the "typicality" or "institutional reciprocity" of actions and forms of action and secondly, the "typicality" or "institutional reciprocity" of the actors themselves. In other words, actions and forms of action (and forms of forms of action, and so on), are recognized as performable or relevant to not only particular actors, but to actors of certain types (types of types and so on). In essence, the institution posits that actions of type X will be performed by actors of type X such that the institution is as much typification of the actor as it is of the action [10].

Thus the practice of "carbohydrate loading," the various calisthenics of the warm-up practice, the proverbial pre-race dinner, and the act of participating in the marathon are actions that can be grouped together and categorized as being of a distinct type as are the individuals who characteristically engage in them. Such actions are considered "institutionalized" when they are recognized as both appropriate and applicable to other individuals in similar circumstances. Actions of this type are distinct and typical for actors in this situation.

Admittedly, this is a simple example, but it does serve to illustrate the general thrust of the institutionalization process, that is, the association of meaning with action, and its retention for future use. Language, of course, is basic to this process of meaning construction

---

[9] Ibid., p. 54.

[10] Ibid.

as it is primarily through language that these experiences can be shared on a societal scale. Clearly, only a small portion of such experiences could possibly be retained in human consciousness. As Berger and Luckmann explain, the typification of actions requires that these have an "objective" sense; we must, in other words, have some form of a common "language," a vocabulary relating to our routinized actions and types of actions and actors such that we can speak of actions and their senses apart from the individual performers. Only in this way, can these actions become available on a societal scale; moreover, only in this way, can we transmit our experiences from one generation to the next [11].

Thus institutionalization can be conceptualized as a routinizing, standardizing, naming process. Words, gestures, pictorial symbols, and the like, are attached to actions/actors and thereafter standardized, such that a word/gesture/symbol means the same thing each time it is used and to all who use it. In short, institutions are created.

On the other side of the dialectic (society defines "man") it is institutions that we use as a frame of reference in future interactions. As predefined patterns for conduct in different contexts, and as different schemes for categorizing persons/places/processes/events, institutions serve as scripts (or at least stage directions), supplying typologies for individual actions and world view and helping to make sense of the actions of others. Because there is general agreement about the meaning of types of actions/actors, and about the various typifying schemes, we can, upon seeing someone performing activity, make some sense

---

[11] Ibid., pp. 67-72.

of behavior. Importantly, institutions are germane to all major functions in societal life as well as those of lesser significance. Typificatory schemes are available for all categories of events and experiences, for all the major routines of everyday life. I know, for example, how I am expected to behave in any of various socialization functions, say, as a teacher. I know the activities and rights and obligations that go along with this position as do the others with whom I am expected to interact--students, parents, administrators, and so on. There exists a similar body of knowledge regarding research, political, and production functions and for the activities and possible roles through which they might be carried out.

By defining problems and solutions in this way, institutions channel human behavior in certain directions, narrowing the range of the many courses theoretically possible. In this capacity, institutions can be considered similar to the construct anthopologists and sociologists have traditionally called norms, defined as "customs with a binding quality" [12]. Institutions, however, are generally considered to be more than norms first, because of the degree to which they are applied and supported, and secondly, because of the degree to which they exhibit structure [13]. As we have seen, institutions do not concern single, isolated actions but complexes of actions exhibiting an appreciable degree of regularity and relationship. Socialization functions, for example, are manifest in a number of different institutional entities

---

[12] Nutt-Powell, p. 3.

[13] Williams, p. 37, quoted in Nutt-Powell, p. 3.

e.g., the family, the schools, the courts... each dealing with particular aspects of socialization but related to one another in fixed and definable ways. Similarly, economic functions are manifest in such a wide variety of forms as the Federal Reserve Bank, the U.S. Treasury, the local credit union, and these too are related to one another in fixed and identifiable ways. Thus, institutions not only concern the what, i.e., the normative aspects of behavior, but the how/when/in what form, as well. As Nutt-Powell sums up, ". . . an institution has both form and meaning; it persuades, but it also constrains; it charts directions and sets contexts" [14].

Thus we have described the dual aspects of institutions, the two sides of the dialectic in which they are involved. On the one hand, institutions always originate in action; they are the products of our interactions, our routine behaviors and interrelationships. At the same time, institutions serve as framework or backdrop for our actions; in supplying a pre-defined typology for action, they channel our behavior along certain paths, limiting the range of behaviors theoretically possible.

Because there are two sides to the dialectic, one must be careful not to over-emphasize either. For example, one might hold an overly deterministic view of institutions as rigid formulae or blueprints for behavior. But, as noted earlier, institutions typically include varying levels of compulsion and varying levels of reward and sanction. Thus there is almost always some margin of choice or variability inherent in

---

[14] Nutt-Powell, p. 5.

institutionalized modes of conduct. Moreover, there may be ambiguity if not overt internal conflict among institutions, thus mandating individual choice. Any individual has a particular social and religious origin, a given occupation, and is perhaps a member of different formal and/or informal organizations. Consequently, there are likely to be many relevant institutional typologies and modes of conduct not all of which are likely to be in accord, or entirely explicit as to their differences. Thus it is not always possible to fulfill them all. There may also be differences in personal psychological makeup, and thus different perceptions or interpretations of institutions (e.g., their normative content, their sanctions, and so on) thus making inevitable varied responses to institutional imperatives and deviance from institutionalized modes of conduct.

Even in principle, though, institutions should not be taken as rules or determinants of behavior. It is more accurate to see them as providing a framework for action. In the same way that roles in the theatre may be ad libbed, or rejected altogether, even on stage, the same is true of institutions. Situations, in other words, are examined and appraised "over and against" the institution, and in the resolution reached after examination and appraisal, the institution is either sustained or changed [15]. Time brings forth new situations requiring a testing or reassessment of our institutions. Institutions must thus be reaffirmed in the actions of everyday life if they are to remain institutions; expectations can, of course, only continue as expectations

---

[15] Ibid., p. 4.

to the extent that they are proven reliable through action. Thus, while it is correct to say that institutions originate in action, the view that institutions are themselves a priori determinants of action should be avoided [16].

At the same time that we avoid such an overly deterministic view of institutions, we must also avoid going to the opposite extreme and negating the significance of institutions in human behavior and in the social world in general. For the fact is, despite some variability in interpretation, once established, institutions have a tendency to persist. To the extent that it does occur, institutional change proceeds at a very slow pace. This is true at least for the most important of our institutions, those dealing with the most fundamental human situations and involving many individuals, e.g., law, education, finance. One reason for the stability and permanence of our institutions is the fact that institutions and the institutional order always precede us. We had no part in its making; essentially it is "presented" to us during the course of socialization: "this is how these things are done." Thus institutions may not only seem factual and compelling, but also, self-evident and self-validating. (They are there whether we like it or not; we cannot wish them away and if we are to take part in the social world we must "go out" and learn about them [18].) They may become, as one sociologist has phrased it, a "commonsense" reality, in essence, a

---

[16] This view is also elaborated in Silverman, Chapter 6.

[17] Berger and Luckmann, pp. 59-60.

[18] Ibid.

world taken for granted [19]. To the extent that they are fully internalized during the course of socialization, when we comply with the institutionalized typologies for conduct, we believe that we are acting in the most logical, natural way, doing what any reasonable individual would expect.

It is also important to realize that the maintenance of our institutional order satisfies a human need for order and stability. Needless to say, without some degree of coherence and stability in our actions as well as predictability of what others will do under given circumstances, there could be no cooperation, no sharing of knowledge, in short, no society. Even the simplest situations would become confusing, resulting, in the extreme, in utter psychological disorder and alienation, ("If we are lacking in the biological means to provide order/stability for human affairs, it is this very situation that makes it imperative that we construct a stable background for our actions" [20]). Thus, as Silverman notes: "...the fact that the stock of knowledge upon which action is based tends to change rather slowly reflects the vested interest that we all have in avoiding anomie by maintaining a system of meanings which daily confirms the non-problematic nature of our definitions of ourselves" [21].

It is this quality of stability and order that best characterizes the functions served by institutions. Above all else, institutions ensure

---

[19] Alfred Schutz, The Phenomenonology of the Social World, Chicago: Northwestern University Press, 1967, quoted in Filmer et al., p. 7.

[20] Berger and Luckmann, p. 52.

[21] Silverman, p. 134.

that life in human society is experienced as comprehensible as well as commonplace. On the one hand, there is little cause for surprise when individuals act in institutionally prescribed ways. The actors and the actions are simply taken for granted; they are, in a word, routine. But institutions are of perhaps even greater significance in providing us with a framework within which to understand the new. For example, when unexpected events occur [22] the usual response is to look around for an already learned definition of the situation, i.e., an institution. In other words, we try to relate the unfamiliar to what we already know. We use our existing institutions to try to explain the new situation--indeed, given the definitional quality of human reality, this is the best we can do. In thus relating and integrating the new into the existing institutional structure, it too becomes stable and routine; part of the common stock of knowledge, in other words, part of the framework within which still newer things may be explained.

Though institutions serve many other purposes still, in the final analysis, the underlying structure of institutions and the institutionalization process is one of stability and routine. Even though there is no pre-defined social world, no pre-defined patterns for human interaction, and even though the world around us is constantly undergoing reassessment and change, it is made both comprehensible and manageable by institutions, which exist and seem stable because we

---

[22]Here we define an "unexpected event" as a situation that contradicts our expectations, a situation we have yet to experience in common and thus for which we have yet to develop shared assumptions and expectations, i.e., institutions.

"name" them [23]. In sum, though they are undergoing constant change, at any point in time there exist certain expectations and assumptions we share about how to go about doing x, y, z, about how to carry out life in the social world. These institutions serve to provide order and stability; they serve as the framework within which anything "new" will be known [24].

Innovation Defined

Innovations stand in direct contrast to institutions. Where institutions are things with social meaning, identified as shared assumptions and expectations, and thus representing the stable and the routine, innovations are "new" things, that is, things which have yet to acquire social meaning. However, an innovation need not be objectively new. To qualify as an innovation it need only be perceived as new. It is also important to point out at this defining stage that however new and/or unusual an innovation may appear, or however vast the changes it necessitates in institutional functions, activities and roles, it always has antecedents. Given the definitional quality of the social world, coupled with the dialectical nature of change, an innovation is typically a combination of existing things; it is the manner and perception of this combination that makes it new.

The process through which an innovation is introduced (known commonly as diffusion),has been described from a variety of perspectives.

---

[23] Nutt-Powell, p. 5.

[24] Berger and Luckmann, p. 66.

Although the terminology varies depending on the discipline of the analyst, most analysts focus on the stages or phases that individual adopting units (i.e., institutional entities) go through in encountering the innovation. Most models of the process include at least five stages: awareness, interest, evaluation, trial, and integration/rejection [25]. In general, after an entity becomes aware of an innovation (through any of a variety of means) further information is sought if it appears that the innovation might possibly apply to the entity's particular needs. Then, to the extent that the attributes of the innovation are evaluated positively, in regard to existing institutional meanings and routines, the innovation is tested. Later, on the same evaluative basis, the innovation is either rejected or integrated (in original or modified form) into the entity's routine. It becomes, in other words, a routine part of the adopters behavior, that is, it is institutionalized.

Over time, the same process is repeated by other institutional entities in the sectoral area (say other members of the industry, or other offices in a branch of government) until all entities have been so introduced. Institutional entities in different sectoral areas relate to one another in fixed and definable ways. (They are thus often called social systems). It is through the course of the exchanges between and

---

[25] Everett M. Rogers and F. Floyd Shoemaker, Communication of Innovations: A Cross-Cultural Approach, New York: The Free Press, 1971, pp. 99-133 passim. See also Ronald G. Havelock, Planning for Innovation through Dissemination and Utilization of Knowledge, Ann Arbor: Center for Research on Utilization of Scientific Knowledge, University of Michigan, 1970, Chapter 8, for a discussion of Rogers' model and other major innovation diffusion theories.

among entities that information about the innovation is passed on. Thus most analysts also consider the communication channels and the media by which an innovation is introduced. The whole diffusion process is, in fact, often framed in terms of the communication model. An innovation (i.e., something new) is communicated through certain channels over time among the members of a social system i.e., institutional entities with routinized relationships, shared values, and the like [26].

These models of the innovation diffusion process are useful for highlighting some of the critical elements involved; however, on the basis of the preceding discussion on institutions, the diffusion process would appear to be far more dynamic and variable than these models imply. In the same way that social order and social meaning is not simply given or fixed, neither are the attributes of an innovation. Of course certain attributes are fixed (e.g., a solar energy system with flat plate collectors, storage bins and so on is a "heating" system to all who use it.) However, on the basis of such objective attributes an innovation generates its own meaning structure which must in turn, be "institutionalized." Moreover, there are other, perhaps less tangible, attributes of the system, e.g., whether it is a symbol of status or a symbol of efficiency, which can only be determined in the course of the interchange between the innovation and the environment.

Most importantly, an innovation can only be understood in terms of what is already known i.e., existing institutions. An innovation may

---

[26] Ibid., p. 18. See also Havelock, Chapter 10, for a discussion of the "social interaction" model of the innovation diffusion process.

thus appear different to different institutional entities. Moreover, an innovation may not effect all of these entities at the same time. Thus, in so far as the innovation acquires social meaning in interchanges with institutional entities, the innovation itself will have different meanings at different times. The same innovation may appear different to the same institutional entity when encountered at different times. Another element contributing to the dynamic nature of the diffusion process is the fact that the innovation may be modified in objective (i.e., technical terms) as well. That is, in response to actual use and meanings acquired from exchanges, the primary attributes of the innovation may themselves be changed, once again setting the stage for a new round of changed (as well as varied) perceptions on the part of existing institutional entities.

Taking these factors into account, Nutt-Powell describes the diffusion process as occuring over time in a series of stages as social meaning is accumulated and sustained [27]. Although this is an ongoing process, for analytic purposes, three distinct stages are assumed, each stage identifiable by virtue of different objective characteristics of the innovation [28]. In the first stage, the innovation is said to be "undifferentiated;" that is, it is initially perceived in single form because there is no body of knowledge, i.e., social meaning, regarding it excepting, of course, the body of knowledge sustained by the inventor of

---

[27] Nutt-Powell, pp. 24-25.

[28] Ibid.

the innovation [29]. In these first encounters though, it may be assumed that the innovation does acquire social meaning. (The innovation will be defined in some way by the institutions encountering it). In turn, the innovation is assumed to change in objective form. In the next stage, the innovation is encountered by additional institutional entities. Like the entities that encountered it in the first stage, these newer participants will initially perceive the innovation in a single form, i.e., as undifferentiated; however, the innovation will appear differentiated at least to some extent, to the institutional entities that encountered in the previous stage. For these entities there is some social meaning, some shared experiences and expectations with the innovation. A comparable process occurs in stage three as additional entities encounter the innovation [30].

In sum, innovation diffusion occurs through a series of stages as different institutional entities establish exchange relationships with the innovation and social meaning is accumulated. Each stage and the process as a whole involves work on the meaning structure and can be characterized as a process leading from unknown to convention, innovation to institution and no social meaning to social meaning" [31]. Although institutional entities may encounter the innovation at different times. (An innovation may have proceeded through any number of cycles before it

---

[29] Ibid., p. 25.

[30] Ibid., p. 26.

[31] Ibid.

is encountered by an entity for the first time) the process is not, on the whole, necessarily cumulative [32].

Critical Elements in the Diffusion Process

Progress in the diffusion process--the rate at which an innovation is tested and adopted and whether it is adopted at all--is thought to depend on a wide range of issues. Though the precise terminology and usage varies by the discipline of the analyst, most focus on three sets of variables. Much emphasis is placed on the characteristics of the innovation. Rogers and Shoemaker, for example, consider such variables as relative advantage, compatability, complexity, triability and observability, as the perceived attributes of innovations affecting the rate of adoption [33]. Similarly, Havelock considers the scientific status of the innovation, i.e., reliability, validity, communicability, a variety of cost factors, e.g., psychological costs, financial costs and the amount and type of change the innovation will require [34].

Characteristics of the social system are also considered, for example, the general character of the institutional entities, whether they are generally tradition-bound versus modern, open or resistant to change, and so on, as well as the structural characteristics of the sector under analysis. Here Havelock notes such variables as size,

---

[32] Ibid., p. 27.

[33] Rogers and Shoemaker, Chapter 4, pp. 135-172.

[34] Havelock, Chapter 8 passim.

centralization versus decentralization, vertical versus horizontal organization, among others [35].

The third area of concern centers on the communication of the innovation, the information flow channels and patterns between and among entities within the sector as well as the media used. Both channels and media are considered to have different intrinsic as well as institutional meanings and therefore different effects on diffusion and adoption rates.

These variables are, no doubt, helpful in providing some means of gauging the likely course of the diffusion of any given innovation in a given sector. However, they may be synthesized to form a more fundamental hypothesis. That is, if an innovation will always be introduced in an established institutional environment and will therefore only be understandable and acceptable to the extent that it is consistent with or at least appearing to make sense with existing institutional meanings and routines, the obvious implication for affecting a successful diffusion process is to maximize the bases of similarity between the innovation and existing institutions. In ideal circumstances the innovation would appear sufficiently connected or related to existing institutional forms so as to appear not only understandable but the logical, commonsense thing to do.

On this basis, it is suggested that innovation acceptance is likely to be higher if an innovation is introduced through existing institutional entities and in contexts that are consistent with current institutional meanings and routines. In so introducing an innovation,

---

[35] Ibid., Chapter 6 passim.

the newness and the uncertainty of the innovation may be mediated and the innovation itself may be made to appear more stable, more routine. Similarly, by association with the existing institutional structure, the meaning of the innovation may be deliberately manipulated and modified; in other words, it may be made to take on a meaning that is more compatible with existing institutional meanings and routines.

This is not to imply that an innovation will be accepted simply because it is encountered through existing institutional entities and/or in institutionally supportive contexts. As noted earlier, innovations always have certain fixed and objective characteristics; for example, product A currently costs \$x; it functions at x_1 level of efficiency under conditions y_1, at x_2 level of efficiency under conditions y_2, and so on. Thus certain innovations may be inherently more congruent or consistent with existing institutional meanings and routines.

What is being stressed here is that innovations are not likely to be accepted on the basis of their intrinsic characteristics alone. Innovations are, as noted, new things which cannot be entirely objectively understood. As noted in the first section, we use our existing definitions and expectation, i.e., our existing institutions, to try to understand innovations; however, it is only in rare cases, when the intrinsic characteristics of the innovation are extraordinarily similar or in some way comparable to our existing things, that we can fully grasp what is meant or implied by an innovation. Thus, the process by which a potential user evaluates and eventually determines to accept or reject an innovation is rarely an entirely objective one. As suggested in the previous section and explained more fully below, innovation acceptance is not based on judgments regarding the intrinsic characteristics of an innovation alone.

Most importantly, it is necessary to realize that innovations, like institutions and social order in general, always involve "social meaning;" in other words, the meaning we attribute to an innovation, the attributes we assume it to have, are not fixed or immutable, nor are they necessarily intrinsic to the innovation alone. The meanings we attribute to an innovation are the meanings we ourselves develop. Put in a different way, they are the meanings that develop through our use and through association and interchange with entities in the existing institutional environment. As explained in the first section, innovations are always introduced into an existing institutional environment, that is an environment of shared meanings and assumptions about persons, places and events, assumptions about what types of behavior are appropriate in what contexts, and for which individuals and groups. And the point is, that we not only use such meanings and assumptions to try to understand and evaluate new things, they are also likely to color our view toward an innovation. In short, how we view an innovation will depend, at least to some degree, on the manner or process through which it is encountered, in terms of existing institutional environment.

Thus, innovations are new things, which, by the very fact of their being different, cannot be objectively (or routinely) understood, while, by contrast, institutions are things which we explicitly (or routinely) understand, things which we have, in fact, come to agree upon. Thus, I may not fully understand what product A entails, what X promises to do, or how it intends to achieve such ends. However, I do know, that individual B has always given me good advice in the past; he has always kept an eye out for my interests and introduced me to things that served me well. Thus I may expect this to be the case in the future. Similarly, if I see B using A, or behaving in an X manner in relation to A, I am likely to view A in relation to B's behavior and use. Using the assumptions and expectations that I have for individual B, product A or behavior X takes on a certain meaning, likely very different from the meaning or the assumption I might make about them if I saw Individual M or Group N using A or behaving X. (Clearly, it is easy to see that we would have different assumptions about the same product or process if, say, we saw Jerome Weisner using them on the one hand and Sister Theresa on the other!).

Utilization of the existing institutional structure in this way, i.e., associating an innovation with an existing institutional entity and/or context, is also important for reasons relating to uncertainty and risk. By definition, all innovations are, at least to some extent, uncertain and risky. After all, they have not been tried before; we have not experienced them and thus we have yet to develop any expectations or means of predicting what they will involve. On the other hand, institutions are by definition stable and routine. Because they have been used and experienced, we have certain assumptions, and expectations about them.

Thus, connection of an innovation with an existing institution would appear to have a mediating effect. As noted above, the innovation itself, may be made to appear more stable and more routine if the institution itself is stable and routine. If I see K doing something new, in X environment, under Y circumstances, all of which I understand, this something new is not only immediately more understandable but also less novel, less uncertain and risky. In associating this new thing with group K, in an understandable X context, I immediately have a context or framework for viewing it. Obviously, it is not all that new anymore; I can try to understand it in terms of its association with the existing institutions; further, I can expect to learn something from K's experiences and use of the innovation.

In sum, while an innovation must obviously have some minimal degree of commonality or congruence with existing institutional meanings and routines if it is to be accepted, the process of innovation is likely to be both objective and subjective, the proportions depending on both the intrinsic characteristics of the innovation and on the process through which it is encountered in the existing institutional environment. In other words, there is always likely to be some middle ground, some range within which the meaning of an innovation can be manipulated and positively changed if it is encountered through existing institutional entities and/or in institutionally supportive contexts. Though both source and context are important, personal sources of information, in particular, are more likely to facilitate innovation acceptance through these means as it is "easier as well as more stable and routine to identify whom one trusts (these exchanges happen constantly) than to decide what one trusts" [36].

---

[36] Nutt-Powell, p. 32.

The propositions put forth here are indeed very simple:

(1) An innovation is something new, something involving some uncertainties and risks, and something that is not altogether clearly understood,

(2) An innovation is always introduced and evaluated in terms of existing institutional meanings and routines,

(3) The probability of innovation acceptance increases by purposely maximizing the bases of similarity between the innovation and existing institutions, by connecting the innovation to things that are already known and accepted.

In sum, though an innovation is by definition disruptive, with intrinsic characteristics which may not be in keeping with existing institutional meaning and routines, and thus demanding changes in institutional functions, activities, and roles, innovation acceptance is likely to be higher to the extent that the innovation is encountered through the existing institutional structure, personal sources of information in particular. Though this does not guarantee acceptance of an innovation, in introducing an innovation through the existing institutional structure, the risks and uncertainties may be mediated and the innovation given a meaning more compatible with existing meanings and routines.

CHAPTER 2: THE HOMEBUILDING INDUSTRY

Introduction

This chapter surveys the homebuilding industry from the institutional perspective, noting the major institutional entities, their routines and the linkages between and among them. The industry is described as both unique and complex; it is an environment of high risk and uncertainty, horizontally stratified and economically precarious in its organization.

The review will consist of three major sections: first, a brief introduction of the industry is provided, highlighting the factors which contribute to its uniqueness and complexity; next, the housing production process is reviewed, noting the major institutional entities involved at each stage, their activities and the considerations which affect their views. The final section examines some industry-wide dispositions in light of their implications for innovation and technological change in the industry.

Overview

The homebuilding industry, defined broadly to include all firms and individuals sharing in the receipts of expenditures for housing is, by all counts, one of the most complex as well as distinct of all economic sectors [1]. As most housing analysts point out, the uniqueness of the industry, its organization, structure, and the characteristics of its members, evolve largely from the characteristics of the good itself.

---

[1]Report of the President's Committee on Urban Housing, (The Kaiser Committee Report), A Decent Home, Washington, D.C.: U.S. Government Printing Office, 1969, p. 113.

One attribute frequently noted, for example, is the localism of the industry. Because housing is inevitably tied to land, which has traditionally been locally regulated, and also varies in such factors as tradition, neighborhood, geographic and climatic conditions, housing markets differ widely from one locality to the next. Thus key actors in the housing production process typically restrict their activities to a small geographic areas. (Only a few of the largest firms are active on national or even state levels [2].) A local building fraternity predominates and major socialization activities are carried out on the local level. Thus geographic location may be as important an indicator of an actor's overall disposition and mode of operation as an actor's particular profession or trade.

Another distinguishing factor frequently cited is the horizontal fragmentation of the industry. In contrast to most other developed industries, operations in the homebuilding sector are highly disaggregated, with responsibility for nearly all major activities divided among several different actors. (The Kaiser Commission estimated that, on average, the construction of a single-family dwelling unit involved 14 different subcontractors and a multi-family project 20 [3]! These various specialized actors combine into working teams on

---

[2]According to the most recent survey of the National Association of Homebuilders, about 97 percent of the builders build only in one state and 2.4 percent in two states. Only 1 percent build in three or more states. Michael Sumichrast et al., Profile of the Builder and His Industry, Washington, D.C.: National Association of Homebuilders, 1979, p. 27.

[3]Kaiser Committee Report, p. 151.

short-term, ad hoc bases, disbanding at the project's end. This rather flexible organizational pattern is largely a response to the 'individual' characteristics of the housing product. Housing is, of course, a very personal item, with many varieties in demand. Moreover, because of local variations in climate, topography, and the like, no two construction jobs are exactly alike; different projects thus require different combinations of skills.

Another factor of major importance is the discontinuity or volatility of industry work. Housing is costly to produce and consume; the activities of the sector are therefore dependent on credit and extremely sensitive to interest rates, investment patterns and general economic conditions. When the economy is active and interest rates rising, the industry is unable to compete with other major users of capital; housing production declines as funds flow away from the mortgage market. (In turn, the economy is itself slowed down because housing has such forward linkage, i.e., involves so many different sectors of the economy.) Conversely, housing production begins to pick up when the economy is less active and interest rates decline. This, in turn, helps to revive the economy. These so-called "countercyclical" tendencies, and the corresponding fluctuations in the rate of production, are not only naturally occurring but made more severe because of traditional federal reliance on monetary policy to stabilize the economy. Housing production rates are made even more volatile because of seasonal variations. Although the traditional slowdown during the winter months is believed to be as much a result of tradition as of necessity, it is easy to see how day-to-day weather changes might have serious implications for on-site construction work.

This variability in the rate and continuity of housing production contributes to the fragmentation noted earlier. Under a system of functional specialization, industry firms are better able to diversify their operations moving into other sectors of the construction industry, e.g., commercial, industrial, when demand in the homebuilding industry is slack. Volatility is also a major contributor to other industry characteristics, most importantly, the unusually high rate of entry and exit of industry firms, their size and investment patterns and also, the characteristics of the construction labor force. Except for a few of the materials supply houses, firms in the industry are characteristically small, employing few full-time workers and building fewer than 25 units per year [4]. Similarly, homebuilding firms typically invest little in labor-saving equipment, or in the training of large segments of the labor force. The average builder has neither the resources nor the motivation to formally train all members of his work force; construction labor is too easily bid away by other higher-paying industrial sectors. Thus the construction labor force is itself highly stratified, both by skill level and trade. The labor environment of the industry is also unique because of the existence of trade unions which exert enormous influence on construction operations.

Also of considerable consequence is the lack of investment in traditional research and development (R&D) activities. Industry firms

---

[4] See Sumichrast et al., pp. 40-41, 61-62.

are typically too small and undercapitalized to undertake such activities. In fact, the industry as a whole is lacking in large organizational bodies of the kind that might assume R&D functions, the only exceptions being the National Association of Homebuilders and some of the larger trade unions. These organizations do engage in research activities but the scale of such efforts is minor when the size of the industry is considered. Historically, most R&D activities of importance to the industry have been carried out by individuals and firms in other industrial sectors. Typically, the benefits of such research come to the homebuilding industry after having exhausted the industry for which they were initially undertaken [5].

In sum, the homebuilding industry is a combination of many small operators fragmented by size, location, and function, engaging in production through the continual formation and disbandonment of short-lived teams. Not only are these entities dependent on one another because of such specialization, their size and capital resources but they are also dependent on factors over which they have little direct influence or control, for example, general economic and weather conditions. Taken together, these factors combine to create an environment that is, at best, replete with risk and inherently unstable. This is a situation having considerable consequence on the nature and

---

[5] I beams, for example, were developed for use in the building industry only after they had exhausted the railway market. See Donald A. Schon, Technology and Change, New York: Delacorte Press, 1967, Chapter 6, pp. 139-171. See also Michael Furlong and Thomas Nutt-Powell, "Institutional Analysis of Research and Socialization in Housing: A Preliminary Exploration," Cambridge, MA: MIT Energy Laboratory, 1979, p. 17.

rate of technological change within the industry, an issue to be more fully discussed below. However, at this point it is useful to follow the process by which housing is produced in order to gain a more comprehensive view of the organization and context within which the industry operates.

The Housing Production Process

As the preceding review suggests, the housing production process is both complex and diverse, enlisting the participation of many groups and individuals and bounded by an equally wide array of laws, customs and other institutional constraints. The process varies depending on housing type (single- or multi-family) [6], tenure (owner- or renter-occupied), and also on production initiation (custom or speculative building). Certain activities and arrangements are common to all projects. Thus the housing production process can be viewed as advancing through a series of identifiable stages. For the purposes of this study, four such stages have been identified: preparation, production, distribution and service [7]. In the review that follows the intent is to describe the activities and entities characteristic of housing production in general, as well as those pertaining to certain housing types.

The first phase in the production process, preparation, includes such preliminary activities as: generation of the building concept,

---

[6] In this study, the term "single-family" refers to structures of housing with 1-4 dwelling units and "multi-family," those with 5 or more units. Multi-family is usually income-producing property.

[7] This four-stage approach generally follows that outlined in the Kaiser Committee Report, p. 115.

determination of project feasibility, translation into detailed plans for building design and development, land acquisition and securing of building permits, zoning approvals, and the like.

The idea for a building might come from any of a variety of sources; planners, engineers, private investors, public and private agencies might each initiate building projects. The term "developer," [8] however, is typically reserved for the individual (or group) taking responsibility for judging project feasibility (i.e., determining whether the idea is to become an "active project") as well as responsibility for the financial risk that project development necessarily entails. This actor will play the lead role throughout the production process, having responsibility for coordinating and organizing all other participants and having veto power at all times. He/she is thus initiator and entrepreneur as well as manager of the development process.

Feasibility at this stage is typically a function of two sets of factors: (1) regulations--the proposed development must comply with zoning laws, building codes, and other applicable statutes; and (2) market conditions--whether there is sufficient demand for housing of the type under consideration and whether it can be produced at a cost within bounds of the resources available. As noted earlier, housing is a highly personal item involving more than simple economics. Typically, the housing consumer is conservative, not wanting anything radically different from the norm. Because housing markets are competitive,

---

[8] In the construction of single-family housing, the term "builder" is generally used instead of "developer." In this study the terms will be used interchangeably.

developers make careful assessments of the characteristics of local demand as well as the costs of development.

Developers often vary in the criteria they use for making the final decision regarding project feasibility. Criteria used depend on a number of factors, including the size of the proposed development, the size of the developer's operations, and working capital, as well as the organizational arrangements planned for the development process. Particular criteria vary among developers; what may appear a highly appealing proposal to one developer may seem altogether infeasible to the next. What is important to realize, though, is that even if profit is not the sole or even primary motivation for involvement in housing production there will always be limits on financial resources. Assessment of market conditions is thus the critical step in determining whether or not to proceed with a proposed development.

Market conditions are surveyed at varying levels of detail and through a variety of means, depending on the size, complexity and risk involved. For example, developers of large-scale, income-producing projects typically go to considerable lengths in their analyses, engaging specialists such as market researchers or financial analysts to carry out detailed projections on supply and demand characteristics so as to estimate the project's expected return on investment. Public developers (e.g., nonprofit development corporations and public housing authorities), are less concerned with the "profitability" of the development and thus more likely to focus their analyses on how user needs can best be satisfied within the available resources.

Small-scale developers, for example, the average speculative builder producing fewer than 10 units/year, typically go about assessing market conditions and potentials in a more informal way, noting the prices and items included in units recently sold and obtaining estimates from local contractors and materials suppliers as to the costs of producing them. In general, small-scale builders are believed to be more conservative than developers of income-producing properties. Because of size, lack of capital, and importantly, their reputation in the local community, their primary concern is the production of an "acceptable," i.e., easily marketable, product.

When a project is deemed feasible detailed planning and design begins. For the small-scale builder this activity is actually a continuation of the previous stage. Having surveyed the local market and determined the constituents of an "acceptable" product, on the basis of recent sales, the builder simply reproduces these designs, often without the assistance of an architect. Frequently, the builder uses stock plans from plan books (compiled by architects) and modifies them according to site, climate and expressed demand. In the competitive conditions in the typical housing market, builders are concerned with the costs of items included in the design. As a rule, items are included when there is a fair degree of certainty (determined on the basis of past experiences) that features will be seen as adding to the marketability of the house and thus included in the property valuations of lenders. Otherwise, the builder's personal cash involvement (i.e., equity requirement) will be greater, this being something that builders/developers typically try to keep as low as possible because of the risk and cost of borrowing money.

Similarly, the marketability of the home might suffer, as a higher down payment would likely be required for the prospective homebuyer, this being something that homebuyers typically avoid for reasons similar to the builder/developer. For these reasons, the typical speculative single-family builder is generally reluctant to break with tradition and pioneer design changes.

By contast, in the design of multi-family housing, the variety of actors increases as does the number of constraints. In most cases, an architect is engaged to translate the original ideas first into schematic models and later into working drawings. Usually a series of designs is drawn, each with different attributes at different projected costs. Here the constraints of marketability are most evident. In general, project design is first based on an estimate of rents that can be charged for that location and that general housing type. More specific design features are based on estimated construction costs and financing terms. (Here developers consider the relationship between construction and carrying costs, and projected rents.) As with single-family developments, the inclusion of specific features is largely dependent on the extent to which lenders will see them as adding to the value of the project and thereby increasing mortgageability. Because of the higher costs of multi-family development and the costs and risks associated with borrowing such large sums, multi-family developers have even more reason to try to keep personal cash involvement as low as possible. Multi-family developments are typically carried out for investment purposes with returns to be realized in the form of cash flow or non-cash items such as depreciation, expenses and other tax write-offs.

Thus, the multi-family developer wants to leverage the equity investment; front-end costs are most important. Items that increase such costs, even those that may be profitable on a long-term basis, are typically avoided.

Depending on the size and complexity of the project, the design of multi-family developments may involve specialists in addition to the architect. For example, any of a variety of engineering professionals (mechanical, structural, electrical) may be consulted on technical matters. Similarly, site planners, landscape architects, urban designers, interior designers, and so on, might be consulted on matters relating to site design, the appropriate integration of the structure with its surroundings, user needs and employment of space. Although any of these professionals may assume a major role in the design process, in most cases, they are brought in by the architect after preliminary design plans have been executed. Although the developer maintains final say on all design decisions, the architect (acting as the developer's representative) typically has responsibility for assigning and coordinating the work of these specialists in executing the final design scheme and in drawing up the final plans and specifications.

In addition to these specialists involved in plans for the physical design, another group of actors usually provides information and advice on design constraints, financial planning, and other more procedural matters for carrying out the development process. Among these are attorneys, who advise the devloper on the legality of different development approaches and matters relating to tax laws; real estate and land brokers, who provide information on local market conditions; and public officials such as zoning and building code administrators, planning officials who, like attorneys, provide information and advice on design constraints and development approaches permissible under the law.

The latter two groups of actors, i.e., real estate professionals and public officials, are important in the two remaining activities carried out during the preparation phase. Real estate brokers, together with title companies and attorneys, assist in land acquisition (an activity that is usually carried out concurrent with design development) while public officials are involved in various regulatory activities, such as the granting of building and zoning permits and the determination of property tax status. This final activity tends to be a routine procedure for the single-family builder who is typically conversant with local regulations and also likely well acquainted with local officials. It is primarily for this reason that the builder confines his activities to a particular locality. This procedure is, however, often more complicated for the multi-family developer because of the large scale and thus potential impact--economic, physical as well as social--on the surrounding community. Because time is the equivalent of money in industry operations, developers often begin negotiations for plan approval as soon as possible in order to avoid the possibility of having to delay at a later stage. (On similar grounds, builder/developers often avoid the inclusion of design features which might cause controversy and thereby delay the plan approval processes.)

Production, the second stage of the housing process, entails three major activities, two of which, team formation and project financing, are typically carried out before the third activity, construction, begins. As noted earlier, because of the seasonality and cyclicality of construction work, and the diversity of the housing product, industry participants are characteristically small and horizontally fragmented by function, such that few actors have the resources or skills to complete a construction job singlehandedly. Thus, while one individual might have proceeded through all activities in the preparation phase unassisted (and, as noted, small-scale speculative builders of single-family housing typically operate in this fashion), at this stage, it is necessary to initiate if not finalize arrangements for carrying out the development. In short, the building team must be formed.

Formation of the building team is essentially matter of contracting. Because the extent of contracting varies, contracting arrangements take many forms. The single-family builder, for example, typically keeps on staff only those skills needed throughout a construction job, the most important of these being carpentry. Operations most often performed by subcontracting include heating, plumbing, and electrical work, as well as site preparation activities, for example, surveying and grading. Larger single-family builders, say those producing greater than 50 units/year and multi-family developers, may keep some of these skills on staff, but they too generally contract for most of their work.

In multi-family developments the developer typically selects a general contractor either through private negotiation or public bidding, the former being more common for the smaller-scale operator. Individual contractors ad developers may know one another through the local builder community and frequently work as a team. General contractors typically serve as managers during the construction process. In most cases, the developer and contractor agree on a fixed price contract implying that the general contractor is free to carry out the construction in his own manner provided he remains within the terms specified by the contract. (Typically, contracts call for purchasing and installation costs, time schedules, and, in some cases, construction methods.) Although general contractors vary in size and scope of operatons, like the builder, most subcontract the bulk of their work to specialty contractors, again on the basis of bidding or negotiation. (Here too, contracts typically call for materials and installation, although in some cases, materials may be chosen by the general contractor.) Both contractors and subcontractors are usually selected on the basis of reputation and past performance because of the obvious importance of remaining within projected budgets and timetables.

Contracting for single-family construction follows a similar pattern, although in many cases, particularly for small-scale speculative projects, there is no general contractor involved; in other words, the builder himself serves as the general contractor hiring subcontractors on an as-needed basis. (There are, in fact, no major differences in organization structure between the typical general contractor and the typical small-scale builder [9].) Reputation and performance in the local building community are critical factors in contractor selection. In many cases, builders and subcontractors work together on more than one project and enjoy continuing, close working relationships.

Thus, for single-family development the building team typically includes builder-subcontractors or, in larger projects, builder-general

---

[9] Kaiser Committee Report, pp. 152-153.

contractor-subcontractors. For multi-family developments, the usual team is developer-architect-general contractor-subcontractors; however, in larger, more complex projects any of the professionals noted in the design stage, e.g., engineering specialists or designers, might be part of the project team.

Arrangements for project financing typically begin once team selection and contract negotiations are well under way if not altogether completed. As noted earlier, debt financing is necessary for nearly all housing developments; builder/developers typically require financial assistance for development and construction activities, and long-term financing is needed for the homebuyer and multi-family investor. Although only the capital for construction and development is usually required at this point, it is nonetheless customary for arrangements, or at least negotiations and commitments for the long-term loans, to begin at this time as well; short-term lenders want some assurance that they will be repaid when the construction phase is completed. Thus, most lenders insist on a commitment for long-term financing as a prerequisite for a short-term construction loan. Similarly, builder/developers want assurance that, upon completion of the structure, capital will be available either for the homebuyer or the housing investor. Thus, most builders/developers do not proceed without at least informal commitments for long-term financing [10].

---

[10] Single-family builders expect to repay short-term loans from the proceeds of sales and thus often gain advance commitments from lenders to provide loans for particular properties, upon approval of the prospective buyer by the lender.

Many different types of institutions provide funds for housing. The most important of these are savings and loan associations (S&L's), mutual and commercial banks, and life insurance companies, which, together furnish nearly 80 percent of all mortgage monies [11]. Added to this are the mortgage investment trusts, funds from pensions and similar holdings and, on occason, funds from individuals. Another group of institutions is important in providing loan guarantees, insurance and interest subsidies, and thereby supporting the activities of the lending institutions. This group includes federal credit agencies such as the FHA, the VA, the FmHA and private mortgage insurance firms and institutions specializing in secondary market operations such as FNMA, GNMA, and the FHLMC.

In general, the major mortgage institutions do not compete to make mortgage loans; the institutions vary in their primary reasons for existence and thus have different reasons for engaging in mortgage lending. Of the three major lenders, thrift institutions (i.e., S&L's and mutual banks) are best suited for and specialize in long-term loans because their primary source of funds is least subject to withdrawal. Commercial banks are more oriented toward short-term needs as their principal source of funds, i.e., checking accounts, necessitates their maintaining a high degree of liquidity. By contrast, the life insurance companies tend to invest wherever the yields are greatest given the long-term nature of their liabilities. It is important to realize though,

---

[11] Sherman J. Maisel and Stephen E. Roulac, Real Estate Investment and Finance, New York: McGraw-Hill Book Company, 1976, p. 190.

that even lending institutions of the same general type may differ in the importance they attach to mortgage lending and the conditions by which they engage in such activities because of varying state and local regulations, size, or simply on the basis of a local tradition. For example, a savings and loan or a mutual bank may perform some of the functions traditionally associated with commercial banks simply because of a longtime local need.

In spite of these many variations, certain generalizations are necessary about the lending community overall and construction and long-term financing more specifically. Financial institutions tend to be on the whole very conservative in their operatons. Although they may vary in the extent of risk they will customarily assume, all are careful in their analyses of risk, and typically adhere to fairly fixed routines and step-by-step procedures for mortgage lending; they are not ones to test the unproven merely for the sake of novelty.

Of the two types of loans, construction lending is considered to be far more risky. Many things may occur during construction to cause the borrower to default on the loan and/or require additional funds from the lender to complete the project. Cost overruns may occur simply because of poor management or faulty estimates on the part of contractors or subcontractors, developers' losses on other properties, or because of events over which the developer and contractor have little control, e.g., strikes and bad weather. Thus a lender may end up with a structure that is incomplete and for which additional resources must be committed if the lender is to get its money out, or at least minimize losses. Moreover, even if a structure is complete, in the event of cost overruns, the lender may have to assume responsibility for any outstanding debts to subcontractors and/or material suppliers.

Recognizing these risks, construction lenders typically focus on three areas when considering an application for construction financing:

(1) the overall reputation and credit worthiness of the builder/developer and members of the development team--whether they can "perform," whether they have steady financial sources of their own to handle any difficulties that might arise;

(2) the marketability and value of the structure, taking into account such factors as the site, the locaton, the neighborhood, design, layout, and amenities, and

(3) the estimated construction costs and schedules, whether these appear realistic for carrying out the proposed development [12].

In general, the reputation and credit worthiness of the applicant followed by the overall marketability of the structure are the most important issues in determining whether or not to lend. This is particularly the case for the small-scale single-family builder with a reputation in the local building community. In most cases, banks are inclined to lend to those with good standing in the community and with whom they have already done business. Moreover, with the exception of the largest financial institutions, banks lack the skills needed to examine the technical details of construction. Thus, for the average single-family project, as compared with reputation, plans and specifications are generally not too closely examined.

---

[12] American Savings and Loan Institute, Lending Principles and Practices, Chicago, Illinois: American Savings and Loan Institute, 1971, Chapter 15 passim. See also Maisel and Roulac, pp. 77-82.

Requirements for multi-family developments are, of course, more stringent. Plans and specifications are carefully reviewed; if a bank does not have a construction management capability in staff, it often consults, on a contract basis, with engineers and construction specialists. Here, in addition to the credit worthiness of the developer and his team, another critical determinant in the lending decision is the expected income of the project, that is, whether the income to be generated will be sufficient to cover repayment of debt plus other expenses. Thus lenders carefully analyze the applicant's pro forma statement, i.e., the financial statement itemizing major components of gross expense in determining whether or not to lend.

As for the level and terms of the loan, the focus is on the value of the project, that is, how much it would be worth in the marketplace under normal circumstances. This is determined by a number of different measures, one of which is project cost. It is important to realize though, that cost may not always be identical to value; certain items (known as "overimprovements") may cost more to purchase and install than they are worth in the market. More specifically, for single-family dwellings, appraisers generally determine value on the basis of the sale of comparable properties in the same market. Certain designs, layouts, and amenities are accorded standard values and those features deemed overimprovements discounted in value [13]. For multi-family income-producing properties, the measure of value considered most

[13]Thus the influence of lenders in the design process noted earlier; builder/developers generally aim to minimize personal cash involvement and thus exclude from their design items which they anticipate lenders will not consider mortgageable.

accurate and typically employed is based on the property's expected income discounted over time [14].

Construction lending is distinguished by a unique disbursement method. Because the security for the loan is in the value of the project, lenders want to ensure that at any time such value exists; in other words, if they had to take over the project and complete construction they would be able to do so within the remaining budget. Thus, although the total amount is negotiated beforehand, construction loans are planned to be disbursed in stages during the construction process, usually after the completion of certain major activities, e.g., the foundation, the rough flooring, the roof, and so on, and, in the case of large complex projects or those considered risky, after inspection by the lender [15]. In most cases, lenders also try to ensure that the amount of the loan is less than the value already included in the property. Thus, lenders often plan to hold back a stipulated percentage of the loan until the entire structure has been completed to the lender's satisfaction. These procedures have important consequences for the builder/developers, forcing them to rely on their own capital (or credit) and decreasing their overall liquidity during construction [16].

---

[14]This is another reason for excluding items that increase front-end cost; anything requiring financing means a reduction in income and a decrease in value and consequently, an increase in the developer's equity requirement.

[15]Not all projects are inspected by the lending source; the manner in which a development is inspected, or whether it is inspected at all, will depend on the type and complexity of the project, the builder/developer's credit standing and whether there are any liens against the property.

[16]Maisel and Roulac, pp. 77-82.

Long-term financing, although less risky than construction lending, is made on the basis of similar criteria. Here it is the reputation and credit worthiness of the housing purchaser and investor in lieu of the builder/developer and members of the development team that is under consideration. In addition to the value of the property estimated as described above, the income of the housing purchaser is of central importance in loans for single-family housing. Most lenders use a comparison of projected housing costs to an applicant's income as a guide to determining the maximum loan for which a given individual can qualify; the standard most widely followed is that housing costs should not exceed 25-30 percent of income. Also of importance are the stability of income and motivation of the borrower in maintaining the home. Loans for multi-family developments are again more closely scrutinized on all counts. In contrast to single-family loans, the characteristics of the property--expected income and general marketabilty--are most important. Whereas the purchaser (or builder) of a single-family unit might obtain a loan on the basis of reputation and credit standing alone, this is rarely the case with single-family developments because of the larger scale and greater risk involved.

The construction phase begins after financing arrangements have been made. As noted, construction work is carried out on the basis of contracting; work progresses through a number of different operations, each performed by different work groups or teams. Here the intricacy (as well as the precariousness) of the homebuilding enterprise is most evident; the work assigned to one team can usually be carried out by that team only, and, in most cases, the work must be completed in ordered succession. In other words, work of one group is dependent upon the completion of the work of one or more other groups.

As noted earlier, it is typically the job of the general contractor (or the small builder acting as general contractor) to select and assemble the work teams, either from his own staff or through subcontracting and thereafter, to coordinate the work process. Although not a specialist in every aspect of construction to the extent of the specialty subcontractor, a general contractor must obviously have an in-depth experience in each area as well as knowledge of all relevant codes and regulations in order to monitor and supervise the work. He must also have an understanding of basic architectural and engineering matters in order to be able to communicate with these professionals. (Although it is the general contractor's job to carry out construction, architects and/or engineers typically monitor the work in progress, checking to see that it is carried out in accordance with plans and speficiations; also, it is not uncommon during construction for them to call for design changes, called "change orders," with which the general contractor must comply.) Additionally, and perhaps most importantly, the contractor must possess basic management skills to ensure effective and efficient management of labor and materials such that work is completed on schedule and within budgetary limitations. Subcontractors, under contract to the general contractor as opposed to the developer, generally possess the same set of skills as the general contractor although obviously, on a smaller, more specialized scale.

Materials for construction are provided through a decentralized system sharing many of the general characteristics of the building industry. Materials are manufactured by a large number of firms in different industrial sectors. Although building supply firms are generally more concentrated than those in the builder industry overall, there are still few dominant firms in any of the four major building supply categories, i.e., lumber and wood, stone and clay, HVAC and primary iron and steel. Most producers serve highly diversified markets often supplying all sectors of the construction industry.

Between these manufacturers and the builder/developer are dealers or distributors who operate on the local or regional level, serving essentially as middlemen and performing many useful functions for the industry. Typically, they warehouse, merchandise, and distribute a wide assortment of supplies. The range of services offered varies by dealer. Some install their products, thus serving as subcontractors; some service the products they distribute. In all cases, though, their function is critical in saving the builder/developer from having to maintain inventories, an operation which could obviously be very costly given the wide fluctuations in production.

Local dealers are also important in the local building community by serving as intermittent sources of credit. Because they operate on the local level and know many of the builders and contractors personally, they frequently allow individuals and firms with good standing in the community to obtain materials on credit and in this way compensate for the holdback provisions and timed disbursement schedules of construction lenders.

Local dealers are also enormously important as sources of information about new building products. Typically, the dealers watch for new equipment and products; manufacturers often persuade local dealers to stock new materials as they are developed. Although a dealer's general concern is to carry products already in demand in the area, because of the role as a trusted and close associate of other principals in the building process and moreover, the ability to set prices, the dealer has the capacity to influence product demand. Historically, the major impetus for change in the industry has come by way of materials manufacturers and dealers.

Another group of major importance during construction is labor. Construction labor faces a highly unstable work situation, having to move from job to job, usually from employer to employer, and in nearly all cases, having to deal with intermittent periods of unemployment during the winter months and general economic slowdowns.

Major differences exist between the union and non-union labor sectors. As a general rule, the union sector includes workers in multi-family high-rise (i.e., above 4 stories) construction and workers in metropolitan areas, although certain trade specialties, e.g., mecahnical and structural trades, are more likely to be unionized in all areas. Like the industry in general, labor unions are highly fragmented by specialty (with no fewer than 19 national unions serving the industry [17]). Also characteristic of the industry, the operating unit is on the local level.

---

[17] Howard G. Foster, Manpower in Homebuilding: A Preliminary Analysis, Philadephia, Pa.: The Wharton School, University of Pennsylvania, 1974, p. 42.

The functions served by the local associations vary widely, but most perform important services regarding employee training, the typical union program being modeled on the apprenticeship system, combining on-site experience with off-site instruction. Unions also play a major role in labor management functions, for example, matters regarding hiring and firing practices, wages, and the like. Again, services vary by particular union, however, most act as sources of information and contact for their members, not unlike employment centers. For example, contractors will notify the unions detailing the types and number of workers they require and the unions in turn, notify their members and thereafter, negotiate the terms and conditions of employment. (This function, known as the union "hiring hall," is typically performed by the union business agent.) Sometimes the unions negotiate with the contractors' association or, more often, with individual employers.

Unions also play a central role in regulating on-site work operations. Each union typically has a long list of rules regarding such matters as the use of machines and tools, jurisdictional requirements, the pacing of work, requirements for crew size, and the like. At any time during employment a union worker can turn to his union in the event that such requirements are not adhered to or to resolve any practical difficulties that might arise. (Typically, this is the job of the union steward, a laborer appointed by the union.)

It is work rules and practices of this sort that are often alleged to be restrictive and to impede technological progress and change in the industry. For example, new products may require a redefinition of the responsibilities of many trades and thus involve a jurisdictional dispute. And although such incidences have occurred, the situation is, needless to say, hardly so clear-cut. What is seen as a safety measure by some is inevitably taken by others to be deliberately restrictive; moreover, as the report of the Douglas Commission notes, some rules that are blatantly restrictive (meaning that they are motivated purely out of a concern for job security, and the like) are not enforced, while those that are may be ignored [18]. In the final analysis, therefore, such allegations must be taken as, at best, problematic. (This does not imply that they do not have consequences in the production process and the industry overall however, a matter to be discussed more fully in Section 3 of this chapter.)

By contrast, the non-union labor sector, which encompasses a high percentage of the total labor force in the industry, [19] operates in a far more informal, almost haphazard manner. There is no equivalent to the union hiring hall, and the process of matching jobs to workers, obviously of central importance because of the intermittency of most construction jobs, is carried out through a network of information contracts. For example, a builder may solicit applicants from former

---

[18] U.S. National Commission on Urban Problems (The Douglas Commission), Building the American City, Washington, D.C.: U.S. Government Printing Office, 1968, Part III, Chapter 4.

[19] As the NAHB Survey reports, most residential construction is performed by non-union labor. In fact, in a large number of labor markets single-family homes were found to be built almost exclusively with non-union labor. According to the survey, 8.1 percent of the builders use some unionized crafts while 91.9 percent do not. Further, the proportion of union/non-union was found to be approximately the same for both single-family and multi-family builders, e.g., 92.1 percent of single-family builders employ non-union labor as compared to 82.9 percent of multi-family builders. Sumichrast et al., p. 63.

employees, his subcontractors, or even from his competitors in the local market [20]. Job training procedures are similarly less formal. In fact, there are few formal efforts of any kind and with the exception of a few apprentice-style programs administered by the NAHB and instruction in vocational schools, most training is done on the job. But even this is not likely to be carried out in any systematic manner. As noted earlier, formal training is too costly for the average builder, and there is no guarantee that a trained worker will remain with the employer when the training sessions are completed. Thus, in contrast to the union sector, a large portion of the homebuilders' labor force is only partially skilled. Typically, general contractors and subcontractors have a few highly skilled workers which they employ year round (known commonly as the "construction core") and the remainder of the work force is hired on an as-needed basis as industry activity demands [21].

In addition to those involved in actual construction work, one final group of actors is important for supervisory and regulatory functions during this phase. This includes engineers and/or architects inspecting the work for the developer. Inspections may also be carried out by the lending source and/or by a variety of public officials. Typically, representatives from different public agencies must inspect and certify the work at various stages during construction.

The final two stages in the housing production process--distribution and service, are comprised of a series of activities recurring throughout

---

[20] Foster, p. 104.

[21] See Foster, Chapter 4, for a more complete discussion of labor training and skill development in the industry and Chapter 5 for a discussion of the hiring process.

the life of the structure. After the completed structures have been inspected and certified by local officials as suitable for occupancy, distribution activities may begin. Here major differences are apparent between sales and rental housing. For sales units, housing distribution marks the first complete cycle in the housing production process. Following completion, a prospective buyer is sought sometimes with the assistance of local sales brokers or on-staff marketing personnel. Typically, the small-scale builder handles marketing efforts himeslf; only the large-scale builders employ outside specialists. Then, upon location of a buyer, and with a commitment for financing, transfer of the deed takes place and the buyer assumes responsibility for subsequent use and disposition of the property--in other words, there is no ongoing relationship between the buyer and actors in the previous stages.

In general, few other persons are involved in the distribution of sales housing. Attorneys may provide assistance and advice to prospective buyers and assist in the closing of the sale. This same set of actors is involved upon resale of the property to a new owner.

By contrast, the distribution of multi-family housing is more complicated, involving the developer (or someone with similar profit motives) in an ongoing process. Obviously, because he/she retains the controlling financial interest, the developer maintains an active role in assuring the projects continued marketability. Upon completion of the structure, the developer turns to marketing and management specialists to make detailed plans for "rent-up" and cost schedules for operatons. (In most cases, preliminary planning for these activities begins well before this time, as it is only with expectations of certain rents and thus anticipation of certain returns on investment that the development continues beyond the preparation phase.) Typically, some management skills are provided in-house, although it has become customary for developers to employ outside management specialists as well.

The service phase following distribution involves three major categories of activities--maintenance and management, repairs, and improvements. Once again, these activities entail major differences for sales and rental housing. As with distribution activities, in rental housing, maintenance and management are ongoing processes. Typically, during the "rent-up" phase in the distribution stage, the property management firm gains familiarity with the structure and makes detailed assessments and plans for ongoing maintenance and repairs. For income-producing properties, there are standard rules for projecting service needs and expenses; operating budgets typically include allowances for such items as vacancies, routine maintenance procedures, as well as major annual repairs. To carry out maintenance activities, management firms either hire a maintenance staff directly or contract the services of local maintenance firms. In the case of repairs and other ongoing service needs, property managers also maintain relationships with utility companies, tax assessors, and so on, as well as a variety of firms specializing in building repairs. In some cases, these may be the original subcontractors, although there are many firms specializing in repair work which are more often involved. In all cases, though, it is the reputation of the firm in the local community that is critical in its selection.

Typically, many of the building components are covered by warranties or certificates for workmanship and parts. For example, construction contracts often have warranty periods extending over several years as do the major pieces of equipment, for example, plumbing and mechanical parts. Thus, it is possible for any of the subcontractors or the general contractor or materials suppliers to be consulted during the life of the structure whether or not they are employed in more routine repair matters. Similarly, the architect and the engineer have legal liability for their work; thus, they too may be consulted in the event of major difficulties.

In contrast, in sales housing, responsibility for ongoing maintenance is with the home owners. Here too, building components are likely to be covered by warranties for installation and parts. In some states builders themselves provide warranties for their work. (For example, Massachusetts just recently authorized a program of this type.) Thus, though less likely, it is possible for actors involved in the previous stages to take part in repair work during the life of the structure.

In addition to such general maintenance and repair work, it is customary for major improvements or renovations to be undertaken during a structure's life. When this occurs a series of activities takes place similar to those involved in the initial production of the structure. Here too, major differences exist for single and multi-family developments; there are different constraints on development and different decision factors on the part of key actors in the process.

For single-family housing, initiation of the project comes from the homeowner. The type of improvement is obviously much of a personal matter, dependent on taste, need, income, and so forth. But in most instances, property owners are concerned with how the improvement will affect the marketability of the home, for example, whether the full cost of the improvement can be included in the future sales price as well as possible cost savings in such areas as maintenance or utilities. (The average homeowner moves every 5-7 years; thus a 5-year payback period is often used when calculating estimated savings in operations.) It is important to bear in mind though, that because the homeowner typically looks upon his home only partly as an investment, the homeowner might still go ahead with the improvement even if such projections proved not entirely favorable. Again, because of the "personal" characteristics of housing, the calculus is not entirely an economic one.

Improvements for single-family homes are typically carried out by specialty contractors (or, on small jobs, sometimes by the homeowner himself.) Often property owners look to hardware stores, lumber yards, and other building supply outlets for information on particular productions and/or the names of local contractors. Some contractors though, promote and solicit business for their particular products.

Labor requirements for home improvements are generally more demanding than in new construction. New features must often be custom fit and installed to fit the existing structural frame. Financing requirements, though, are generally less important in single-family improvements than in new construction. Here, the lender's principal concern is the borrower's reputation and credit worthiness as opposed to the type or value of the improvements. To the extent that lenders assess the type of improvements they are typically more concerned that a borrower obtain a reputable product and proper installation rather than to assess the attractiveness of the item from an investment point of view, on the assumption that dissatisfied or defrauded consumers are more likely to default on a loan [22].

Single-family improvements typically involve few other actors or constraints. Only rarely are architects or engineers involved. Similarly, building permits, zoning approvals and other permits are less frequently required and/or secured.

On the other hand, multi-family improvements typically involve a wider range of actors and constraints. As a general rule, developers carry out improvements solely on the basis of the "return on investment" calculus. In brief, when the developer anticipates the return from the improvement to exceed the return from the property without it and moreover, when the gain anticipated over time is greater than might be obtained from alternative investments, an improvement will be made. Investors in multi-family developments typically have short-term investment horizons and thus judge possible improvements on the basis of 2-5 year payback periods. Included in these assessments are any of a variety of government subsidies aimed at encouraging building improvement and/or the inclusion of specified design features, often in the form of tax write-offs, as well as possible changes in the tax status of the property, most importantly, whether a tax increase is likely to result.

----

[22] David Barrett et al., "Home Mortgage Lending and Solar Energy," Prepared for the U.S. Department of Housing and Urban Development, Washington D.C.: U.S. Government Printing Office, (023-000-00387-2), February 1977, p. 23.

Financing for multi-family property improvements is typically more difficult to obtain as well as more costly than long-term financing. As with new construction, banks play a central role in determining the types of improvements to be undertaken; again, the developer generally wants to keep personal cash expense to a minimum and is thus likely to undertake only those improvements which banks are willing to finance.

As with single-family improvements, multi-family projects are likely to be carried out by specialized contractors; general contractors may be involved on large jobs. Building permits and zoning approvals may be necessary, obviously depending on the type of improvement. Similarly, architects and engineers may be consulted.

Implications for Innovation Acceptance in the Homebuilding Industry

We now turn to some of the broader considerations affecting the views and dispositions of industry members and the general institutional climate of the industry. Of particular importance to this study, and thus the focus of this section, are the implications of such dispositions and industry structure on the potentials for change in the industry.

This is a subject that has received much attention from both scholars and practioners and has been, on occasion, the source of much controversy and debate. For example, one conception long popular has been that the construction industry, the homebuilding industry in particular, is technologically stagnant and largely incapable of major technological change. In brief, the craft-based, manual operations of the homebuilding industry are compared with the more routine, technologically based activities in other industries, for example, in manufacturing or the automobile industry. From this and related comparisons, it is concluded that the homebuidling industry has missed out on the major technological breakthroughs of the twentieth century [23]. In the words of one major study:". . . technological change has been primarily evolutionary, in small increments, significant only in the aggregate . . . it can hardly be called innovation." [24]

Perhaps not all analysts have been so extreme in their assessment of the industry, but the popular view is that the industry is overly tradition-bound and generally lethargic if not outright resistant to innovation. Often this predicament is explained by pointing to the industry's structural characteristics or one or more of the many risky or problematic activities in the housing production process, some of which have already been alluded to in the preceding section: local building codes deter the development and use of new products and new designs because of variations from locality to locality and because the process of code change is typically a long and tedious one; labor unions impose overly restrictive rules and regulations in the production process in their efforts to ensure job stability for the construction labor force; the homebuilding industry is lacking in the organizational capacity to undertake research and development activities and moreover, the organizational capacity to transfer technology from the stage of

---

[23]Francis T. Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction," Ph.D. dissertation, MIT, 1973. See Chapter 1, pp. 18-62.

[24]Arthur D. Little, Inc., "Patterns and Problems of Technical Innovation in American Industry: Report to National Science Foundation," September 1963, p. 133, quoted in Ventre, p. 31.

development to actual application; the financial community is unwilling to assume the risks associated with new products and practices; the typical builder/developer has little additional capital, i.e., risk capital, with which to try out a new product or work process, and so on.

Though in general agreement on the problematic nature of the homebuilding industry and the difficulties presented by these and related issues, other analysts, however, take pains to show that significant changes have occurred even if the process has been incremental and at times, a difficult one. One analyst, for example, claiming the homebuilding industry to have experienced a "veritable technological explosion since the 1950's," traces the progress of fourteen innovations to show that their time periods for adoption (i.e., the time taken for most potential users to adopt) have generally been as rapid as the adoption of innovations considered equal in significance in other industries [25].

According to this view, many of the important changes that have occurred have been bypassed by traditional analysts and so-called "sidewalk superintendents," first, because these changes are, in most instances, not easily visible in the finished product--changes, in other words, are deliberately masked by homebuilders because of the conservatism of the housing consumer--and second, because of the measures used--the structure of the hombuilding industry, its fragmentation and

---

[25] Francis T. Ventre, "Innovation in Residential Construction," Technology Review, November 1979, pp. 51-59. Note that the findings reported in this article are based on the author's doctoral dissertation, i.e., Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction."

the small size of industry participants coupled with the discontinuous nature of the homebuilding enterprise, make the industry unique such that conventional measures, e.g.,capitalization rates, value-added measures, etc., are entirely inappropriate indicators of industry performance [26].

Further, these analysts point to studies on industrial innovation, notably the study by Myers and Marquis, that confirm the view that the process of industrial change is more likely to be based on small, incremental changes rather than major scientific breakthroughs and further, that the impetus to change is often external to a given sector [27]. In other words, the lack of an R&D capability, while clearly not a facilitating factor, need not be taken as an a priori cause for lack of innovation in the industry.

In general, analysts of the latter persuasion see the problems confronting the industry more holistically; in other words, it is not simply the resistance of the unions, the conservatism of the financial community, the variations in local building codes, or any one of the so-called obstacles in the building process that account for the industry's disposition toward change. Also important is the homebuilding industry taken as a whole, in other words, the net effect of the

---

[26] Similarly, other industry characteristics, e.g., the small size of industry firms, reliance on manual skills, the high rate of entry-exit, need not be taken as reliable indicators of the industry's overall receptivity toward innovation nor as indicators of disfunction in the industry. Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction," pp. 18-62.

[27] Sumner Myers and Donald Marquis, Successful Industrial Innovation: A Study of Factors Underlying Innovation in Selected Firms, Washington, D.C.: National Science Foundation, 1969.

plurality of interests and groups that typically have a stake in an innovation. As Ventre sums up this position:

> "Our studies of the construction industry, including the housebuilding subindustry, lead us to conclude that such scapegoating betrays an ignorance of the dynamics and complexity of the construction enterprise . . . The 'frictions' that delay the evolution of building technology are more complex than obsolete building codes and restrictive union practices . . . A more useful formulation of the industry's dynamic can be drawn by analogy with other systems in which power and responsibility are dispersed among large numbers of actors, no one of which has more than a small fraction of the resources and power required to redirect the whole. Our analogy is with democratic, multifaceted political systems, where hesitation in the face of technological innovation proliferates through the whole" [28].

In essence, according to this view, to understand the industry's overall disposition toward change, and toward any one innovation in particular, one must first come to terms with the social relationships within.

Though the latter viewpoint seems a more useful framework for the present study, the purpose here is obviously not to resolve the different emphases in these views toward the industry. Nor is it the objective to determine the extent of industry change. Rather, on the basis of these accounts and the preceding review of industry operations, some broad generalizations regarding industry disposition toward change will be drawn to provide a framework for understanding the industry's response to an innovation like solar thermal.

From both the preceding discussion and the review of industry operations, one point is clear: the homebuilding industry in an institutional environment which poses significant challenges to

---

[28]Ventre, "Innovation in Residential Construction," pp. 57-58. See also Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction," pp. 57-60.

innovation, whether it is a matter of being outright resistant or just generally hesitant or lethargic to change. First, it is easy to see why the process of change is likely to be slow and incremental on the basis of the industry's structural characteristics alone. The extreme fragmentation of responsibility, as noted, the fact that of the hundreds of actors involved in the industry, there are few dominants with power or resources to redirect the system as a whole, ensures that considerable time will be needed if only to disseminate information on new ideas to industry members and thereafter, (assuming this new idea or product is acceptable) to coordinate their efforts and gain experience with the new practice or product. Obviously, the more disaggregated and functionally fragmented the organizational units and the fewer the formal mechanisms and channels for information dissemination and coordination (another major industry characteristic) the more difficult the logistics of change.

While industry change is thus likely to proceed slowly and in somewhat piecemeal fashion, simply for logistic reasons, it is also essential to recognize that industry members may often be lacking in basic incentives to commit themselves or even to experiment with innovations for many of the same and related reasons.

For example, the fragmentation which makes diffusion slow and difficult, dramatically increases industry interdependencies and thereby, the vulnerability of industry members, a condition further heightened by the small size and lack of capital of the average industry firm. Moreover, as the preceding review displayed, every stage in the production process and nearly every activity in each stage, entails at least some uncertainties and a fairly high degree of risk. Again, this may be for logistic reasons. Financing arragements, for example, might take longer than anticipated, or materials might not arrive on time and thereby, hold up the construction process, and so on. But it might easily involve substantive matters as well. The bank might determine the project to be too risky and thus refuse to provide a mortgage loan; market conditions, consumer preferences and/or production costs might easily be misjudged; contractors, labor, or any member of the development team might prove incompetent, and the like. There are also the external constraints--seasonality and economic conditions--further heightening the general atmosphere of uncertainty and instability in the industry.

In sum, the homebuilding industry is already so unstable and its operations perpetually so uncertain that industry participants, particularly the builder/developer, must be considered high risk-takers simply for their involvement in the industry. On these grounds alone, it would be understandable for industry members to look for ways to reduce uncertanties and risks or at the least keep them to a minimum by "sticking to the proven," the "routine." However, as explained, innovation always involves some measure of uncertainty and thus an increase in risk; by definition, it is partly on account of this newness, this unfamiliarity, that something is considered an innovation.

Further, it is important to consider the potential effects of industry structure and industry operations on the actual process of change in the industry--what, in other words, an actual change (product or process) would entail. Most importantly, because of the fragmentation of industry functions, the sheer number of activities and individuals whose efforts must be coordinated in the production process, and because of the uncertainties inherent in each of the activities themselves, it is largely inevitable for any innovation to go through a period of uncertainty as it is first introduced in the industry, irrespective of the uncertainties inherent in the innovation itself. Clearly, even if all participants were to agree, there is little chance of their doing so simultaneously. Nor is there much chance that they could all ready themselves for the innovation, in other words, make all the necessary changes for the innovation, in a given period of time. During this period of introduction and adjustment, the uncertainties and risks in the housing production process would be greatly compounded, as any of the various problematic activities might serve as constraints. For example, during this time, a builder might be delayed if a new product does not yet comply with existing building or zoning codes, or if a supplier does not yet have the product "on the shelf." Similarly, labor might be unfamiliar with a new material or the banking community might refuse to finance it, not wanting to assume any additional risks. What is critical to realize is that even though these factors may not prove problematic in every instance--it is possible that a new material will <u>not</u> require code changes or that labor unions will ignore rules and regulations that would ordinarily restrict the use of a new product--they may serve as constraints simply because of the uncertainty then engender. They are likely perceived by industry actors as possible deterrents to innovation even though this might not be true in each and every case.

Thus, industry structure and organization, and the general nature of industry operations, likely impede the acceptance of innovations by compounding the uncertainties and risks in an environemnt that is already so uncertain and risky under routine conditions. At the same time, however, this discussion should not imply that such factors serve to preclude acceptance of innovation across the board, as many popular conceptions assume. For one thing, it is clear that all activities in the housing production process are not of equal importance to the various actors involved. Nor are they of equal magnitude in risk. In so far as uncertainty and risk are invoved, the scale might be tipped in favor of an innovation; in other words, it is at least possible that an innovation will reduce the uncertainties and risks involved. For example, it would likely be in a builder's best interest to try a new financing process which, though somewhat uncertain and risky in itself (as all innovations are apt to be) promised to lead to a lower equity requirement or lower carrying charges, in turn enabling a possible reduction in the overall risk of the housing development process and/or a greater or surer profit. Perhaps an even more obvious example though, would be an innovation dealing with consumer demand. It would appear to be in the builder's best interest to try an innovation if it promised greater certainty in the projection of consumer demand, importantly, even if this meant engendering greater uncertainties and risks in other activities in the production process. This is, in fact, one inducement to innovation that is acknowledged by most industry analysts; when consumer demand is evident, builders have been known to respond readily and quickly, in spite of uncertainties engendered in other activities in the housing production process.

Thus industry structure and activities need not serve as a priori deterrents to innovation, in other words, there are certain circumstances under which innovations appear worthwhile for industry actors to pursue. But the fact of the matter is that aside being of a rather limited range, such circumstances do not often occur. For example, the builder is likely to respond to changes in consumer demand; it is in the builder's interests to do so. But as explained earlier, housing has unusually strong normative associations; it is "more ego than economics" [29]; and the housing consumer does not want anything that breaks too radically with tradition. In fact, as Ventre noted, "so traditional are consumers' preferences when it comes to their own housing, builders deliberately disguise changes in technology . . ." [30]

Perhaps, in the final analysis, the decision to innovate on the part of any one of the many participants in the homebuilding industry is best conceptualized as a trade-off, depending in part, on the intrinsic characteristics of the innovation and its compatibility with existing motivations and routines, e.g., low first-cost items in the case of the builder/developer, in addition to the various uncertainties and risks the innovation is likely to entail. This latter consideration is also likely to depend on a wide range of factors, including, for example, the uncertainties and extent of risk inherent in the innovation itself, the activities and actors involved (some obviously being more important in the production process overall and in relationship to one another) the number or proportion of the industry likely to be involved, and the extent and type of change involved. Though rather overwhelming, all such

---

[29]Furlong and Nutt-Powell, p. 1.

[30]Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction," p. 51.

factors are important to consider, as innovations varying in these areas are likely to prompt different sets of issues, engendering different responses on the parts of the many actors in the industry, and different receptions in the industry overall.

For example, a builder might be expected to favor a process-oriented change vs. a product or materials change because a process change is more easily disguised from the housing consumer, and because it typically involves fewer actors in the production process (and thus presents fewer coordination problems, and a reduced likelihood for any of the various activities in the building process to serve as constraints, e.g., building codes, labor unions). Moreover, process changes are typically small and incremental and do not require drastic changes in the activities of other participants in the building process. (This too, of course, translates into reduced probability for the emergence of obstacles [31]. Similarly, industry participants might be expected to differ in their dispositions toward innovations which add to existing services or products as contrasted to those which replace existing products, for example, products that perform the same service as one already in existence only doing so through different means or with minor levels in improvement. In these cases, it is easy to see how innovations of the former kind are much advantaged. Still further variations in

---

[31]By contrast, materials and product changes do not always easily fit the rather unique supply and distribution system of the industry, and therefore, often require major changes on the part of many participants in the production process, thus subjecting the builder/developer to many problematic situations and a much increased risk. See Ventre, "Innovation in Residential Construction," pp. 51-59.

response to innovation are likely to depend upon the social structure and organization of the particular individuals and groups affected by the innovation, if, for example, there are formal channels for information dissemination, established organizational entities to serve as a forum for events, the resolution of disputes, and the like [32].

Needless to say, any of an incredibly wide range of responses is possible, and these examples and qualifications could continue ad infinitum. The intent, however, is to point out the wide range of issues relevant to the consideration of innovation in the industry. We can sum up this discussion by restating the original proposition only now in a somewhat qualified form. That is, though not a question of unilateral resistance or even lethargy to change on the part of all actors in the industry, on account of the industry's structural characteristics, and the many uncertainties already existing in the industry environment, individual actors in the industry are generally conservative, even suspicious of change. In a certain sense, insofar as it is "new" things, things different from existing institutional routines that industry members characteristically avoid, on one level, the homebuilding industry is "institutionally" opposed or at the least hesitant toward innovation.

---

[32] For example, in the Ventre study, innovations affecting plumbers were identified as the most difficult change in eight times as many localities as were changes affecting electricians. Ventre attributes this result to the existence in the electrical contracting industry of the Council on Industrial Relations, a national labor-management forum designed to remove the causes of friction . . . by providing a forum for . . . settlement of controversies between local chapters of the International Brotherhood of Electrical Workers and the National Electrical Contractors Association." By contrast, there is no counterpart in the plumbers' trades, Ventre notes. See Ventre, "Innovation in Residential Construction," pp. 56-57; and Ventre, "Social Control of Technological Innovation: The Regulation of Building Construction," Chapter 6.

Moreover, given the fragmentation and many interdependencies of industry participants, there is one further complication still. That is, the question of system effects, in other words, the result of one industry actor predicating his or her behavior on that of another and this actor, in turn, predicating his response on that of another still. Such "second-guessing" is easy to imagine in an industry as fragmented and interdependent as the homebuilding industry. While, as Ventre notes, such systems effects might go either way, in other words, for or against the acceptance of an innovation [33], this would nonetheless appear to be a further deterrent to innovation in the industry. For one thing, it is easy to foresee the possibility of prisoners' dilemma type problems, as each actor waits until another tries it, that is, until another bears the risk. But at the same time, given the extreme fragmentation, it is clear that no major innovation can be accepted in the industry until a significant number of industry participants concur, certain participants, i.e., the builder/developer most importantly.

---

[33]Ventre, "Innovation in Residential Construction," p. 58.

CHAPTER 3: THE HOMEBUILDING INDUSTRY AND SOLAR ENERGY ACCEPTANCE

Introduction

Thus far the theoretical framework for the study of innovation acceptance has been described. Briefly, innovation acceptance was explained to be a process taking place in the context of an existing institutional environment. Thus, innovation acceptance is said to be facilitated to the extent that the innovation appears consistent with existing institutional meanings and routines.

Chapter 2 described the homebuilding industry from the institutional perspective, noting the major institutional entities, their routines and the linkages between and among them. The chapter concluded with a brief assessment of the potentials for change, i.e., innovation, in the industry.

In this chapter we will apply the theoretical framework to consider the issues likely to be involved in the introduction and institutionalization of a particular innovation, i.e., solar thermal. Solar thermal technologies offer many obvious advantages over conventional energy sources, and while interest in solar thermal appears to be increasing, the technology is far from the stage of institutionalization in the industry. Most generally, this chapter aims to explain the current industry resistance to the use of solar thermal and the manner in which the process of institutionalization might be helped along. Finally, the details of the research design devised to test the usefulness of the theory are presented.

The Innovation: Solar Energy

Solar energy refers to an assortment of energy technologies--photovoltaics, solar thermal, biomass, wind power--to name a few [1]. Though all convert sunlight into heat, electricity, or other energy forms, it is important to distinguish clearly among them because they vary considerably in scale and complexity and are presently at varying stages of technical and commercial development. The particular technologies under consideration in this study are the small-scale, on-site, space and water conditioning technologies known commonly as solar thermal [2]. Further, the concern here is with "active" (as opposed to "passive") systems, termed "active" because they utilize a number of movable parts and mechanical systems to collect and circulate the sun's rays. In contrast, a passive system is where the structure is sited and designed to take advantage of the sun directly; in other words, the heat "moves itself" to and throughout the structure.

---

[1] In an attempt to clear up the confusion over the term "solar energy," the Department of Energy has identified eight different types of solar technologies and has grouped these into three major categories: 1) Thermal (heating and cooling) applications; a) heating and cooling of buildings; b) agriculture and industrial process heating; 2) Fuels from biomass; a) plant matter; 3) Solar electric; a) photovoltaics, e.g., solar coils; b) solar thermal electric, e.g., the power tower; c) wind; d) ocean thermal electric; e) hydropower. Each of these categories can be further subdivided. See U.S. Department of Energy; "Solar Energy, A Status Report," Washington, D.C.: U.S. Department of Energy, (DOE ET-0062), June 1978, Appendix A, Solar Technologies, pp. 13-39.

[2] Typically "solar thermal" includes both heating and cooling technologies. This study, however, focuses exclusively on heating technologies because of the differences in engineering and commercial advancement between the two and also due to data availability. Solar cooling technologies can, however, be expected to prompt a similar set of issues at a later date.

Of active systems, solar thermal technologies are generally agreed to be the simplest (i.e., in terms of design and engineering) as well as the most technically and commercially advanced of those in the on-site group. Their principles of operation are well known. In brief, the heat of the sun is collected and concentrated by panels (generally made of glass, aluminum, and/or plastic) which, in turn, heat air or water in coils or tubing that flows through them. Fans and/or pumps then circulate this heat to a water-filled storage tank which can be used directly for hot water or further circulated by conventional means, e.g., radiators, to wherever it is needed for space heating [3].

Essentially, solar thermal is a fuel replacement technology. Conventional heating systems may still be needed for back-up, however, during periods of sustained cloudiness. (Techniques for storing the sun's heat for long periods of time have yet to be developed.) Though a much debated subject, a typical solar thermal system is believed capable of supplying only one-half to two-thirds of total heating needs. Solar thermal would, however, serve as the principal energy source, in other words, replacing (rather than simply adding to), a portion of the services provided by oil, gas and other conventional fuels.

Considering current U.S. energy prospects the potential benefits from widespread use of solar thermal are clear. Buildings play a significant role in total energy consumption; home energy use alone (hot water, space heating and cooling) accounts for roughly one-fifth of the national

---

[3]For general information on active solar technologies, see Bruce Anderson, Solar Energy: Fundamentals in Building Design, New York: McGraw-Hill, 1977.

energy budget. In some parts of the country solar thermal is capable of supplying over 70 percent of a building's thermal requirements. Though estimates vary, even the most conservative forecasts project savings of at least 50 percent in residential energy use if the majority of homes in the U.S. were to become partially or wholly heated by solar thermal systems [4]. Solar has other attractions as well. Not only is it a nondepletable, renewable source of energy, but it is not beset by the degrading environmental consequences of present conventional sources nor the potential health and safety hazards of others. Use of solar obviously adds no new heat to the environment. Further, solar is an ubiquitous energy source, free, and not subject to foreign control.

This recounting of benefits is familiar. Indeed, solar advocates, a small group generally associated with the "counter-culture" set, have been proclaiming them for years. It has only been within the last decade (actually since the oil embargo of '73) that solar thermal came to be approached with any degree of seriousness and that solar-related research R&D and commercialization activities of any significant scale began. For a general sense of this change in attitude towards solar energy, the federal budget is instructive. During the entire period from 1951 to 1973 something less than ten solar or solar-related bills had been introduced with funding at generally no more than $10 million in the most extravagant of the proposals. None of these was passed. By contrast, during the two-year period of the 93rd Congress,

---

[4] John S. Reuyl et al., "Solar Energy in America's Future: A Preliminary Assessment," Menlo Park, California: Stanford Research Institute for the Energy Research and Development Administration, 1977.

the period immediately following the embargo, more than twenty-five solar and solar-related bills were introduced, all with funding levels set at well over $10 million. And since that time federal involvement and budgetary outlays have been increasing dramatically. Funding for federal research, development and demonstration (R,D&D), for example, increased from $14.8 million in FY 1974 to $151.6 million in FY 1976 to well over $500 million in FY 1979, including $96 million for solar thermal technologies alone [5].

Similarly, where a solar thermal industry was virtually nonexistent in the early '70's, today it is highly active and growing. According to a recent survey, industry sales, including installation, increased tenfold in a three-year period, from $25 million in 1975 to $269 million in 1977. In 1977 alone, 3,300 space and water heating systems and 63,000 solar hot water systems were sold [6]. Similarly, DOE's annual survey of solar collector manufacturers' activity reveals continued growth in industry volume (e.g., the sixth semiannual survey in the first half of 1977 revealed a 54 percent increase in productivity over the previous period) as well as indicators of increasing industry stability. (Few industry firms have dropped out; some new firms have entered, but on

---

[5]For a useful summary of current federal policies, programs and expenditures for solar energy technologies through FY 1979, see U.S. Department of Energy, "Domestic Policy Review of Solar Energy: A Response Memorandum to the President of the United States," Washington, D.C.: U.S. Department of Energy, (DOE-TID-22834), February 1979. See especially Chapters 1 and 2.

[6]Stobaugh and Yergin, p. 188.

average, production volumes have increased [7].

In one sense, solar thermal might be viewed as the innovation par excellence. Currently, the whole field of solar energy is in a state of flux; in addition to the high level of entrepreneurial activity, a good deal of R&D activity is under way in both public and private sectors; the intrinsic characteristics of the technology are undergoing continual modification, for example, in engineering, design, and cost. And in these variously changed forms, solar thermal technologies are being introduced and experimented with in a variety of economic sectors, e.g., residential, agriculture, industry, and so on.

Thus it is reasonable to characterize solar thermal as being in the early stages of the institutionalization process. Nonetheless, solar thermal has a long way to go to achieve full-scale acceptance in the homebuilding industry. One point is clear: solar thermal has yet to be taken seriously by the general public and key actors in the homebuilding industry. Perhaps they have heard about solar thermal; perhaps even expressed something more than a casual interest. This is, however, obviously a far step from routine acceptance of the technology. In fact, it is not yet routine for members of the homebuilding community to even consider solar thermal as a serious alternative in typical building operations.

There can be little doubt that major innovations take time for diffusion and adoption. As explained earlier, institutionalization is

---

[7] For a presentation and discussion of the findings of DOE's Annual Survey of Solar Collector Manufacturing, see Allan Frank, "Flat Plate Collector Manufacturing: Up Again, and Steadying," Solar Age, June 1978, pp. 36-39.

almost always a slow and cumulative process. However, the slow pace at which the innovation is being accepted in the industry is likely something more than the usual time lag experienced in innovation acceptance. As a matter of fact, there appears to be a substantial mismatch between the solar thermal technology in its current state of development and major homebuilding industry routines and dispositions.

The Innovation and The Industry

We have described the homebuilding industry as being a difficult environment for innovation acceptance. The logistics of change are problematical and the participants are generally conservative as they avoid things perceived as uncertain and/or risky. Change can and does occur, however, only under a rather limited range of circumstances. As explained, industry acceptance of an innovation is likely to depend on a number of factors, including the intrinsic characteristics of the innovation, the actors and activities of the housing production process most affected by the innovation, the number of actors, the extent of change required, and so on. The fact is, in reviewing solar thermal in its current state of development, the technology appears to present many problems in these areas. On numerous counts, there appears to be a firm basis for industry resistance.

First, solar thermal directly counters routines of particular importance to critical industry actors. The most obvious incompatibility is economics. For the user, solar thermal is often not yet economically competitive with conventional energy systems. An even greater economic obstacle, though, is that solar thermal systems will invariably involve a higher first cost even if they are economically more attractive on a life cycle basis. As noted in the previous chapter, both the builder/developer and the homebuyer are highly sensitive to initial investments. Because of the high costs and difficulty of borrowing money both the homebuilder and homebuyer typically look for ways to reduce front-end costs, even if this means foregoing the chance for lower operating cost. Further, to the extent that they are willing to increase initial investments, time horizons are characteristically short. As a recent study of consumer response to solar thermal revealed, consumers want a fast return on their investment and expect to recoup the additional front-end cost spent on installing the system in a short number of years [8].

Design and aesthetics is another area in which solar thermal entail outright incompatibilities with current industry standards and routines. Clearly, a house with solar panels bolted on the roof looks different from a house in which the heating system is enclosed and "out of sight" in the conventional manner. Just the idea of having the heating system on the roof is something "new and different." As noted earlier, because housing is a highly personal good, "more ego than economics," the housing consumer wants to maintain tradition, in short, a house that "looks and feels" like the traditional home. Moreover, neither the builder/developer nor the homebuyer want a house that appears too

---

[8] On average, a five-year payback, i.e., the investment recovered in fuel savings in five years, was found necessary to attract serious consideration by the homebuyer. And in order to get 80 percent of the respondents to think about installing a system, a two-year or better payback was required. Stobaugh and Yergin, p. 191.

unusual, as deviation from the norm (here in design and aesthetics, mainly) is likely to limit the resaleability of the home.

These issues point to a matter of perhaps even more basic incompatibility and cause for industry resistance to solar thermal, in particular, resistance by the builder/developer. That is, the issue of uncertainty. As discussed earlier, all innovations, by definition, entail some measure of uncertainty and risk, as they have yet to be used and experienced on any significant scale. Further, there can be little doubt that solar thermal is an innovation currently involving more uncertainty and more risk than most, or at least uncertainty and risk at a scale far beyond the threshold for most actors in the homebuilding industry, notably, the central actor, the builder/developer. As explained above, the whole field of solar energy is currently in a state of flux, solar thermal technologies in particular. Indeed, there appears to be few things about solar thermal which are not perceived to involve a good deal of uncertainty and high risk at the present time.

First, as seen in the instances of incompatibility cited above, solar thermal engenders uncertainty in the one aspect of the housing production process of most importance to the builder/developer, i.e., market demand. Building with solar thermal at the present time entails building something that deviates from current design standards and traditional notions of what a house "should" look like. It also has a large capital cost and requires a high down payment, further limiting marketability and thereby jeopardizing the builder/developer's position in the housing production process overall.

It is likely that these instances of incompatibility and the increased risks they involve would suffice to cause resistance from the average builder/developer. However, it is worth noting some of the other uncertainties currently confronting the technology, some of which will undoubtedly increase the resistance of the builder/developer as well as the homebuyer. Most important are uncertainties concerning the technology itself. The fact is, solar thermal is not only uncertain in terms of economics and consumer demand, but on basic technological matters as well. For example, at the current time there appears to be little agreement on such a fundamental issue as whether the technology is ready for commercial application or whether further design and engineering development are required, or at least desirable. On the one hand, there are the numerous studies and scientific reports going as far back to the study by the National Science Foundation [9] in 1972 claiming the near readiness of the technology. In the words of one recent study, "solar thermal is not waiting for a technological breakthrough; this assumption represents a great misunderstanding . . . active heating is a here-and-now alternative to imported oil." [10] And then there are the programs and demonstration projects designed to support such claims, to demonstrate the presumed readiness and viability of the technology, the HUD SHAC Program, for example. But concurrent with such efforts and analyses are the many instances of mismanagement and technological failure, and massive efforts at R&D in both the public and private

---

[9] NSF/NASA Solar Energy Panel, "An Assessment of Solar Energy as a National Energy Resource," Washington, D.C.: U.S. Government Printing Office, (NSF/RA/N-73-001), 1972.

[10] Stobaugh and Yergin, p. 188.

sectors [11].

Such simultaneous efforts at commercialization and R&D (both with federal support) might confuse even the solar advocate. Clearly, the fact that those who support the technology "don't really know" likely serves as a substantial disincentive to both the homebuilder and the homebuyer. Why should they try it if even the experts cannot even decide if solar thermal is technically viable.

Similarly, there is much uncertainty if not direct disagreement on matters dealing with product durability, safety, reliability, and the like, in both design and performance. This is true for most solar thermal products on the market today. The further disincentive caused by this situation is apparent when one considers that conventional systems are not only tried and proven in all these areas but are "backed up" by a wide assortment of product guarantees, certificates, and warranties, not to mention the reputation of the supplier, the installer, the builder, and so on. As a new technology solar thermal has yet to earn such credentials [12].

---

[11] See for instance the Report by the U.S. General Accounting Office, "Solar Demonstration on Federal Residences--Better Planning and Management Needed," Washington, D.C.: U.S. Government Printing Office, (EMD-78-53), April 1978.

[12] Currently there is much activity in these areas. For example, standardization activities involving members of the voluntary consensus system, representatives from industry, and public and private groups, have been under way since 1975. Similarly, efforts have been under way to develop warranties, procedures to accredit testing laboratories, procedures to certify, label, and rate solar components, and the like.. These and other efforts have resolved certain issues, e.g., intermediate minimum property standards were published in 1977. But the point of the matter is that data from these efforts are not readily available in a form that enables easy comprehension of the state of the art, and different solar products. See Thomas E. Nutt-Powell and Judith Wagner, "Solar Heating and Cooling Standard Setting: An Institutional Analysis Case Study," Cambridge, MA: MIT Energy Laboratory Report, 1979.

There are also uncertainties on basic procedural matters relating to product procurement and distribution. To date the major firms in the solar thermal industry are small. In this early stage of commercialization, the industry has yet to develop a marketing and infrastructure capacity to match the local and fragmented structure of the industry. The builder/developer cannot simply visit the local sales representative or order solar systems from local dealers or distributors, in the same way he might routinely obtain conventional heating systems. (Further, given the lack of standardization, the builder/developer cannot easily order the various components comprising a solar system from different manufacturers, as he does other HVAC products, as there is no guarantee of product compatibility.)

As solar thermal has yet to establish a system to meet the unique needs of the industry, neither does it appear to have established a parallel system of its own. A few of the largest firms are addressing these issues and have developed some uniformity in their practices [13]. However, for the most part procurement and distribution practices are idiosyncratic, meaning that even the simplest applications of solar thermal must be custom ordered and arranged. Moreover, availabilities and procedures for purchase and distribution can be expected to undergo constant changes as the industry expands, new product lines developed,

---

[13] The Daystar Corporation, for example, one of the largest solar manufacturers in the U.S., has developed a system with local dealerships emanating from a central production location in Burlington, Vermont. All dealers have installment capability, "primarily out of concern for legal and reputational liability." Interview with Barry Tepper, Daystar Corporation, January 18, 1978. Similarly, Grumman, another major manufacturer, is aggressively addressing management and marketing issues. See Stobaugh and Yergin, p. 190.

existing products modified, and so on. Thus, at this stage, even if a builder/developer tried to follow the pattern of a completed project, while obviously helpful, there stands a chance that procedures and possibly products would no longer be the same.

Further uncertainties are likely for other major activities in the housing production process, in fact, for nearly every major activity described in each phase, from preparation through distribution. Because the average builder/developer does not yet have even a general understanding of the technology, he is not equipped to design a solar thermal system or to integrate a solar thermal system into his routine process of home design. At the same time, the solar industry is generally unprepared to provide the technical assistance required at the local level. Further, it is clear that solar will entail some changes in the design process notably in involving engineering skills in different ways in both single and multi-family developments. Currently, engineers are rarely involved in the design of single-family dwellings and in multi-family projects, only on a subcontract basis, in most instances, after all major design decisions have been made. Yet for optimal efficiency of a solar dwelling design, engineers should assume a more central role from the start of the design stage. Added to the impact of such organizational changes is the fact that at the present time there are few architects or engineers qualified to provide such services. As one recent study discovered, a solar engineer or an architect with more than three years experience is a rarity [14]. Thus, in using solar

[14] Stobaugh and Yergin, p. 194.

thermal, the builder/developer would not be able to select members of the building team on the basis of reputation as is the customary practice in the industry.

After the actual design of the structure, use of solar thermal will likely involve further uncertainties in the code approval process. Of the thousands of codes in existence, only a few presently have provisions regarding solar thermal usage. That most codes provide specification (as opposed to performance) standards (i.e., specifying the use of particular products and/or materials rather than the conditions to be satisfied in operation) means that solar technologies are apt to be prohibited, thus ensuring some measure of uncertainty, even if code officials have in the past ignored such laws or express a willingness to do so in the future. Similar legal uncertainties exist regarding zoning laws, whether, for example, solar thermal is allowable under existing statutes. Also at stake is the issue of "solar access" or "sun rights." Presently few zoning codes include solar access provisions and there exists little legal precedent in this area.

Uncertainties are also likely to occur in the production phase. First, given the short supply of solar skills (engineering, architecture, HVAC, and so on) team selection could only be an activity of a highly uncertain nature. Indeed, without an understanding of the basic technological issues and the process of solar thermal design, coupled with the lack of firms and individuals with established repuations, it is difficult to imagine on what basis a builder/developer would establish the "building team," to say nothing of establishing project cost estimates, schedules, and the like. Also at this stage, project financing is likely to be uncertain. For example, questions remain concerning the willingness of lenders to provide mortgage funding for homes with solar thermal systems as well as questions relating to the terms of the loans. Most importantly, precedents for the valuation of solar thermal units have yet to develop. By virtue of the newness of the technology, the lending community is itself uncertain as to solar thermal's market value. Ultimately, the market will be the final arbiter, but in the meantime, the builder/developer as well as the housing purchaser cannot be assured that solar thermal will not be treated as an overimprovement and thereby excluded from the value of the mortgage loan [15].

Still further uncertainties are inevitable during the construction phase. To date it is unclear whether solar thermal will require the establishment of new jurisdictional boundaries among the work of various trades, e.g., the plumbers and the roofers. For example, will collectors mounted on flat roofs be treated as other conventional roof-mounted HVAC components and thereby considered the work of the trades? Will this vary if the collectors are integrated into glazed window walls in the form of vertical wall systems [16]. While these and related questions remain

---

[15] See David Barrett et al., Financing the Solar Home, Lexington, MA: Lexington Books, 1977, and Barrett et al., "Home Mortgage Lending and Solar Energy."

[16] As one study notes, conventional wall systems are normally installed by glazing and miscellaneous metal or iron workers, yet wall collectors would require the use of plumbers. Richard Shoen, Alan Hirshberg, and Jerome Weingart, New Energy Technologies for Buildings: Institutional Problems and Solutions, Cambridge, MA: Ballinger, 1975, p. 95.

unanswered, at this time, an even more basic question persists: will new skills and new techniques be required for installation of solar thermal systems? In other words, will the existing labor force have the requisite technical skills at all? As noted, solar skills are in short supply. It is the solar installation technician, often the plumber with no experience in working with solar thermal equipment, who is believed to be the weakest link in the chain [17]. Further, even if labor skills were sufficient, the construction phase would remain a period of uncertainty because of possible mechanical problems with the system and its integration with the conventional heating system, in addition to possible problems in procuring systems parts. It is not difficult to imagine a situation similar to the foreign auto repair process in this country, where a customer, in this case the builder/developer, would be forced to wait weeks on end for a certain system part, or for someone to redesign the system such that it would function without such components. Further, considering the builder/developer's lack of understanding about the technology, and infrastructure uncertainties, the builder/developer is likely to have a difficult time supervising and managing the construction process. Clearly, with the many uncertainties and deficiencies mentioned above, the builder/developer's position during construction could only be a highly precarious one.

There are undoubtedly other uncertainties still [18]. However, this

---

[17] Stobaugh and Yergin, p. 194.

short review should suffice to demonstrate that the builder/developer has good reason to resist the use of a technology like solar thermal. First, it is incompatible with routines of critical importance to the builder/developer, and as a result, vastly increases the uncertainties and risks in the most important of all aspects of the housing production process, i.e., marketability and consumer demand. On this basis alone, it is clear that use of the technology would undermine the builder/developer's position. However, there are further uncertainties adding to the builder/developer's already risky position. The technology itself is not proven, and as it is just now being introduced into the homebuilding industry, it entails major uncertainties at nearly each and every stage of the housing production process.

Though the principal concern in this study is with the builder/developer, it is important to recognize the circularity of the problem and some of the many system effects likely to occur. For example, the builder/developer is likely to refrain from use of the technology because of the many incompatibilities and uncertainties concerning the product and its use. Yet without market demand, the solar product is not likely to improve, nor is the industry infrastructure

---

[18]For example, one other major problem still to be resolved concerns the role and attitudes of the utility companies. Solar thermal will almost always require backup systems, and the rate structure for such sources will determine the ultimate cost competitiveness of solar thermal vs. conventional systems. Many utility companies are currently investigating solar thermal opportunities and the roles they might assume. However, there has yet to develop a pattern as to the manner in which the utilities will cooperate, or if they are willing to cooperate at all. For a more complete discussion, see "Utility Involvement: A Roundtable Discussion," Solar Age, December 1978, pp. 12-17.

likely to develop. Clearly, without some certainty in levels of demand, the solar manufacturer will find few justifications for "tooling up" for production and for developing marketing and distribution systems tailored to the unique needs of the industry. If using solar thermal at the present time is too costly and risky for the builder/developer, such efforts, typically involving large capital investments, are likely too costly and risky for the average solar manufacturer.

While these factors in themselves are obviously deterrents to both the builder/developer and the solar industry, it is also important to recognize the effects caused by the response of the housing consumer. For while the current state of the solar art and the many uncertainties regarding industry infrastructure serve as deterrents to the use of the technology on the part of the builder/developer, it is clear that the builder/developer will not use the technology if consumer demand is not evidenced. And yet the consumer is not likely to favor solar thermal, for one thing, until the costs have improved, and this, in turn, is at least partly a function of industry efforts. Nor is the consumer likely to favor the technology until it is technically proven, in other words, of demonstrated viability in terms of efficiency, safety, reliability, and so on. This, too, is a function of builder/developer and industry combined efforts.

Studying Solar Acceptance in the Homebuilding Industry

On reading the previous section, one would conclude the acceptance of solar thermal technologies in the homebuilding industry to be an altogether formidable proposition. Indeed, by this brief review, it would appear to be nearly impossible. But it is the case that innovations are accepted in the homebuilding industry, and that certain builder/developers have used solar thermal technologies, in spite of the many uncertainties and other reasons seeming to deter their use. This section sets forth an approach to studying and understanding those factors which have influenced acceptance of solar thermal in the homebuilding industry, despite the apparent sources of resistance discussed in the preceding section.

As discussed in Chapter 1, an innovation is something "new," that is, something that has yet to acquire social meaning. It will always be introduced in the context of an existing institutional environment; thus to be acceptable, it must be comprehensible in terms of existing institutional meanings and routines. Comprehensibility, however, is not likely to be achieved on the basis of the innovation's intrinsic characteristics or objective status alone. For one thing, because innovations are new things we have yet to use or experience, they can rarely be altogether objectively seen and understood. Indeed, as explained in Chapter 1, it is almost definitionally impossible to "objectively" evaluate something that qualifies as an innovation. Secondly, as new things which we have yet to use or experience, innovations always involve some degree of risk and uncertainty, which, as explained, institutional entities in the homebuilding industry characteristically aim to avoid.

Thus, there must be factor(s) other than intrinsic charcteristics which account for the acceptance of an innovation. The proposition put forward in this study is that innovation acceptance will also depend, at least to some extent, on the process or manner in which the innovation is introduced and presented in the institutional environment. That is, innovation acceptance is likely to be higher if, in its introduction, the innovation is linked or associated with existing institutional entities and routines. For example, Widget X is deemed more acceptable to Builder A if his conservative banker friend B introduces him to Widget Salesman C. Here the innovation acceptance probability is higher because the innovation is introduced by a credible information source. Similarly, as explained in Chapter 1, an innovation encountered in a context that is institutionally plausible (that is, at a time or in a context when or where one typically expects to encounter things of that type) has a higher probability of acceptance. By thus introducing the innovation through the existing institutional structure, maintaining existing routine, the newness and uncertainty of the innovation may be mediated. The innovation itself may be made to appear more stable and routine. Similarly, by association with existing entities and routines the innovation itself may be given a particular meaning, thus seeming both more compatible and more routine.

In sum, though by definition an innovation is something new and risky, and may even have intrinsic characteristics that counter favored institutional routines, its acceptability is likely to be higher if the innovation is introduced or in some way connected with institutional meanings and routines, notably personal sources of information. It is this general proposition which is investigated in this study.

Identifying and assessing the importance of institutional factors in facilitating the comprehensibility of solar thermal technologies in the homebuilding industry requires a close look at the decision processes of potential users. Specifically, we will have to examine the criteria by which they have determined to accept (or alternatively reject) the technology and the process by which such criteria evolved. In other words, what does solar thermal mean to potential users, and how did it come to be seen in this way?

For the purposes of this study we will use the HUD Solar Heating and Cooling Demonstration Program as a data source. This program, initiated in 1974, was the first in a series of energy-related programs prompted by the oil embargo. It was the first public intervention into the housing market intended to encourage the use of solar thermal technologies in the homebuilding industry. The HUD Program (known commonly as the HUD SHAC Program) employs a single focus intervention strategy, that is, financial grants to builders/developers. More specifically, the program provides grants to builders/developers to cover the incremental costs due to installation of solar thermal systems in residences. HUD has been awarding these grants in a series of cycles, each cycle stressing increasing technical and market performance in its requirements. In all cases, though, only builders/developers proposing complete, "marketable" packages, for units to be sold or rented on the open market have been eligible to apply [19].

The HUD SHAC Program was not, of course, specifically designed to explore the kinds of questions of concern in this study. It is therefore

---

[19] U.S. Department of Energy, "National Program for Solar Heating and Cooling of Buildings: Annual Report," Washington, D.C.: U.S. Department of Energy, (DOE/CS-0007), 1978.

necessary to consider how the program alters the industry/innovation relationship as we have described it. Most important, of course, is the HUD subsidy to cover the additional costs of using solar. By providing this subsidy, HUD obviously assumes a large part of the additional financial risk that use of a solar thermal technology entails. However, this element should not significantly affect the data for this study. The HUD subsidy may be important, perhaps even a necessary factor in making the intrinsic characteristics of solar thermal more attractive, and the innovation overall, more comprehensible. However, given the many other issues at stake in the use of solar thermal, the subsidy alone would appear an insufficient basis for making solar thermal altogether comprehensible, or at least of sufficient comphrensibility and appeal to be used.

Thus in studying the participants in the HUD SHAC Program we will want to examine the participants' full set of reasons for using solar thermal seeking to determine the basis by which the innovation appeared comprehensible. Careful attention will be given to the meaning given to solar thermal and the process by which project participants came to the decision to use the technology, for example, the contexts in which they encountered the innovation, their principal sources of information, the form of the information, and so on. In this way, we will try to come to some conslusions as to the extent to which institutional forces were able to compensate for some of the less favorable attributes of the technology and overall, facilitate its acceptance. Similarly, conclusions will be drawn regarding forces in the institutional structure of the homebuilding industry of potential use in facilitating acceptance of this new technology.

The case study format was chosen for presentation of the material because of the nature of the information sought and because of obvious resource constraints. Specific projects were selected on the basis of indicative sampling, that is, the likelihood of illustrating institutional interactions of the type hypothesized here [20]. The primary variable used in sample selection was developer type, as the background exploration into the homebuilding industry suggested that comprehensibility would vary in this manner. (As described in Chapter 2, different developers have different motivations for becoming involved in housing development, work under different constraints, and so on.) Ten developer types were identified, although only three, the small-medium sized speculative builder, the non-profit development corporation, and the housing cooperative, are illustrated here.

Data collection efforts were carried out primarily during January and February 1979. Following an initial note to the builder/developer on record for each project, site visits were held; an open-ended, semi-structured survey research instrument was used (see Appendix: Exhibit A). Additional interviews were held with other project informants upon recommendation by the builder/developer.

---

[20]The projects selected for study are among those used in the Photovoltaics Institutional Analysis Project conducted at MIT. This project, part of a larger project involving the MIT Department of Urban Studies and Planning, the MIT Energy Laboratory, and the Sloan School of Management, is intended to explore the institutional forces in the homebuilding industry so as to guide future tests and demonstration programs for photovoltaic technologies. See Thomas E. Nutt-Powell, "Research Design for Institutional Analysis of HUD's Solar Heating and Cooling Demonstration Program," Cambridge, MA: MIT Energy Laboratory, 1979, for a more complete account of the sample selection procedures, data collection methodology, and other matters relating to the research design. For an account of the other projects studied, see Thomas E. Nutt-Powell et al., "Solar Heating and Cooling of Housing: Five Institutional Analysis Case Studies," Cambridge, MA: MIT Energy Laboratory, 1979.

CHAPTER 4: THREE SOLAR HEATING AND COOLING CASE STUDIES

Introduction

This chapter presents in depth case studies of participants in the HUD SHAC Program, the objective being to uncover and more fully understand the processes and criteria by which members of the homebuilding industry (notably the key actor, the builder/developer) determine to accept or reject (or at least experiment with) a new technology such as solar thermal. Three case studies are presented. They are: Project Solar for Indiana, a group project under the sponsorship of the Home Builders Association of Indiana, with different builders constructing a house with the same design and solar unit in seven different regions of the state; 924 West End Avenue, a project involving the solar retrofit of a 65-year-old, cooperative apartment building on New York City's West Side; Cathedral Square, a 100 unit development for the elderly and the handicapped in Burlington, Vermont, developed under the sponsorship of a non-profit church group.

Though each case is presented separately, a common format is used. First, a brief introduction of each project is provided, noting the characteristics that distinguish both the project and its developer. Next, the project chronology is presented, tracing the progression of activities and events having bearing on the project and project participants' general attitudes toward solar thermal. The third section discusses the project chronology and the project developer from a more analytic perspective.

In the previous chapter it was explained that, though solar thermal counters many industry routines, innovations are not likely to be accepted on the basis of intrinsic characteristics alone and that institutional factors might, in some ways, compensate for negative attributes as well as the risk and uncertainty that innovations characteristically entail. In this section then, we will try to determine the means by which program participants were able to resolve the particular attributes of the technology countering their routines and in the end, find solar thermal sufficiently attractive to be used. By focusing on the roles adopted by different individuals and groups, and the contexts in which the innovation was encountered and used, we will try to come to some conclusions as to their full reasons for using solar thermal and the extent to which institutional factors played a part.

Project Solar for Indiana

Project Solar for Indiana, a participant in HUD Cycle 3, involved seven builders, each building a single-family house, identical in terms of design, square footage, insolation factors and solar units, in seven different regions of the state. Though each builder applied separately for the grant, Project Solar was essentially a group project. The builders' efforts were coordinated and assisted by the Home Builders Association of Indiana (HBAI), the statewide organization for builders and related professionals to which all seven project participants belong; the applications were submitted under a common identity, Project Solar for Indiana.

Project Solar for Indiana illustrates the case of the small- to medium-sized builder, in particular, the speculative builder producing units for sale on the open market. This category of builders, responsible for the bulk of the country's building, is distinguished first, by a strong financial motivation (speculative builders engage in housing production on entrepreneurial bases) and second, by a single-handed mode of operation; the small to medium-sized speculative builder typically carries out all major activities in the housing production process himself, without the assistance of architects, designers, engineers, market analysts, or other building specialists. Because of the uncertainties and large risks involved in these activities and the builder's small size and limited capital resources, the small to medium-sized speculative builder is typically conservative. He is not one to pioneer design changes or make radical breaks with tradition simply for the sake of trying something new. In general, new products and/or practices are accepted only when they have been proven to reduce costs and ensure a higher profit or when they have been shown to reduce risks and uncertainties in any of the major activities in the housing production process, most importantly, uncertainties relating to local market conditions and consumer demand.

Project Solar for Indiana illustrates how this generally conservative predisposition of the small to medium-sized speculative builder can be moderated in favor of innovaton acceptance when the innovation is encountered in the context of a supportive institutional environment. As we shall see in this study, when solar thermal is introduced and associated with an organization of unusual prominence in the state's homebuilding industry, a network of supporting figures is generated, giving the builders easy access to a wide range of resources and expertise--general and specialized facilitating skills as well as technical expertise.

Project Chronology

To fully account for the origins of Project Solar for Indiana, it is necessary to go back to 1975. Though the HUD SHAC Program had been in operation since 1974, Tom Kibler (then Director of the State Energy Office) did not hear about it until after the first-cycle grants had already been awarded. After reading about the program in a publication of the Energy Research and Development Administration (ERDA), Kibler, in turn, informed his supervisor, then Lt. Governor Robert Orr, who "hit the ceiling" because Indiana had received no funds. Orr was particularly disappointed because Indiana had recently legislated a property tax incentive to encourage the use of solar thermal, being the first state in the country to do so. Thus Kibler and Orr decided that something be done to ensure Indiana's involvement in Cycle 2 of the HUD SHAC Program.

Thus following his attendance at an ERDA-sponsored program for state energy officials in March 1976, Kibler's office (now with a staff person specifically assigned to solar) planned a seminar to publicize the availability of the HUD SHAC grants and to stimulate interest in the program. Over 400 invitations were sent to trade associations, architects, developers, and other building-related professionals. Three hundred responses were received; however, of these, only twelve were builders, a response state officials attributed to the cautious and conservative nature of Indiana. As John Chaille of the State Energy Office remarked, "It's a particularly closed state when it comes to taking money from the federal government. Builders shy away from federal programs because of perceived delays, red tape, and perhaps, some moral reservations . . . there's a hard work ethic out here . . . no one likes to think that they (or anyone else) is getting something for nothing." Moreover, as one builder explained, "Most builders didn't know very much about solar energy then, and most weren't in any great rush to learn. There didn't seem to be much opportunity or promise in it." In sum, neither federal programs nor solar energy seemed very popular in the Indiana building community at the time.

There was one notable exception, however--Steve Moulder of the Moulder Corporation, of Greenwood, Indiana, a relative newcomer to the homebuilding field. An engineer by training, he had always been interested in architecture and building "in a special way." After building on a small scale, he entered the market as a full-time homebuilder doing custom building in 1971. Moulder had been intrigued by the first solar installation in the area. (A solar thermal system had recently been installed in the office of Dr. Thomas Bohnert, a prominent Indianapolis dentist.) Then, after hearing about the HUD SHAC Program at the seminar hosted by the Energy Office, he began to think more seriously about it. Explained Moulder, "Although still somewhat skeptical, like everyone else, after attending the meeting I contacted my heating contractor, who put me in touch with his equipment supplier, Lee Kennedy of the Hedback Corporation, Indianapolis distributors of heating and cooling equipment. I was curious to see if solar could be adapted to houses of the type I was used to building."

Moulder spent the next thirty days learning about solar from Kennedy. (Kennedy had first learned about solar when assisting architect Gordon Clark in integrating the solar unit with the conventional heating system in the Bohnert office.) Then, with Kennedy's assistance, Moulder applied for the grant. As Moulder explained, an important motivation at this time was publicity: "Because of the conservatism of Indiana builders, their skepticism, and reluctance to get involved in federal programs, I was nearly certain that no one else would apply; thus, I could get the only Indiana grant."

Moulder's predictions proved nearly correct. Of the few builders to apply, only Moulder received a Cycle 2 award, in May 1977. Later he was to benefit significantly from this: coverage by all local television stations, press releases, full coverage in the Indiana Bildor (the monthly newpaper of the HBAI), ribbon-cutting ceremonies with the Lt. Governor, and the like. As Moulder summed up, "I entirely capitalized on it and got twelve months of heavy publicity."

It was during the time that Moulder was busy taking advantage of his participation in the program, and in his words, "becoming hooked on solar," that the next round of activities with solar began, this time under the sponsorship of the HBAI. This organization is one in a network of national organizations serving the building community, and on the basis of the high proportion of the state's builders and related professionals enlisted in its membership, and its high level of activity, one of obvious centrality to the building industry in the state. As Bob Weiss, the HBAI's associate director explained, "The Association is generally regarded as the representative of the state's building industry. We sponsor a wide range and number of activities--seminars, conventions, our monthly newspaper, for example. Most of our members take a real interest in these affairs. They want to know what's happening in the industry, and we try to keep them abreast." In addition to these formal activities, functions and services, the HBAI, like any formal association, is a place for personal interaction. "It's been a source of a good number of contacts and connections, both personal and business-related," explained Weiss.

Within the HBAI, Project Solar for Indiana was the idea of the newly elected association president, Thomas Laycock. In assuming this position in January 1977 and drawing up the association's annual agenda, as he put it, "what he wanted to accomplish during the year," Laycock proposed that the HBAI sponsor a group of builders to participate in Cycle 3 of the HUD SHAC Program. Presently owner/director of A.H.M. Graves, Inc., Builders & Developers, Laycock is an architect by training, and as he explained, he had always taken an interest in energy conservation in buildings. Thus, considering the energy situation, Indiana's very cold winters and the availability of funds (which he knew about via Moulder as well as an ERDA publications) it sounded like "a good idea to get some solar activity started in Indiana." Laycock favored the idea of a group project, that is, having a group of builders use the same house and the same solar unit, to allow the measurement of energy efficiency in different climatic regions of the state. Moreover, Laycock reasoned, "Different builders do things different ways: a group project would be more meaningful, more visible. Also, in making the project appear more unique, it might help in ensuring grant awards for all the builders in the group."

Thus, following the approval of the proposal by the HBAI's executive and general boards, Laycock turned to his friend and fellow HBAI member Kenneth A. Puller, for assistance in exploring the matter. Shortly thereafter, he asked Puller to chair the HBAI's Solar Energy Committee, taking responsibility for formal direction of the project. Puller knew very little about solar energy at the time. As he explained, "As usual with Tom's foresight and wisdom, he picked somebody who knows absolutely nothing about solar heat . . . Under Tom's direction the blind were leading the blind." But Puller obviously had other areas of expertise. Currently president of Puller Mortgage Associates of Indianapolis, a mortgage banking operation which he describes as a "one-stop clearinghouse," Puller had extensive experience in real estate sales, management, and building development, as well as an equally diversified array of experiences during eight years at HUD. Puller also had extensive involvement in local land development and housing affairs, for example, he had recently assisted in the writing of the statute for the state's housing finance agency. Furthermore, as one associate explained, "Puller had a known talent for making people work together." Puller did not know exactly what the job of chairman of the Solar Energy Committee would entail, but he agreed to take the position, wanting, as he put it, "to help give the builders a start."

To notify the state's builders and get the project under way, Puller and Laycock then turned to the internal structure of the HBAI. Laycock called a meeting of the six area vice presidents, asking them to publicize the effort. The intention at that time was to have one applicant from each of the six membership areas, but to the surprise of Puller and Laycock, over a dozen builders expressed interest in participating in the project. In general, the motives expressed by the builders were twofold: a desire for publicity, and a desire to learn about solar.

In the meantime (while preliminary discussions with the builders were being held), the members of the Solar Energy Committee, under the direction of Puller, were trying to become more familiar with solar and the workings of the HUD SHAC Program. But here, even after pooling their resources, they considered themselves still to be sorely deficient. Explained Puller, "No one in the group really knew anything about solar heating. So naturally, we turned to the only known expert, Steve Moulder, and asked him to join our committee."

Moulder then agreed to assist the group, and shortly thereafter, the first formal meeting was held with Laycock, Puller, Bob Weiss, A. William Carson (executive director of the HBAI), Moulder, and the builders (now numbering seven). After the preliminary meeting, only seven of the builders remained seriously committed to participation in the project.) Here, Moulder recounted his experiences with the program and also advised the group on basic technical matters. Recalled Puller, "Here we were with lots of unanswered questions and here he was with all the answers . . . Here was someone who had been there before."

After this first meeting in February, the group began to meet on a regular basis with the continuing assistance of Moulder. Early on in the discussions, Moulder actually took the entire group out to Greenwood for a tour of his solar home. In addition to Moulder, the group was offered assistance from professors from Ball State University, who thereafter provided advice on technical aspects, and also Lee Kennedy. On a recommendation by Moulder, Kennedy had been contacted by the committee and he too began to advise the group on the technical aspects of solar. Puller summed up the group's predicament and general attitude at the time, "All possible resources were actively sought and utilized because of the obvious lack of expertise . . . The first meeting had generated tremendous interest and excitement about the procedures and requirements of the grant and particularly about solar energy in the home. . . But there were still so many shaky areas. At the same time we knew that we had many things to decide on, and that we were going to have to proceed quickly if we were to meet a March 29th deadline."

One of the earliest decisions to be made by the group concerned the design of the house. Each builder was asked to bring in a plan suitable for the "project house." After some initial difficulties in agreeing upon a common design, a plan was selected. At this point, Al Vandermeer, director of Sales and Marketing of Davidson Industries (a large manufacturer and distributor of building components) and an an associate member of the HBAI, was contracted to make the house "energy-efficient" and to draw up the blueprints and specifications, as he had done for the Moulder house.

The other major decision made by the group, executed concurrently with the house design, was the choice of a solar unit, a matter which proved to be far more difficult. As Puller explained, "The group had learned something from Moulder and Kennedy as well as the professors from

Ball State; they at least knew how the system was supposed to work and what they were supposed to look for. But when it came down to actually choosing a system, they didn't know what to do . . . So, when in one day they heard presentations from three solar equipment distributors, Westinghouse, Solaran, and Hedback, they didn't know who to go with. Recalled Puller, "Westinghouse had the best presentation . . . but because of our uncertainty we pretty much had to go with our gut reaction here." After a period of some indecisiveness, they chose Rom-aire, the product distributed by Kennedy's firm, the Hedback Corporation. As Puller explained, "Hedback was a local firm, with a local reputation, and would be around when we needed them." But even more important, "Hedback (i.e., Kennedy) had previous experience with Moulder and the HUD SHAC Program; like Moulder, they had been there before."

With these decisions made, the group spent the remainder of the time compiling the necessary information and preparing the grant applications. Members of the HBAI, notably Bob Weiss, assisted the group by gathering support letters from elected officials, government agencies, and generally keeping abreast of what everyone else was doing. Lee Kennedy prepared the technical areas in the application as he had done for Moulder. Puller and staff, notably Patricia Shure, Puller's assistant at the time, coordinated and packaged the effort, holding group meetings to instruct the builders section by section in preparing the application, and later, reviewing and reworking the applications in order that they conform to HUD standards.

Thus concluded the planning stage for Project Solar for Indiana. News of the grant awards was received in late May, each builder receiving the requested amount, i.e., $8,500, and work on the houses began in early summer. No major difficulties were experienced during construction. In general, the contractors followed the instructions given by Lee Kennedy. (After his firm's selection, Kennedy had hosted a series of seminars for the builders and their respective heating and cooling contractors on installation procedures for the units.) However, as Weiss explained, "Because this was each contractor's first solar job, there was still much uncertainty as to whether the systems were being properly installed, and even the builders couldn't help them." "So," continued Weiss, "as one might expect, there were constant calls to Lee Kennedy, who, in his typically cooperative manner, provided ongoing assistance. One might even go so far as to say that Kennedy supervised the jobs, even if only informally."

By the fall of 1977, all houses were nearly (if not completely) operational and the builders were preparing them for marketing. As they had hoped, the solar component proved quite an attraction for most. Hoosiers may be conservative about and even skeptical of solar, as one builder noted, but they are curious nevertheless, and at least a few were interested in buying. None of the builders reported any difficulties selling their homes. (In fact, two of the seven are still holding their homes by choice, for publicity and related reasons.)

Project Analysis

In analyzing the project "approach" to solar thermal, we will examine the means by which solar thermal came to be of sufficient comprehensibility and appeal to be used by the builders, despite the negative intrinsic charcteristics of the innovation. Similarly, we will consider how the builders managed the planning and design-related activities that use of solar and participation in the HUD SHAC Program entailed.

First, it is necessary to elaborate upon the routines and general disposition of the small to medium-sized speculative builder and on this basis the likely predisposition of the Indiana builders toward a technology such as solar thermal. As explained in the introduction, the small- to medium-sized builder is motivated by financial incentives and engages in housing production on an entrepreneurial basis. Another distinguishing factor is the "single-handed" mode of operation. Typically, the small to medium-sized builder carries out all major activities in the production process himself. For example, on the basis of an assessment of the local market and consumer demand, he alone devises the general building concept as well as the building design. Similarly, he "single-handedly" arranges for the financing needed for construction and then, acting as the general contractor, directs all activities during the construction period; in most cases, the builder handles the marketing and sale of his units as well.

Given the many risks and uncertainties involved in these activities, the general vagaries of the market and economic conditions, and the builder's limited supply of capital, the precariousness of the builder's position is easy to see. If everything proceeds smoothly, he can be quite successful, but problems or complications in any of these activities, (for example, misjudgments in market demand, delays in financing or zoning approvals) can easily lead the speculative builder to failure. Thus it is easy to understand why the builder is often cautious in terms of technological innovation and generally conservative in the products and practices he chooses to employ. True, a competitive edge on the local market is always desired and thus there may be some motivation to try something new. However, the small to medium-sized speculative builder's principal concern is with the production of an "acceptable" product, in other words, a product that will easily and quickly sell and that is easily designed, financed, and constructed as well. As a general rule, the small to medium-sized speculative builder will accept new products and/or practices only when they will positively affect the marketability or saleability of his units (and only when he has a fairly high degree of certainty that this will, in fact, occur) and/or when new products or practices will enable the builder to reduce costs or risks in production, enabling a higher and/or surer profit.

Though this does not rule out the possibility for innovation, it is, of course, not entirely favorable in this regard. Given the intrinsic charcteristics of solar thermal in its present state of development, one might anticipate much resistance on the part of the small to medium-sized speculative builder in this particular case.

Most obvious is the issue of product cost, notably the matter of higher first cost. Because items of high first cost require a higher downpayment and increased carrying costs for the homebuyer, they automatically reduce the marketability of the home. Thus, in the competitive conditions of local housing markets, small to medium-sized speculative builders have characteristically considered decisions to increase housing costs with much care. For similar reasons, further resistance to solar thermal might be expected on the basis of design and aesthetic issues, that is, how the appearance and the general idea of solar thermal affect the marketability of the home. As explained in previous chapters, marketability is never a straightforward question of economics; housing is a highly personal good, and the average homebuyer wants a traditional-looking home.

Still further resistance is likely to result from the generally turbulent state of the solar art. As explained above, the small to medium-sized speculative builder is already in a high-risk position and characteristically tries to reduce his risks in the housing production process. He not only wants a product that he is sure will sell, but a product that will be readily available from the dealer or manufacturer, a product easily financed, easily installed, easily serviced and repaired, circumstances not presently characteristic of solar thermal.

It is also likely that the small to medium-sized speculative builder will be the least informed of developer types about a new technology like solar thermal on account of his local focus and lack of capital resources with which to "seek out" and experiment with new products. Thus, even if many of the uncertain issues presently confronting solar thermal were to be resolved, this information is slow in reaching the speculative builder/developer. This is even more likely to be the case for midwest builders, as compared with builders in the southwest, an area of much greater solar activity and therefore more generally available information.

Thus there are many reasons why the typical small to medium-sized speculative builder in Indiana might have little knowledge and interest in a technology like solar thermal. Why then, in the face of all such uncertainties and deterrents did the Indiana builders determine to use solar thermal and participate in the HUD SHAC Program? How were they able to assemble all the resources needed and to successfully manage all the planning and design activities that use of the technology and participation in the HUD SHAC Program entailed?

A review of the project chronology reveals that Project Solar for Indiana is the result of the workings of a diverse group of organizations and individuals, who, because of their positions and previous experience in the state's homebuilding industry, were able to perform a variety of supporting and generally facilitating functions, to convince the builders of the "do-ability" of solar thermal and participation in the HUD SHAC Program, and to help them achieve such ends. The part played by the HBAI was, of course, of central importance throughout. As noted, it was the HBAI's newly elected president Thomas Laycock who conceived of the idea for the project and first introduced it to the HBAI. As an architect and developer with some years experience in the local building community, Laycock was clearly an individual viewed with both personal and professional respect. He had served as an officer of the HBAI for three years and had recently been elected association president. Thus, on the basis of personal and professional status alone, one would expect Laycock's ideas to be considered seriously. However, rather than Laycock's personal and professional stature, it was his association with an organization of the stature, resources, and general facilitating capabilities of the HBAI, that helped make solar thermal seem a reasonable technology for the builders to use.

The HBAI is a highly active organization, respected in the state's building community and a reliable and credible source of information. Moreover, as a focus for activities of the state's builders and related professionals, it encompasses an unsually rich and diversified complex of resources and capabilities. As such, the HBAI functions as an opinion leader; it is the place that industry members customarily turn to learn about new products and practices. It is equally important to recognize the socialization functions of the organization. The HBAI is a formal, understandable, institutional entity with internally shared norms and values, and established social groups with routinized patterns and relationships. Interpersonal contacts, information exchanges, work processes and activities are all guided by rules as well as custom and/or tradition. The act of organizational affiliation, and acceptance of and participation in its activities, is a central routine in Indiana's homebuilding industry.

Thus, as association president, Laycock did more than simply pass on information about the HUD SHAC Program or suggest, as one colleague to another, that the builders use solar thermal. By associating solar thermal with the HBAI, and with his term as president, Laycock legitimated the technology itself. Because of its position in the state's building community, the HBAI acted as a "seal of approval," validating the use of solar thermal as well as the participation in federal programs.

Further, the familiar HBAI operations and procedures were able to mediate uncertainties and risks inherent in the technology. In particular, the HBAI's role as a project facilitator (sponsoring projects, access to and organization of diverse resources, and so on) made Project Solar for Indiana almost a routine activity. It was "just another HBAI project," not the risky acceptance of an uncertain technology.

The contribution of the HBAI was not, however, merely a symbolic one. With Laycock's prompting, the HBAI took on major project development functions, allowing the seven builders to pool and therefore dilute, individual risk. For example, appointment of Puller to head the effort was undoubtedly critical. Though Puller had no experience with solar thermal, he was highly skilled in housing finance, management, development, and the like, and plays a major role in the Indiana homebuilding industry in these areas. He has, as his associate described, a talent for making people work together well. Furthermore, Puller has an understanding of the public bureaucracy, notably HUD, and the process of obtaining federal funds. He is also active in the HBAI, and a personal friend of Laycock. Puller thus carried both formal and informal legitimacy of the organization and its current president.

Thus Laycock transformed one innovation (solar thermal) into something more routine (an HBAI project) while Puller folded a second innovation (federal grant funds) into another, the first routine (the HBAI project) adding the weight of another routine (project coordination/leadership by Puller's mortgage company). In this way, the general sense of uncertainty expected on the part of the builders was eliminated, while at the same time, the builders were provided the means by which to compensate for solar thermal's high first cost, i.e., through the posssibility of a grant from the HUD SHAC Program.

Where the HBAI thus provided the impetus for participation in the project, and Puller removed the uncertainties about funding and application procedures, it was Moulder who provided the legitimacy of actually using solar thermal in a successful development venture. Though Moulder was obviously an individual with more of a predisposition toward risk than the average small to medium-sized speculative builder/developer, i.e., a "plunger," he was also a fellow builder with interests and concerns similar to the seven builders in the project. As such, he was a generally credible information source. Moreover, irrespective of the extent to which the builders could identify personally with Moulder, they could certainly identify with the house Moulder had constructed and the attention that this solar house was attracting to Moulder's subdivision. In short, here was concrete evidence that building a solar home and participating in the HUD SHAC Program met marketability criteria. Further, like the HBAI, Moulder's role proved not just a symbolic one; he too provided direct assistance, translating solar thermal into the routines of speculative homebuilding. As Puller succinctly put it, "Moulder's presence was of great assistance, in a word, invaluable. Only with his agreement to join our effort, only with the recounting of his experiences with solar thermal and the HUD SHAC Program, and moreover, the excitement he conveyed, did we become convinced that we could and would go ahead with Project Solar."

Importantly, Moulder also served in the capacity of a linking-pin through his introduction of the group to Kennedy. In turn, Kennedy further reduced the uncertainties by taking the highly technical information about solar thermal and putting it into a form that the builders could more clearly understand, as he had done for Moulder. Kennedy could be trusted, not only because of his membership in the HBAI and his importance as a materials supplier, but also because of his previous experience with Moulder and the Moulder home. That the information had legitimacy because of Kennedy's personal (as opposed to "technical") status is revealed in the group's selection of his firm as solar supplier based on "gut reaction," despite the excellent (and presumably "technical") presentation given by Westinghouse. In a similar manner, Vandermeer's final drawings of a group-developed design provided a legitimacy to solar based on ongoing routines.

Thus we now see both why and how seven Indiana builders agreed to use a new technology--solar thermal--as well as a new financing mechanism--federal grant funds. Project Solar for Indiana is a prime illustration of the importance of supportive institutional networks in facilitating the acceptance of innovation in the homebuilding industry. In the first two cycles of the HUD SHAC Program, only one grant was given in Indiana, to a builder whom we have characterized as a plunger, an innovator. In the third cycle, seven builders became involved, encouraged by the interest and support given the program by the HBAI. The HBAI's sponsorship proved the initial motivating institutional force, eliminating the barriers of lack of information, general uncertainties, and individual risk. Puller's packaging made the financing aspect more of a routine. Moulder's advice reduced the barriers in the production process, and those relating to marketability. Kennedy resolved uncertainties about design integration and provided ongoing technical support, while Vandermeer provided the final drawings, again maintaining routine.

As Bob Weiss of the HBAI summed up, "Without the HBAI's formal sponsorship, without Puller's supervision and packaging of the application and without Moulder's and Kennedy's assistance in technical matters, there would have been no Project Solar for Indiana." What made it thinkable was that it was an HBAI activity, organized and run in a manner consistent with other association projects. What made it understandable for the individual builders was the evidence of a colleague (Moulder) who could show that it worked and was profitable; and the interpretation of the innovation by an expert (Kennedy) in the technical area in which he was trusted. What made it happen in relation to financial bureaucratic complexity was the coordination of an expert (Puller) who acted in a manner consistent with other dealings the builders would have with him. What made it visible were the drawings by a source (Vandermeer) who routinely illustrated project ideas. Thus, what was otherwise complicated, mysterious and confusing, became an activity which was, in many respects, routine. In Indiana, Project Solar for Indiana was, to a very large degree, "business as usual."

Chronology

Project Solar for Indiana

1975	
December	Thomas Kibler (then director of Indiana State Energy Office) reads about the HUD SHAC Program in an ERDA publication; informs Lt. Governor Robert Orr.
1976	
May	Kibler's office sponsors seminar for state builders and related professionals to stimulate interest in solar thermal and the HUD SHAC Program.
Summer	Steve Moulder, an attendee of the meeting, consults with Lee Kennedy of the Hedback Corporation about the possibilities of solar thermal; with Kennedy's assistance, Moulder applies for a HUD Cycle 2 grant.
October	Moulder receives the HUD SHAC grant; begins construction of solar unit.
1977	
January	Thomas Laycock assumes the presidency of the HBAI and proposes that the HBAI sponsor a group of builders to participate in Cycle 3 of the HUD SHAC Program; project idea approved by the HBAI's executive and general boards; Kenneth Puller agrees to take formal direction of the project as chairman of the HBAI's Solar Energy Committee.
	Puller and Laycock hold meeting with six area vice presidents to publicize the project; preliminary

	discussions with the builders held.
	Puller asks Moulder to join the HBAI Solar Energy Committee and to assist project efforts.
February	First formal project meeting held with Laycock, Puller, Bob Weiss, A. William Carson (HBAI administrators), Moulder, and the builders attending.
	Group meetings held throughout month with the continuing assistance of Moulder and also, Lee Kennedy brought in on a recommendation by Moulder.
	Group decides upon a common plan for the "project house;" Al Vandermeer contracted to make the house "energy-efficient" and to draw up the blueprints and specifications.
	Group hears presentations from various solar equipment distributors; selects Rom-aire, the product distributed by Kennedy's firm (i.e., the Hedback Corporation); Kennedy hosts a series of seminars for the builders and their respective heating and cooling contractors on installation procedures.
March	Grant applications prepared under supervision of Puller and with assistance of Weiss and the HBAI; submitted to HUD.
May	HUD awards each builder grant of $8,500.
	Construction of units begins.
Fall	All units completed; builders prepare for marketing.

<u>1978</u> Five of the seven units marketed.

<u>1979</u>

January Two units still held by their builders as models, for publicity and related reasons.

924 West End Avenue

924 West End Avenue, a participant in HUD Cycle 3, involved the solar conversion of a 68 year old, 64 unit, cooperative apartment building on New York City's West Side. Utilizing 117 solar panels in a two story array (i.e., nearly 2,500 square feet of collectors) the project is believed to be the largest solar energy retrofit in the northeast, if not the entire country. The system at 924 West End Avenue is expected to supply 50-60 percent of the building's annual domestic hot water requirements, savings equivalent to an estimated 10,000 gallons of oil a year.

924 West End Avenue illustrates the case of the housing cooperative as developer. In the cooperative form of tenure, residents own their property jointly, i.e., cooperatively, and the project is operated entirely on their behalf. In essence, residents serve as both owners and consumers; they are responsible for determining the type and level of services to be consumed and have responsibility for the financing, management, maintenance, and repair of the services as well. Thus the housing cooperative has good reason to be concerned with long term operating costs and performance characteristics of housing products and services, in addition to the front end investments they may entail. In fact, though overall dispositions of housing cooperatives vary on account of such factors as size and income, it is because of their dual roles and responsibilities as housing owners and consumers, that housing cooperatives tend to be conservative in terms of financial management and in the products and services they use. As a general rule, housing cooperatives will undertake improvements, or at least replacements of

existing services or products, only when long term costs savings can be achieved and further, when the products or services are of proven reliability, durability and quality, in design and performance.

The 924 West End Avenue case illustrates this generally conservative predisposition of housing cooperatives toward the acceptance of product innovations. But importantly, the case also demonstrates how this conservatism may be moderated when the innovation is encountered in the context of a supportive institutional environment. As we shall discuss more fully below, acceptability of the technology is significantly enhanced when it is associated with an organization having access to a wide range of trusted and expert resources, in addition to general facilitating skills of its own, and further, when the technology is promoted by an individual of unusually high standing and credibility in the co-op community, and an expert on energy as well.

Project Chronology

The origins of 924 West End Avenue can be traced back to the mid 1970's when Consumer Action Now, a New York City based public interest organization (known commonly as CAN), determined to change its focus and concentrate exclusively on issues in the energy field. Founded in 1970 by Lola Redford and a group of approximately twenty women, CAN was originally intended to address environmental problems. Of particular concern at the time of its establishment were problems relating to the consumer and the environment. For its first three years, CAN published a newsletter exploring a different environmental/consumer topic each month. By 1973, however, believing the level of public awareness of environmental problems to have increased to the point that they were duplicating efforts, CAN decided to discontinue the newsletter and to undertake projects in other fields, including energy. CAN then established a tax-exempt sister organization, the Friends of CAN, to enable the organization to undertake such projects.

The newly established arm of CAN carried out a variety of educational projects in the following year. Then, in 1974, as the energy crisis assumed national proportions, CAN decided to concentrate its efforts entirely in the energy field. By this time the organization had developed a strong anti-nuclear philosophy. Concerned with what they saw as a low level of public awareness of the "cleaner and safer energy alternatives," i.e., solar, coupled with a lack of adequate information on the subject, they decided to launch a solar energy education program, to inform the public of the potentialities of the technology and generally, promote its use. It was in the context of this effort then, that late in 1974, CAN conceived of the idea of a solar demonstration project for New York City, hoping to demonstrate the viability of the technology for older buildings in urban areas.

Being relatively new to the energy field and lacking actual design experience with solar, it was clear that CAN would require outside assistance. Thus, under the direction of Lola Redford, one of CAN's first steps was to contact Richard Napoli, an individual known to the organization by way of a personal connection; Maryann Napoli, Napoli's wife, had been an active member of CAN since 1972. Presently Deputy Director of the Center for Regional Technology and the Solar Energy Application Center, interdisciplinary research centers at New York

Polytechnic Institute, Napoli had just completed a four year term with New York City's Environmental Protection Administration (EPA) when he was approached by CAN early in 1975. Though he had then had little actual experience with solar thermal--in a recent project at the EPA he had designed some experimental greenhouses, but these had been essentially "passive" solar designs--Napoli had a strong background in the sciences and, as one colleague summed up, "a good working knowledge of engineering." Further, Napoli had an obvious interest and expertise in environmental issues; he had, in fact, taken an active interest in CAN's affairs in the past, participating in some of the organization's informal seminars and meetings. Napoli shared with CAN an interest and commitment to furthering the use of solar thermal. On the basis of these interests and concerns, and what he described as his "in-between job status at the time," Napoli agreed to lead the CAN project team.

Shortly thereafter, CAN also contacted Arthur Weinstein. Now an attorney in private practice specializing in co-op law, Weinstein was at the time the Deputy General Counsel for the New York State Energy Research and Development Administration (ERDA), the state legislated corporation established to investigate energy alternatives. Having been directed to Weinstein by way of a personal contact (Weinstein having worked with a friend of someone then at CAN), CAN approached Weinstein for a sort of introduction to the issues involving both housing and energy. As Weinstein explained, CAN came to him "asking for a briefing on both fields; in other words, what it would take, politically, legally, financially, and so on, to get a solar demonstration project started in New York City."

Weinstein too had had little direct experience with solar and knew very little about the technical aspects of the technology. However, having also been active in the housing co-op movement of the late 60's and early 70's, while employed at ERDA (Weinstein had, in fact, been responsible for the conversion of his building, i.e., 924 West End Avenue, from a rental to a cooperative in 1974, and since then had sat on the Board of Directors) Weinstein was an individual with in depth knowledge of the financial, legal, and management aspects of housing, New York City housing market operations in particular. Similarly, on the basis of his experience with the New York State ERDA, Weinstein had an obvious interest and in depth knowledge of issues and developments in the energy field. And though Weinstein differs somewhat with CAN's energy philosophy, ("I'm not as vehemently anti-nuclear as they,") he too expresses a commitment to the development of alternative energy resources. "We should be willing to consider anything that will reduce our reliance on foreign oils." Thus like Napoli, out of a sense of personal and professional interest and commitment, Weinstein agreed to join efforts with the CAN project team.

With a group established, work on the project got under way in late spring 1975. At the earliest meetings, goals and objectives for the demonstration project were more fully elaborated, as were plans for implementation. One important decision made at this time was that the project be totally private. CAN was concerned with visibility and expediency and they feared, "rightly so," noted Weinstein, that "anything involving public funding would get bogged down in the usual bureaucratic mess and thus not likely to be visible for years." A second important decision concerned the location of the project. Following Weinstein's advice, it was decided to try to locate the project on the West Side of the City. As he explained, "We didn't want solar or the project in general to be criticized as a rich man's play thing, something that might easily have resulted considering the backgrounds and general prominence of most CAN members. It was important that the project have a broad appeal, that it appear a viable alternative for a wide range of income groups and building types in the City."

With objectives so established, the next step was to locate a building suitable for the demonstration project. To these ends, Weinstein introduced the group to a number of West Side property owners, many of which, he noted, he knew on both professional and personal bases. Similarly, CAN contacted property owners known to CAN members. Also at this time, CAN contacted architect Travis Price for assistance with the more technical aspects of the project. In essence, Price agreed to help the group by conducting technical evaluations of the possible sites and executing a preliminary system design. Price had had previous experience with solar, having been the architect and system designer for a small retrofit project in the East Village, which, as the City's first solar retrofit, had received considerable media coverage. CAN knew of Price on this basis and also, because he was a close personal friend of a CAN member.

After a month or so of investigation, Weinstein's building was selected from a number of possible sites. Not only was the building found to heat hot water very inefficiently, especially during the summer months when solar thermal systems are most effective, but it had the proper physical characteristics as well, i.e., a large shadow free roof area, a good southern exposure, and an old coal bin believed suitable for the solar storage insolation tank. The co-op aspect of the building also proved an important consideration. As Napoli explained, "Considering the front end costs, which we realized were likely to be rather high, coupled with CAN's desire to keep the project entirely private, only the co-op form of tenure, where the tenants have a vested interest in operating costs, appeared a realistic choice for the project." Moreover, as everyone involved agreed, "924 West End Avenue was not your usual prime location, i.e., East Side luxury co-op, but one with a highly diversified clientele."

With the proposed site selected, Price put together a preliminarly system design which he presented at a meeting between CAN and the 924 Co-op's Board of Directors in December 1975. Up until this time the Board had made no real decisions on the matter. Weinstein had simply notified them of the possibility of the project when the building was first under consideration. Upon selection, the 924 Co-op Board agreed to meet with CAN and Price, and hear the proposal out. In other words, explained Weinstein, "I set up the introduction; here was CAN's chance to sell the idea to the Board, myself included."

According to one attendee of the meeting, however, Price had not gotten too far in his presentation of the system before the Board stopped him on the issue of projected costs. Recalled Weinstein, "We really understood very little about how the system would work, technically, but we certainly understood the financial end involved . . . Right away we asked the right questions and found out that the system would not pay for itself, at least not with the conventional financing then proposed. This much was clear even if we weren't altogether certain of our current water usage, possible solar efficiencies, and so on, to say nothing of the extra costs associated with building in New York City or the issue of a contingency fund." Thus solar, or at least Travis Price's proposed system, was flatly rejected by Weinstein and the 924 Co-op's Board of Directors. As Weinstein summed up the Board's position at the time, "However attractive solar may have been on political, philosophic or environmental grounds, no one was in any way willing to sell out the building for it."

Though it appeared that the project had come to a dead end, CAN was not willing to give up just yet. For second opinions and perhaps fresh ideas, CAN sought the advice of other professionals, some of whom they knew on the basis of previous projects, others, for example, like Fred Dubin, of Dubin, Bloome Associates, the prominent New York City based engineering firm, through personal contacts and more informal means. Discussions at this time centered largely on alternative means of financing. For example, as Weinstein recalled, "there was initially some talk about trying to obtain bank financing at more favorable interest rates." After a series of such discussions, however, all came to agree that given the high front end costs, the only way to make sense of the project, i.e., to make it acceptable to property owners, whether the 924 Co-op or any other, was to use public monies. A bank, they finally considered, was not likely to assume the risk, while property owners, like the 924 Co-op, could not manage the front end investment on their own.

Having thus agreed to the use of public monies, however, the group was not entirely sure about which program to use. They were aware of the beginnings of the HUD SHAC Program (Lola Redford had, in fact, testified at the Oversight Hearings for the Program in May 1975). However, on the basis of the first cycle grants awarded in the program (awarded in mid January 1976) and moreover, Lola Redford's informal discussions with persons at HUD, CAN perceived something of anti-urban, anti-retrofit bias on HUD's part, and thus did not believe the prospects of obtaining funds for a large scale, solar retrofit project in New York City to be very good. Further, CAN was not aware of any other program that might provide resources of the kind needed for a project of this scale. Thus, as one project participant explained, "Though no one outwardly admitted it, interest in the project began to dwindle. It wasn't that we had concluded the idea to be infeasible, but it was clear from the first meeting with the 924 Co-op's Board of Directors that they would only go ahead with the project with additional financial support, and we had no brilliant schemes in the works . . . so we unofficially tabled the discussions . . . more or less, put the project off to the side for the time."

By late spring the status of the project remained essentially the same. And if plans for the project had been only informally tabled during the spring, they were to be more or less officially held at bay during the summer months when most members of CAN, as well as their volunteer consultants, took their vacations or worked elsewhere. It was just at this time, however, when least expected, that interest and planning for the project was revived once more, this time largely by a matter of chance. By sheer coincidence, Napoli had met Fred Dubin in June, at the Energy Fair at the University of Massachusetts in Amherst, where both were holding seminars. Dubin, who had apparently spoken with persons at HUD since his consultations with CAN, then informed Napoli of HUD's interest in undertaking more urban retrofit projects in future cycles of the HUD SHAC Program. In essence, if CAN had a building and could put together a proposal in conformance with HUD SHAC program requirements, HUD might very well fund it.

Thus, upon returning to New York, Napoli told Weinstein about Dubin's offer and the HUD SHAC Program. With the possibility of resolving the financial issue, Weinstein's interest was once again revived, and Weinstein and Napoli got together to determine what they would need to do to apply for the HUD grant. "It was already so late, recalled Napoli, (the application deadline being approximately eight weeks away) that we knew we could never do a thorough and professional job for a project of this complication and size. But having gone this far, we thought we would attempt it anyway." Dubin then sent one of his engineers to CAN, who, together with Napoli, reworked Travis Price's original design, while Weinstein assembled various support letters and wrote up the project rationale. And through what was described as "an altogether harried and chaotic group effort," they managed to get the application in on time. As Napoli summed up, "It was really only the rough schematics for the project; we had no working drawings, and the application was, overall, very poorly documented; but we sent it in anyway hoping for a chance to prepare a more detailed proposal at a later date.

In mid fall the group was notified of the proposal's rejection. HUD did suggest, however, that they rework the application and re-submit for Cycle 3 which both CAN and Weinstein agreed to do. This time, however, the group determined that both the system design and the application be professionally done. Recalled Napoli, "If we were going to go through it the second time around, we were going to do it right." Thus, he continued, "I contacted the one solar architect whose work I know and trust," this being Donald Watson, known to Napoli through meetings and informal events sponsored by CAN.

Then residing and working in Connecticut, Watson was unable to take the job. He did, however, refer Napoli to an architect with whom he had previously worked, and he explained, he "entirely trusted." This was the Ehrenkrantz Group, a large New York City based firm that, as Napoli explained, "had just begun to make a name for itself with solar." (The Ehrenkrantz Group had just recently designed 50 units of solar assisted housing for the Department of Defense and 20 units for the Navy.)

Early in November, then, Napoli approached the Ehrenkrantz Group who agreed to design the system and prepare the grant application in cooperation with CAN and Weinstein. A new system was then designed for the structure during the ensuing months. Under the direction of Stephen Weinstein, i.e., project architect, the Ehrenkrantz Group maintained formal responsibility throughout the design process; however, as Arthur Weinstein noted, "he and Napoli as well as Dubin were consulted from time to time on major aspects of the design." For example, the choice of a solar manufacturer had been one important decision made, more or less, collectively. Recalled Weinstein, "There was one critical meeting early in the winter of 1976 at the office of the Ehrenkrantz Group; I was there as the building's representative, Napoli as CAN's; representatives from the Daystar Corporation were there too. Here, Stephen Weinstein presented us with a breakdown of solar energy performance efficiency curves prepared at the Daystar Laboratories, the logic being that Daystar collectors were the most efficient ones to use. Moreover, we were informed, the Ehrenkrantz Group had used Daystar collectors in their previous project. Continued Weinstein, "There were many things we should have known about at the time (and the Ehrenkrantz Group should have known them too), i.e., that Daystar collectors are highly vulnerable to water stagnation conditions . . . but the idea of maximizing efficiency was obviously appealing . . . Daystar's simulations, Steve Weinstein's presentation, all sounded reasonable enough, and so we all agreed."

And thus proceeded the design process. With a solar manufacturer selected, the Ehrenkrantz Group completed the system design. They also made preliminary arrangements for the installation of the system, subcontracting the work, with the approval of Weinstein and Napoli, to Harold Crane, of Crane Thermodynamics, someone with whom they had worked before. In the meantime, Weinstein and Napoli touched up the project rationale, compiled a variety of support letters from city and state agencies, government officials, the news media, and the like, and this time, the group was able to submit the application well in advance of the March 29th program deadline.

Thus concluded the planning stage for 924 West End Avenue. In May, notification of the grant award was received; however, it was not for the entire amount. For reasons still unclear, HUD had agreed to give them only $112,000 of the $156,000 requested. Thus, once again, it was time to consider project costs. Explained Weinstein, "By this time we obviously wanted to go ahead with the project, but it was also apparent that a gap of $44,000 put this very much in doubt. At the same time, we knew that if we had any intention of trying to raise the funds, we would have to act fast as HUD had given us less than one week to decide whether or not to accept the grant." Thus, continued Weinstein, "Over the next few days, Napoli, Steve Weinstein and myself got together for a little 'charrette,' trying to see what we could whittle away from our initial cost estimates and also trying to see if we could extract something more from HUD."

The group was unsuccessful in their attempts to gain additional monies from HUD; however, by obtaining a firm quote from Crane, the general contractor arranged by the Ehrenkrantz Group, and as Napoli explained, essentially eliminating any reserve or contingency fund, the group brought the total estimated project cost down to $140,000 leaving a gap of $28,000. This, however, was the bottom line; as one project participant summed up, "The co-op had to come up with these funds or there would be no project."

Weinstein, in turn, explained the current status of the project to the 924 Co-op's Board of Directors. No formal vote was taken; however, a full tenants meeting was held, and after a somewhat lengthy and heated session with the Board, the co-op agreed to assume this expense; this would be its contribution to the project. Explained Weinstein, "Of course, we didn't want to commit co-op resources; it wasn't as though we had the additional funds to spend; there were, in fact, many other ways we might have used $28,000 at the time, for example, to repair the roof, the elevators . . . but as I proposed to the Board, with reasonable interest rates on a bank loan, cost per unit could not be too great; all environmental and political considerations aside, in getting the system at a cost of $28,000, we were sure to get our investment back; it was justifiable on the basis of financial considerations alone."

Thus obtaining the Board's approval, Weinstein notified HUD of their desire to accept the grant and shortly thereafter, set out to arrange the loan. This too, however, proved to be no easy task. Explained Weinstein, "New York City banks were not particularly enthusiastic, perhaps, understandably so; solar is risky and there is nothing really backing up a loan like this. Finally, Manufacturers Hanover agreed to make the loan, "but only after a lot of legwork on my part; I certainly earned this one," recalled Weinstein.

With project financing all lined up, a system design ready, a solar subcontractor who had been "highly recommended," it seemed that all headaches were over and installation could begin; with Crane commencing work in late summer, it was expected that the system would be ready for use early in the following spring. But like the planning and financing phases that preceded it, the installation period proved replete with difficulties as well. For example, simply locating the building's existing steel roof beams, onto which the steel supporting structure for the array was to be welded, proved an altogether formidable task. The original architectural drawings from 1911 were inaccurate, and after punching a few holes in the roof and finding nothing, they had resorted to the use of a mine detector to locate the beams through the roofing material. Similarly, just drilling through the eighteen inches of concrete between each floor of the building stairwell proved no simple task, nor was the job of getting the collectors up to the roof; weighing nearly 150 pounds apiece and measuring four feet by six and one half, Weinstein and other co-op members had actually unloaded them from the delivery truck themselves in efforts to keep down project costs.

The most serious problems, however, problems which were to delay the operationalization of the system for over one year, were those that developed after the system was in place. As Weinstein explained, "We had many difficulties all the way through installation, but through Crane's expert supervision, our patience . . . somehow we managed; the panels were in place by early spring, and we thought we'd have the system working by mid summer, at the very least. Only then did we learn, however, that not only would our system likely not work, but there was a good chance that the panels might melt . . . The Daystar collectors we were using are highly prone to water stagnation; in a sense, they're too efficient for themselves; they collect an abundance of heat to the point that the safety valves just blow up."

Most infuriating, though, explained Weinstein, was the manner in which the co-op first learned of this predicament, how HUD's technical representative from Boeing had simply mentioned, in a very off the cuff manner, that projects similar to theirs were experiencing difficulties, and that their system would probably not work. "Solar may be a new field," commented Weinstein, "but you have to be some kind of bloody genius to anticipate problems like these . . . and why HUD didn't inform us, I don't know. HUD certainly knew what kind of collectors each project was using because it insisted that project participants remain with the solar manufacturers listed in their applications."

Needless to say, Weinstein and co-op residents were not pleased. In any event, after discussing the matter with the Ehrenkrantz Group, who apparently had been unaware of the problems with this particular Daystar collector, Weinstein contacted Daystar, informing them of the difficulties and further, the co-op's refusal to accept the panels, their refusal to pay for them, that is, until the system was thoroughly tested and brought to proper working order, whatever this necessitated on Daystar's part.

And thus began a period of seemingly endless discussions between Daystar and Weinstein, and Daystar efforts to repair the faulty system. After some initial difficulties, Daystar proved entirely cooperative, explained Weinstein, "promising to do whatever was needed to resolve the situation, to make good on their contract." "But what made the situation so difficult," continued Weinstein, "was that no one really had the technical sophistication to fully comprehend what was involved in the redesign at each and every step. Daystar conducted many tests and analyses, and there were many solutions proposed at different times . . . but there could be no guarantees; solar is a new field; it's not like you can pick up a phone and dial some center for technical assistance."

But finally, after nearly a year's work, Daystar devised a new system that under test conditions, appeared to take the strain off the collectors and insure a more effective dissipation of heat (now using a row of thin tubing under each row of collectors instead of one mechanism at each end). Crane, still serving as the solar subcontractor, but now under contract to Daystar, made the necessary installation changes. And finally, in the spring of 1979, the system at 924 West End Avenue was successfully operationalized.

Project Analysis

In analyzing the project "approach" to solar thermal, we will examine the means by which solar thermal came to be of sufficient comprehensibility and appeal to be used by the co-op, despite the negative intrinsic characteristics described in Chapter 3. We will also consider how the co-op, in conjunction with other project participants, executed the planning and design activities that the use of solar thermal and participation in the HUD SHAC Program entailed.

First, it is important to elaborate upon the routines and general disposition of the housing cooperative as a developer type, and on this basis, consider the co-op's likely predisposition toward a new technology such as solar thermal. As explained in the introduction, the cooperative form of tenure is distinguished by the fact that residents serve not only as housing consumers, but as housing owners as well. Acting through an elected board of directors, co-op members collectively determine the type and level of housing services to be consumed. They alone arrange for procurement, service, management, maintenance, and of course, their financing as well.

Devoid of intermediaries, all cost savings (or cost increases) resulting from the use of new products or practices, accrue directly to co-op residents. Thus, in contrast to the profit oriented developer, who may avoid items of high first cost in order to "leverage" his equity investment, or the small scale speculative builder who must consider how products or services of high first cost will effect the marketability of his homes (higher priced units requiring higher downpayments) the housing cooperative is lacking in "first cost sensitivity." In general, in assessing the financial desirability of replacing an existing product or service with something new, a housing cooperative is likely to consider how the initial investment will balance out in future years, in other words, what the payback period will be.

Thus a housing cooperative is likely to be less repelled by the higher first cost of solar thermal than other industry developers. In fact, at least on the basis of an economic analysis, one might expect a housing cooperative to look with some favor, or at least with some interest, toward a technology of this type, that is, if it appeared that the initial investment would be repaid over a reasonable number of years. By the same token, though, one might expect a housing cooperative to conclude a technology such as solar thermal to be altogether undesirable if it appeared that it would not pay for itself; that is, if it appeared that the front end investment could not be recouped over the desired number of years.

Considering current costs of solar thermal and prospects for the immediate future, the latter proposition appears the more realistic case. Thus, even though a co-op might find solar thermal to be less objectionable than the typical industry developer or housing consumer on account of its high first cost, it would still likely be unable to find economic justification for using the technology.

Further resistance to solar thermal, though, might be expected to result from dispositional elements and factors relating to the current state of the solar art. Needless to say, a new product entails more than financial differences, and a housing cooperative has responsibilities and concerns extending beyond those of financing a product's initial cost. As noted earlier, in the capacity of housing owner, a cooperative must not only finance a new product or service, but must carry out all planning, service, management, and maintenance functions as well. Because the cooperative is also the ultimate consumer of these products or services, it is obviously to the co-op's advantage to see that all such functions are satisfactorily performed and all new products working well. In short, on the basis of this dual status, the housing cooperative might be expected to favor products which will entail few problems or complications in the housing production process (i.e., like the speculative builder or multi-family developer) and, at the same time, (like the housing consumer) products of proven reliability, durability, and quality, in design and performance.

As explained in the preceding chapter, however, solar thermal is presently undergoing many changes, and is likely to be perceived as uncertain or at least problematic on nearly all such counts, whether or not this is actually the case. This includes uncertainties on basic technological issues as well as matters relating to product financing, code and zoning approval, product procurement, distribution and installation--in short, nearly every important activity in the housing production process. Even though a housing cooperative would subcontract the work if it chose to use solar thermal, it could not help but be affected by these and other uncertainties as well. For example, given the generally turbulent state of the solar field and the lack of firms and individuals with established reputations, on what basis would a housing cooperative select a solar subcontractor or a system designer? Similarly, without a working knowledge of the technical aspects of the technology and without product standards, warranties, guarantees, and the like, by what criteria would a housing cooperative select a "good" solar product or determine an installation job well done?

Earlier it was explained that because of industry structure and organization, any new product was likely to undergo a period of some such uncertainty as it made its introduction through the various segments of the industry. It was also noted that because of the unusually high level of activity in the solar field, solar thermal likely entails even more uncertainty (if not outright confusion) than one might anticipate considering the industry's structural characteristics alone. What is important to recognize is that using solar thermal with existing structures involves even greater uncertainties than in new construction because of the possibility of further complications in the integration of the solar system with the existing site. Because of the uniqueness of most existing structures, solar systems must be completely custom designed and custom fit, certainly the case with a pre-WWI structure of the type and size involved in this project.

Thus there would appear to be many reasons why a housing cooperative would not use a technology like solar thermal on its own. On the one hand, the economics, factors of considerable consequence to a housing cooperative, argue against it. Why replace an existing product with one that would, in the final analysis, increase operating costs? Similarly, all of the uncertainties argue against it. Why replace an existing product with one whose operations are not entirely understood, whose qualifications are, at best, uncertain, and may entail complications in nearly every activity in the housing production process?

In fact, considering the current status of solar thermal and the many uncertainties confronting the technology at this time, there seems little likelihood that a housing cooperative would agree to use the technology even if it entailed no additional cost, that is, even with a subsidy such as a grant from the HUD SHAC Program. In other words, however critical a subsidy might be, it alone would appear insufficient to induce a housing cooperative to use solar thermal at the present time. In all, this would appear to be one of those situations where a housing cooperative, if it had any inclination to even consider using the technology, would be better off waiting until the "co-op next door" tried it, rather than being first, that is, the New York City pioneer.

How then, does one explain 924 West End Avenue's decision to participate in the HUD SHAC Program and use solar thermal, in fact one of the largest retrofit projects ever attempted? Further, how were they able to manage all the uncertainties and risks that this entailed? Indeed, one might suspect there to have been unusually compelling reasons to induce the co-op's agreement, even contributing $28,000 of their own funds, and moreover, to have successfully managed the planning and impoementation of a project of such complexity and scale. Needless to say, it would have been altogether unusual for 924 West End Avenue, or any co-op for that matter, to have had all the necessary skills in-house or within easy access, let alone even a basic understanding of the technology and the issues prompted by its use.

By reviewing the major events in the project we can readily understand both how and why 924 West End Avenue came to use solar thermal. Together with the HUD grant, this project is the result of the workings of a large number of individuals and organizations, some in general facilitating roles, for example, CAN, helping to diagnose problems and resource needs and/or providing channels for resource coordination and distribution to users, others serving more specialized functions, either providing more specialized information on substantive issues or serving more specialized supporting functions. Interestingly, nearly all such sources were connected through either formal or informal ties, in many instances by both. Indeed, it is this quality of linkage, the sense of a series of connections from one individual or organization to the next (often termed "networking" in the literature on innovation) that most distinguishes the 924 West End Avenue case.

The critical force in initiating the project and in generating and sustaining the network on its behalf was, of course, CAN. As explained in the preceding section, it was CAN's intention to sponsor a solar demonstration project to stimulate further use and interest in the technology. CAN's interest and concern seem commendable in themselves, but what seems most important is that having once conceived of the idea, CAN knew whom to see, and what to do, to get a project of this sort under way. In other words, though CAN had little prior experience with solar thermal, at least not in terms of practical application, it had an established organizational base from which to work and the organizational skills and resources to facilitate a project of this type. Further, on the basis of CAN's previous work in the environmental field, informal meetings and seminars sponsored by the organization, as well as the personal affiliations of CAN members, the group had ties to leading scholars and practicioners in most contemporary fields, including solar. In short, though CAN did not have all requisite skills in house, it had the organizational capacity to identify major project tasks and needed resources; the personal and professional ties by which to reach them; and established organizational channels by which to assemble and coordinate their efforts. On the basis of such connections and mechanisms for coordination, CAN could serve as a sort of linking institution, and together with its more general skills, project facilitator.

Thus, having determined the need for a demonstration project, CAN knew just where to go for assistance in the areas in which it was deficient to get project efforts under way. For example, one of CAN's first steps was to enlist the support of Richard Napoli. Even though Napoli too had had little practical experience with large scale solar conversion projects of the type then envisioned by CAN, he did have an understanding of the basics involved in solar thermal design. Moreover, on the basis of his experience at the New York City EPA and related work, he had an understanding of the administrative and institutional issues, what, in other words, the planning and implementation of a project of this kind would entail, whether public or private. Thus Napoli was an individual having just the right skills to complement CAN and to facilitate project efforts on both procedural and substantive grounds. Importantly, Napoli's credibility as an information source, his professional competence and expertise, could be readily assumed by CAN, not only because of Napoli's previous positions and work at the EPA or related work done as an environmental consultant, but also, because of his close personal affiliation with CAN, i.e., the fact that he had been introduced through Maryann Napoli, an active CAN member and his wife.

In addition to Napoli, CAN had been able to enlist the support and assistance of another expert, Arthur Weinstein, in a somewhat similar fashion. Weinstein too had had little prior experience with solar thermal and had virtually no understanding of the technical aspects of the technology; but he did have other skills needed to complement the CAN team. For example, Weinstein had an in depth knowledge and practical experience with the political, legal, and financial aspects of both housing and energy. Like Napoli, Weinstein's credibility and reliability as an information source, his expertise in housing and energy related fields, could be assumed by CAN, not only on the basis of Weinstein's professional attributes and credentials, for example, his position as Deputy General Counsel of the New York State ERDA, his knowledge as attorney, in particular, co-op law, but also, from the manner of his introduction. He had come highly recommended as "the expert" by a friend of someone then at CAN, in essence, "the man to see for housing and energy."

Thus with the addition of these resources CAN was able to more fully and realistically assess the situation and to formulate project goals and objectives. Similarly, it was with this assistance that project strategies were devised, for example, deciding, on the basis of Weinstein's advice concerning the politics involved, that the project be located on the West Side of New York, and determining that it be financed entirely with private funding. Having thus charted a more definitive course for the project, it was again on the basis of the organization's personal and professional affiliations that the group had been able to connect with the varied resources needed to facilitate project efforts. For example, as explained in the preceding section, CAN contacted a number of property owners known to CAN members in efforts to locate a structure suitable for the project. Similarly, Weinstein was able to play the role of the linker, introducing CAN to West Side property owners that he knew either personally or professionally. It was then on the basis of another organizational affiliation still that CAN connected with another expert, solar architect Travis Price, and thus obtained the technical skills needed at the time. Importantly, Price too was taken to be a credible and reliable information source, and an expert in solar thermal design, not only on the basis of his professional credentials, and accomplishments, i.e., the fact that he was an architect and had been the designer for the West 11th Street project, but also, by way of his introduction and association with CAN. Price too was reported to be a close personal acquaintance of someone at CAN. In the same way that Weinstein had been highly recommended as the expert, the "man to see for housing and energy," Price was the "one to see for a solar thermal retrofit design."

Thus, on the basis of its wide range of personal and professional affiliations and general organizational skills, CAN was able to serve as an effective linking institution and project facilitator. Having thus located a site believed technically and politically suitable for the demonstration project, i.e., 924 West End Avenue, and arranged for the development of a preliminary system design, the next major step was to convince the 924 West End Avenue Co-op, in other words, to gain acceptance of the technology. At this point, focus shifted away from CAN, and Arthur Weinstein assumed center stage. Without doubt, Weinstein played a part of critical importance in first introducing the idea to the co-op and in making solar thermal appear a conceivable if not altogether reasonable technology for the co-op to use.

Weinstein's power and influence in the co-op community appears the result of both personal and professional attributes and experiences. For example, as an attorney, having had formal responsibility for all legal work involved in the conversion of the building from rental to co-op status, and maintaining an active role in its management since conversion, Weinstein could be taken by the Board as an altogether credible and reliable source of information, someone whose ideas and opinions were to be considered seriously. After all, Weinstein had not only done the legal work involved in the conversion, but had originated the idea in collaboration with another 924 resident. The fact that Weinstein himself resided at the building also seems important. Insofar as it was a new product or service under consideration, Weinstein's advice was obviously more than that of the expert, however great the expertise. By contrast, because he was a co-op resident, Weinstein could be expected to have motivations and interests similar to other co-op residents. What would benefit Weinstein would likely benefit other co-op residents as well. Thus he could be assumed to have their best interests in mind. Another factor that seems important to consider is that energy is an area of particular interest to Weinstein, an area which, like housing and the legal field, he has a proven competence and expertise. Clearly, if anyone was likely to be knowledgeable, on top of new issues and developments in the energy field, particularly as they relate to housing, one might expect this to be Weinstein.

However obvious these factors, or however convincing the case might appear, this discussion is not meant to imply that solar thermal was immediately and unquestionably acceptable to the 924 West End Avenue Co-op simply because it was introduced by or associated with Arthur Weinstein. As it turned out, the 924 Co-op's Board of Directors unanimously rejected the idea when the preliminary system design was presented to them at the first meeting between the Board and CAN. In fact, Weinstein himself, was against it at this point: it had been altogether out of the question. As he had explained at the time, "The economics weren't right; the system wouldn't pay for itself, and however appealing solar thermal might have been for other reasons, no one was going to sell out the co-op for it."

In spite of this initial rejection, however, the idea of using solar thermal had apparently gained something in appeal. For as the preceding discussion reveals, acceptance came to be contingent on financial issues. In other words, the 924 Co-op Board was prepared to go ahead with the technology, admittedly new and risky, and about which their general knowledge and understanding was virtually nill; at the very least, they were still open to using solar thermal at the end of this first meeting; they were interested in pursuing further exploratory studies provided the financial picture improved.

The extent to which Weinstein was responsible for the Board's response is, of course, difficult to gauge. But it is clear, that he acted as more than a simple conveyor of information; he did more than simply inform the Board about the possibilites of the project and the offer of assistance from CAN, say, in the way that a news article or some other written media might have informed them. More likely, on the basis of his personal and professional statuses and his overall role in the co-op community, Weinstein was able to perform as a sort of translator or decoder between CAN and the Board, serving mediating and .enerally legitimating functions. In other words, by introducing solar thermal through Weinstein, the perceived uncertainties, and riskiness were likely mediated. For one thing, it was customary, i.e., in keeping with routine, for Weinstein to suggest trying something new, in particular, things having to do with the management of the co-op as well as energy. After all, these were the major concerns in his professional life, his interests, and areas of expertise. In essence, Weinstein was able to endow the technology with positive attributes because of his own status; it was then something legitimate, something worth a try, if the financial situation could be improved.

Though for a time financial prospects remained dim, and interest in the project appeared to wane, it was once again on the basis of CAN's connections that the group learned of recent developments in the HUD SHAC Program and the possibility of project funding. Even though the June meeting between Napoli and Dubin did not afford sufficient time to fully explore system needs and compile all information needed for the grant, given the chance to reapply, CAN effectively assumed the role of the linker and project facilitator. Again we see a series of connections emanating from CAN, for example, Napoli turning to Watson, the solar architect he knew and trusted (via CAN), and in turn, being referred to the Ehrenkrantz Group, the architect with whom Watson had worked and whom he trusted, and the Ehrenkrantz Group, in turn, contacting Daystar and Crane--in short, one trusted source confirming another all the way down the line.

Thus through its connections and general facilitating skills, under the direction of Napoli, CAN served as the principal actor, assembling all necessary resources and coordinating all efforts to insure that this time the "job was done right." When the grant finally came through, however, for less than the requested amount, it was, of course, Arthur Weinstein who again took center stage. In essence, CAN had set up the project; it had done nearly all that it could do. At this point, it was up to Weinstein to present the situation to the Co-op Board, and if there was to be a solar system at 924 West End Avenue, to convince them to contribute co-op funds.

Again, the precise role played by Weinstein, the extent of his influence on the Board, is difficult to assess. However, there can be little doubt that Weinstein's role was an instrumental one in gaining the Board's final approval of the project and their agreement to use co-op funds. One factor that seems to have been important was the manner in which Weinstein presented the situation to the Board, his emphasis on the financial considerations involved. As opposed to the technical aspects or any of the intangible benefits associated with solar thermal, it was the financial aspects that Board members most clearly understood and to which they were most likely to respond to. Needless to say, financial matters were of major concern to the 924 Co-op (and to all co-ops for that matter) and the possibility of cost savings, as Weinstein put it, of "getting a system worth $28,000," was likely to have much appeal.

Another factor of obvious importance was the personal influence of Weinstein himself. For however appealing the promise of future cost savings, solar thermal was still a technology about which the Board knew very little; in other words, there could be no guarantees. And as expressed at the board meeting, there were clearly other ways the co-op might use $28,000 in funds. Insofar as the Board agreed to the solar project, one might suspect that Weinstein served mediating and generally legitimating functions once again. In the same way that solar thermal was seen as something plausible if not altogether reasonable when first introduced by an individual of Weinstein's competence and expertise, the possibility of financial savings now seemed reasonable with Weinstein's continued support and assurances. Again, solar thermal could not be that risky; the projected financial gains had to be somewhere within reason, with the backing of someone of Weinstein's capabilities.

Thus on the basis of expected financial gains, and Weinstein's mediating and legitimating influences, 924 West End Avenue's final decision to participate in the HUD SHAC Program can be more fully understood. To conclude the project analysis at this point, however, would leave one very important question untouched. And that is, if solar thermal was so risky and uncertain, "such a new field," as Arthur Weinstein commented many times, why Weinstein himself was so ready and willing to go ahead with it. We have explained that Weinstein was committed to furthering the development and use of alternative energy resources and that he believed the co-op's decision to use the technology, even to contribute $28,000 in its own monies, to be justified on the basis of financial considerations alone. Nonetheless, however one assesses the situation, there can be little doubt that Weinstein was putting himself on the line; if anything were to go wrong, financially or technically, it would be easy to point a finger at Weinstein. And, as a co-op resident, by this date, even having established a private law practice with an office in the building, this was not a situation from which Weinstein could easily walk away. At least to some degree, Weinstein's personal and professional reputations were at stake. As Napoli succintly put it, commenting on Weinstein's overall importance to the project, ". . . Art not only had to face a financial problem if the project failed, but having to live with sixty-three other owners made his position extraordinarily perilous. One has to live in a New York co-op to understand the magnitude of Weinstein's effort . . ."

Weinstein's willingness to assume such risks might be explained in two ways. On the one hand, it seems likely that some of the riskiness was mediated by the support and encouragement of the many individuals and organizations involved in the project. CAN, for example, proved itself a highly capable facilitator; indeed, it seemed that CAN had connections and access to resources everywhere. Richard Napoli, in particular, was someone for whom Weinstein had both personal admiration and professional trust and respect. As Weinstein had once explained, "Napoli was thoroughly cooperative; he could only be an asset to any project or group effort of this type." Further, he was someone whose opinion Weinstein had come to trust on technical matters; " . . . he (Napoli) may not have an advanced degree in engineering but he certainly knows the part . . ." Moreover, the Ehrenkrantz Group had had previous experience with the technology, as did Daystar, and importantly, they had been introduced to Weinstein through such a trusted source as Napoli.

Thus, in the same way that Weinstein had performed mediating and generally legitimating functions for the 924 Co-op's Board of Directors, this group of organizations and individuals, i.e., CAN , Napoli, the Ehrenkrantz Group, the Daystar Corporation, Harold Crane, likely served mediating and legitimating functions for Weinstein; with their support, and promises of assistance, they were able to lessen the amount of risk seemingly involved. At the same time, however, it is important to recognize that, given Weinstein's expertise in housing and energy (indeed, it takes an expert to know just how uncertain the solar field is these days) there was undoubtedly a limit on the extent of their mediating influence. In other words, however supportive or resourceful they or anyone else could be, they could not entirely change the situation, and Weinstein assumed his position with at least some awareness of the uncertainties and risks involved. Thus, in the final analysis, one might view Weinstein as an individual with something of a predisposition toward taking risks; in addition to the mediating and legitimating roles assumed by Weinstein, and with CAN and Napoli, the role of project facilitator, by endorsing and promoting the project in spite of the many risks and uncertainties at hand, Weinstein played the part of the innovator, the "plunger," as well.

Thus we see how a supportive institutional network helped to make solar thermal a more acceptable technology. As a housing cooperative, with responsibility for long term management and operating costs, 924 West End Avenue was likely to find the idea of a technology with a high first cost less objectionable than the average industry developer; however, given the unusually large front end investment currently required for solar thermal, the initial investment could not be recouped within any reasonable period of time, and the housing cooperative could not justify use of the technology on financial grounds. For this reason, the subsidy provided by the HUD SHAC Program proved altogether critical, the "sine qua non," as one project participant explained.

At the same time, however, due to the many uncertainties presently confronting the technology, coupled with the co-op's lack of technical expertise, the subsidy was not likely sufficient to induce the co-op to use solar thermal on its own. The critical force in bringing this about was CAN, who, on the basis of general facilitating skills and a network of personal and professional affiliations, was able to identify and assemble all the resources and technical expertise needed to initiate the project, and, time and time again, to keep project efforts moving along. One individual of obvious importance in the institutional network "linked" by CAN was Richard Napoli; on the basis of administrative skills and technical expertise, Napoli was able to serve as a highly effective project facilitator leading the CAN project team. The other critical figure in the network was, of course, Arthur Weinstein. As an expert in housing and energy and with administrative skills as well, Weinstein was able to assist CAN and Napoli on both substantive and procedural matters and generally, facilitate project efforts.

Even more important though, were the mediating and legitimating functions Weinstein served, first, in introducing the idea to the 924 Co-op's Board of Directors and later, in gaining their final approval to go ahead with the project and contribute co-op funds. Because of Weinstein's proven competence in housing and energy, and his prominent stature in the co-op community, solar thermal appeared as a plausible if not altogether reasonable technology for the co-op to use. In a similar vein, the other figures in the supportive institutional network, i.e., Napoli, the Ehrenkrantz Group, the Daystar Corporation and Harold Crane, likely helped to mediate and legitimate the use of solar thermal for Weinstein; however, in the final analysis, Weinstein proved an individual personally disposed to taking risks, and in addition to serving mediating, legitimating and generally facilitating functions, Weinstein played the part of the innovator as well.

Together with the HUD SHAC subsidy, it was by means of this cast of supporting individuals and organizations, performing in their various "linking," "mediating," "legitimating," and "facilitating" roles that solar thermal became something thinkable, that it was moved from the category of an innovation to something more routine. In short, it was the supportive institutional network that made solar thermal acceptable and "do-able" at 924 West End Avenue.

Project Chronology

924 West End Avenue

1973	CAN determines to broaden focus and to undertake projects in the energy field.
1974	CAN begins to concentrate efforts in the energy field; determines to explore the possibilities of a solar thermal demonstration project for New York City as part of a solar energy education effort.
1975	
Winter	CAN contacts Richard Napoli for assistance; Napoli agrees to lead CAN efforts in investigating project possibilities. CAN approaches Arthur Weinstein for assistance in exploring issues relevant to housing and energy; Weinstein agrees to join efforts with CAN.
Spring	First meetings held to formulate project goals and objectives and plans for implementation. CAN begins search for building suitable for the demonstration project; contacts a number of West Side property owners.
Summer	CAN contacts Travis Price for assistance with technical aspects; Price agrees to conduct technical evaluation of proposed sites and execution of a preliminary system design. Arthur Weinstein's building, i.e., 924 West End Avenue, selected for demonstration project.
December	First meeting held between CAN and the Co-op's Board of Directors; Price presents preliminary system design;

proposal rejected by Co-op Board on financial grounds.

<u>1976</u>

Winter	CAN seeks advice of other professionals, e.g., Fred Dubin, of Dubin Bloome Associates, in efforts to resolve financial problem.
Spring	Financial issue not resolved; project efforts, more or less, unofficially tabled.
June	Napoli meets Fred Dubin at Energy Fair at University of Massachusetts; Dubin informs Napoli about possibility of grant from the HUD SHAC Program.
July	Napoli informs Weinstein about possibility of the grant; 924 West End Avenue agrees to apply for grant.
August	Grant application prepared; submitted to HUD.
October	Grant application rejected; HUD, however, suggests re-submission.
	Napoli contacts architect Donald Watson to undertake system redesign; Watson declines offer; refers Napoli to the Ehrenkrantz Group.
November	Napoli approaches the Ehrenkrantz Group who agree to undertake system design and preparation of the grant application.
December	Meeting held at office of the Ehrenkrantz Group with Stephen Weinstein, Arthur Weinstein, Napoli, and representatives from the Daystar Corporation attending; Daystar selected as solar manufacturer.

1977

January	The Ehrenkrantz Group completes system design; makes preliminary arrangements for installation of the system.
March	Grant application prepared; submitted to HUD.
May	Notification of grant award received for $112,000 of $156,000 requested.
	Weinstein (Arthur), Napoli, Weinstein (Stephen) work on project cost breakdown; project costs brought down to $140,000, leaving a gap of $28,000.
	Weinstein explains status of project to Co-op's Board of Directors; tenants meeting held; co-op agrees to contribute remaining $28,000.
	Weinstein notifies HUD of co-op's agreement to accept grant.
June	Weinstein arranges loan with Manufacturers Hanover.

1977

Summer	Installation of system begins.

1978

Spring	System installation completed; Weinstein learns of technical difficulties with Daystar collectors. Weinstein notifies the Daystar Corporation.
	Daystar begins year-long period of investigation of alternative system designs.

1979

Spring	Daystar devises system to take strain off collectors and ensure proper dissipation of heat; Crane executes installation changes.
	System successfully operationalized.

Cathedral Square

Cathedral Square, a participant in HUD Cycle 3, is a 100 unit development for the elderly and handicapped in Burlington, Vermont. Located in the downtown Burlington area, in an expanding urban renewal zone (and adjacent to Lake Champlain), the project commands unusually high visibility. Utilizing nearly 1,700 square feet of solar collectors to provide 50 percent of the building's annual hot water requirement, it is likely the largest solar installation in the region in addition to being the first of any size to receive federal assistance.

Cathedral Square, developed with major commitments of public monies under the sponsorship of the Cathedral Square Corporation, illustrates the case of the non-profit developer. In general, this category of developers is distinguished by what has been termed a "normative" motivation; typically non-profit developers are motivated to become involved in housing development in order to realize certain ideals or beliefs. Financial aspects of development are still important as there are always constraints on resources. Yet for the non-profit developer financial aspects are typically of lesser importance in dictating the terms of the development than the group's norms or ideals.

The Cathedral Square case illustrates the importance of such normative aspects of development, showing how this predisposition of non-profit developers can facilitate the acceptance of an innovation. As we shall see in this study, this is particularly the case when the non-profit's orientation is combined with similarly supportive elements in the institutional environment, i.e., an architect with a strong sense of commitment and ideals and close ties to a network of similarly supportive sources of information.

Project Chronology

Cathedral Square had its beginnings in two separate developments in the early and mid 70's. In 1976, the National Episcopal Church was notified of the availability of $10 million in HUD Section 202 funds, i.e., low interest mortgage loans for the construction of housing for the elderly and the handicapped. The Church had applied for $50 million in funding three years earlier, but been rejected due to the moratorium on federal housing monies imposed by the Nixon administration.

During the same period, the Cathedral Church of St. Paul of Burlington was in the process of changing its image, in general, looking for ways to become more involved in community affairs. A particular interest was to find a "civic-minded" use for a church-owned parcel of land in an expanding urban renewal area, conveniently located to the downtown. The Church's original building had burned in the early 70's. Faced with the question of rebuilding, the Church had re-evaluated its objectives and overall purpose as well. (The old church building had had neither the space nor facilities to afford community outreach activities, and the Church had been, overall, "inwardlooking"--its activities limited to traditional church affairs.) As one parish member explained: ". . . we seriously questioned the purpose of rebuilding; was it truly worthwhile if we were just going to be another stuffy, inward-looking organization? Perhaps, we had some broader, more important mission to fulfill."

Thus, following a period of self-evaluation, the parish had determined to rebuild the church and to alter its image as well. Reflecting this new attitude, "the realization that the church's mission was to better serve the community," the new church structure, erected in 1972, was designed to be flexible, enabling the interior to be used for any of a variety of purposes. The church building was purposely sited on a corner of the parcel (which was to become known as Cathedral Square) so as to leave room for the eventual development of some structure for use by the local community. Also at this time, the Cathedral Church of St. Paul notified the National Church of the availability of the parcel and its desire to sponsor the development of a housing project, most likely, housing for the elderly, given the need for this service in the area.

Thus, in September 1976, when federal monies were made available to the National Church, they went back to the Church of Cathedral Square to see if they were still interested. The Church had not yet developed the land due to a lack of funding; thus, they readily accepted the offer. The Cathedral Square Corporation was thereafter established under the direction of parish member James Viele, as a non-profit corporation to have full responsibility for the development and operation of the housing project, thereby limiting the liability of the church proper. Following the typical development strategy, an architect was then contracted by the Corporation to execute preliminary plans and designs for the development, this being Anthony Adams AIA Architect of Burlington. Adams was himself a member of the Cathedral parish and had assisted in the design of the new church facility in 1972.

With these arrangements made, the design stage for the Cathedral Square housing project began in late September 1976. During this time, in the very early stages of the design period, Adams' firm (chiefly, Adams and Frank M. Guillot, an associate in the firm) considered the possibility of using a solar thermal heating and/or hot water system, in addition to passive solar design techniques. Though Adams had had little actual experience with solar--his firm had been involved in the design of a few single family residences using solar thermal systems, but the systems had been both vendor designed and supplied--Adams had a longtime interest in conservation and alternative energy technologies; (In 1975, he had published a self-help type book entitled Your Energy Efficient Home, illustrating basic concepts in conservation and passive solar design techniques.) Moreover, though he views solar technologies as "not yet sufficiently advanced, at least not in technological or economic terms," he expresses a serious commitment to furthering their development. As he explains: ". . . there are many good things going on in the solar field, but it is still a brand new industry; solar's economic advantages and effectiveness have not yet been demonstrated. Yet someone has to try it; in fact, many must experiment with it if the industry is ever to get its feet off the ground." For Adams, solar thermal has an obvious symbolic value as well: ". . . although it's really an intangible sort of thing, visibility of solar is important; people like to see things like this (referring to the array) . . . you take a public spirited type; he looks at the array, and it makes him feel warm; in general, it gives people confidence that the federal government is trying to do something about our energy circumstances."

With this strong sense of commitment, Adams was very enthusiastic about the possibilities of employing solar technologies at the Cathedral Square Project. However, such enthusiasm was curtailed, after an initial period of investigation. As Adams explained, his firm had researched various solar components and systems in architectural magazines, catalogues, trade journals, and the like, and thereafter, explored the possibilities of designing a system on their own. However, it became clear rather quickly that they would have to abandon the idea of using an active solar thermal system, first, Adams explained, because of cost considerations. "There was absolutely no room in the project budget for the additional front-end costs or the costs associated with installation." Further, Adams recalled, "We were concerned because of the lack of technical support--though we had some understanding of the basics of the technology; it is sort of a hobby in this firm--we were not confident about designing a system of this scale on our own."

For these reasons, the idea of using a solar thermal system was rejected, and work on the design progressed under the assumption that a conventional system would be used. However, after roughly three months into the design stage, Adams learned about the HUD SHAC Program (in January 1977) through a publication of the Energy Research and Development Administration (ERDA). Then, with the possibility of funding, interest in a solar thermal system was revived. Recalled Adams, ". . . reading that projects should be combined efforts of architects, developers and contractors I immediately considered the idea for the Cathedral Square project."

With interest so revived, Adams determined to seek outside assistance. Thus shortly thereafter he contacted Robert Wheeler of Yankee Solar Inc., Burlington, a broad based vendor of energy conserving products and systems in northern New England and also, the local dealer for the Daystar Corporation (one of the largest manufacturers of solar components, also Burlington based).

Adams did not know Wheeler personally, nor had he worked with him prior to this time, but he knew of him by way of the local building community; as the men agreed: "Burlington is basically a small town; people in related fields are likely to know of one another even if only on the basis of reputation." And though Wheeler had no previous experience with the HUD SHAC Program, Daystar had been the supplier for projects in the Program's two previous cycles, and as Wheeler knew, they had provided assistance to the applicants in designing a system and in preparing the application. Wheeler thus expected that Daystar would provide similar services for the Cathedral Square Project.

With these plans in the works, Adams approached the Corporation's Board of Directors with the idea of using solar in January 1977. Initially, the Board's response was one of reservation, if not outright opposition, primarily because of their lack of experience and the perceived riskiness of housing development. As Viele explained: "Just building a $3 million housing project scared us; this was something we felt uncertain about right from the start, and now, on top of this, solar, something about which we knew absolutely nothing."

Further discussions regarding solar were held between Adams and the Board, however, during February 1977. Adams noted the possibility of support from Wheeler and the Daystar Corporation, and explained the advantages of solar and the general appeal of the technology. He did discuss solar thermal's current status, i.e., uncertainties regarding technological and economic matters. But at the same time, he stressed the need for experimentation and experience with solar. Even if there were uncertainties at the time, and as Adams admitted to the Board, "on large scale projects of this type, it was not possible to know just what would be involved beforehand . . ." it was nonetheless critical to gain experience with solar, specifically on projects of this scale. In all, Adams stressed the idealistic or normative aspects of the technology, describing it as the progressive, civic-minded thing to do.

And finally, on the basis of such discussions, the Board concluded solar to be "worth a try." As Viele recalled: "In the end, it was a gamble. But we're good citizens, we were building this project for civic betterment and we are, of course, concerned about the quality of our environment. Obviously, we had to be somewhat concerned with the economics of it . . . but in the end we decided we would be the guinea pigs; we would try it. We bought the farm on faith."

Thus, with the Board's encouragement early in 1977, Adams' firm began investigating the possibilities of solar thermal in collaboration with Wheeler and the Daystar Corporation. The Daystar Corporation had agreed to provide technical assistance with the system design and the HUD grant application as Wheeler and Adams had planned.

Also at this time, while preliminary investigations were under way with Adams, Wheeler and Daystar, Wheeler contacted James Brown, a mechanical engineer and principal of Jennison Engineers, Inc., for further assistance with system design. Also of Burlington, Brown was known to Wheeler by way of the local building community. Brown too lacked actual design experience with solar. But, as he recalled, "the project did interest him, and it sounded like a good way to learn;" thus Brown agreed to join Wheeler and Adams on the project team.

Together then, these three individuals in collaboration with Daystar, had responsibility for planning and designing the solar system at the Cathedral Square project; first, with Daystar's assistance, determining the overall feasibility of the idea; (using computer simulations, it was estimated that a solar thermal system could supply approximately 50 percent of the structure's annual hot water requirements), next; checking out performance data and construction quality of the various types of solar equipment, then; selecting components, designing and integrating the system with the site, and finally; preparing the grant application. Adams served as overall coordinator of the process, having primary responsibility for advance planning and, as is customary in development activities, acting as the representative for the developer, i.e., the Cathedral Square Corporation. Brown was responsible for the actual system design and integration with the structure, while Wheeler, in addition to providing general assistance with technical matters, coordinated the group's efforts with the Daystar Corporation. Later, in preparing the grant application, Adams' office provided the overall project rationale, Brown, the design drawings and descriptions, and Wheeler, the technical information required on the system and the Daystar components.

In spite of these individual responsibilities, the planning process was largely one of a team approach. There was less than five weeks to plan and design the system and get the application in order. (Adams did not receive the Board's final okay until February and the grant application was due in mid March.) Thus, as Adams recalled ". . . we were forced to work closely and quickly; it was then or never." Further, no one in the group had any prior experience with solar. (Wheeler had, of course, supplied solar components on previous occasions but not for projects of this scale). And with the exception of Daystar, the group had few other sources to turn to. Thus as Wheeler summed up ". . . we had to rely entirely on our own judgements, to piece things out together, as we went along; who else could we ask about this? Where could we go?" For similar reasons, the group kept everything in the design as simple as possible. As Adams recalled, "Given time and resource requirements, experimentation was not possible; we took the data and went strictly with the basics, nothing exotic. And we were lucky, even then, to get the system design completed and the application in on time." Bob Wheeler had, in fact, had to hand deliver the application in Washington, on the final day.

Thus concluded the planning stage for the solar portion of the Cathedral Square Project. In spring 1977, notification of the grant award was received for the full amount requested, i.e., $91,000. Additionally, the project was one of the five, Cycle 3 projects selected for instrumentation and monitoring for the succeeding five years (to be carried out by Boeing under contract to HUD).

While the solar aspects of the development appeared to be proceeding smoothly, complications had developed regarding other aspects of the project design, forcing project work a few months behind schedule. (Original plans called for the final design to have been completed by the end of July; in a revised schedule, design completion was postponed until late November.) In large part, these delays resulted from bureaucratic processes and what Adams described as "piecemeal revisions required to keep the project within budgetary limitations and also, in compliance with HUD 202 regulations." Another major difficulty though, and the reason for having to redesign the entire structure during March, stemmed from a problem with a local zoning statute. In 1975, a master plan had been developed for the downtown area including a provision that no new structure "substantially obstruct" the view of the Lake, i.e., Lake Champlain, nor the Mountains, i.e., the Adirondacks. As in many statutes of this type, what specifically was meant by "substantial obstruction" was nowhere further defined. But, as Viele recalled, it was apparent to all involved that the proposed eight story structure, located so near to the shoreline, obstructed the views, at least to some degree. On the basis of discussions with local zoning and planning board members an agreement was reached to increase the height of the structure to ten stories. By thus making it taller, but more narrow, they reasoned, visibility of the Lake and other scenic views was enhanced.

In any event, whatever the logic behind this decision, it obviously required major changes in the project design. And though all agreed that the issue had little to do with the fact that the structure was solar, the requisite changes nonetheless had major implications on the solar aspects of the design. In the taller and narrower version of the structure, the previously rectangular roof was replaced by one with a triangular shape. Thus, as one project participant recalled, "it was back to the drawing boards for the solar array as well"; changes were required in both the size and placement of the panels, e.g., in the final design the panels do not face directly south, the optimal direction for solar ray absorption, but instead slightly to the southwest.

With all such revisions, construction at Cathedral Square began late in the fall of 1977. Work on the structure proceeded on schedule through the spring of 1978, and in early summer, installation of the solar system began. Though this too proceeded according to schedule, it was not without a general sense of uncertainty nor entirely without complication.

For example, one series of complications developed with the roofing subcontractor; at some point during the construction period (some time after the subcontract had been let by Cummings, the general contractor) it was recognized that a steel frame would be required to support the array. This, in turn, necessitated additional changes in the penthouse area of the structure as the steel frame reduced the amount of space available for piping, the elevators, and other mechanical components.

Other complications with the roofer centered on safety concerns. As Adams explained: "Knowing that the roofers might be exposed to additional hazards when installing the solar panels, he had contacted HUD to determine safety requirements." And though he was told that no regulations applied to this situation, and that a protective railing was likely not necessary, when it came time for installation the roofers "balked on the issue of safety"; their insurers would not allow them to work on the roof without a railing. Thus, recalled Viele, a protective railing was finally installed at the Corporation's expense, "with funds drawn up at the eleventh hour."

These complications aside, there were few reported difficulties experienced in installing the solar system at Cathedral Square. Under Brown's supervision, the plumbing subcontractors installed the solar mechanical systems. With the array in place, the system was successfully operationalized in late fall 1978 prior to the occupancy of the structure.

Project Analysis

In analyzing the project "approach" to solar thermal, we will examine the means by which solar thermal was made sufficiently comprehensible to be accepted by the Cathedral Square Corporation, despite the negative intrinsic characteristics described in Chapter 3. We will also consider the means by which project participants were able to execute the requisite planning and design activities involved.

First, it is important to remember that as a non-profit developer the Cathedral Square Corporation is an institutional entity with meanings and routines that differ somewhat from the average developer. The Cathedral Square Corporation could therefore be expected to have a priori a somewhat different disposition toward solar thermal's intrinsic characteristics. In other words, it is likely to be disposed in a manner that it consistent with its practices and routines. Most significant is the fact that the Corporation is undertaking the project not for profit, but rather, on the basis of less tangible, philosophic reasons, as noted in the introduction, as an expression of their ideals and beliefs. Thus one might expect the Cathedral Square Corporation to be less concerned with such matters as the negative economic attributes of solar thermal, e.g., the higher first cost, than the average industry member. Alternatively, it is likely to be more attracted to the positive values or normative dimensions of the innovation, for example, the notion of solar thermal as the environmentally sound technology.

Also distinguishing Cathedral Square is the fact that the project is financed entirely with federal subsidies and will provide housing for the elderly and the handicapped, a group that has traditionally had substantial difficulty locating "decent" housing at rates commensurate with their incomes. Thus one might expect the aesthetic and design attributes of solar thermal, i.e., the deviation from current industry design standards, to be of little or less consequence to the Corporation; the demand for housing of this type is such that the physical appearance of th structure would likely be less of a consideration than for other tenant classes (at least as far as the roof design is concerned). For similar reasons, the issue of resaleability is not applicable to this case.

Thus on the whole, as a consequence of their normative motivation and the captive market quality of the project, the developers of Cathedral Square would seem to have been more favorably disposed to using solar thermal than the average builder/developer. Nevertheless, it is important to realize that there was still enough "wrong" with the technology for them not to have been entirely favorably disposed to solar thermal; in other words, they would not (and did not), readily take action to incorporate solar thermal into their project on their own. For one thing, though they were less concerned with the financial aspects of development, they still had obvious resource limitations at the project's start. They did not then know of the availability of federal subsidies through the HUD SHAC Program. More important though, seems their highly vulnerable position at the time. Even without a new technology such as solar thermal, housing development is, undoubtedly, an activity of high complication and risk. This is true whether one is motivated by profit or ideals. And, it will be recalled, this was the Cathedral Square Corporation's first experience in housing development, as noted earlier, something about which they did not feel entirely sure. In sum, the Cathedral Square Corporation would appear to have had enough of the "new and different" to deal with on the basis of the housing development alone.

How then did the Cathedral Square Corporation come to be a participant in the HUD SHAC Program? Why did they agree to take on the additional risks of experimenting with a new technology, and by what means were they able to deal with those aspects of the technology at odds with their particular routines?

First, in regard to gaining the consensus of the Corporation's Board of Directors, the role of Adams appears to have been critical. As noted, it was Adams who first learned of the HUD SHAC Program and notified the Board of the availability of public funds for use of the technology. Thus Adams is important for his role as a linker, passing on knowledge from one source to potential users. Clearly though, Adams did not perform in so limited a capacity as a simple conveyor of information. The information was not passed on exactly in the manner in which it was received, and the Corporation's Board of Directors did not determine to participate in the HUD SHAC Program and use solar thermal simply because they were then aware of it. Instead, this development seems the result of the effects and influences of Adams, influences resulting from Adams' overall status, i.e., the roles legitmated and assumed by him, and further, because of the manner in which Adams presented the idea to the Board.

The first and major factor having bearing on the Board, i.e., Adams' status, is based in two distinct areas, that is, personal and professional attributes. First, Adams is a member of the local community, known and respected by the Corporation's Board of Directors. Moreover, and likely of greater importance, Adams is a longtime member of the Cathedral Square Church, known and respected on this level as well. Insofar as Adams shares a common background with the Board, he is linked to his client in the sense of being "one of them"; he is a member of their group.

On the basis of these personal attributes alone, one might expect Board members to have been sensitive to Adams' suggestions, open to his opinions and ideas. In other words, Adams could serve mediating functions, that is, making solar thermal seem less risky and less new. He could serve legitimating functions as well, endowing the technology with a positive status or authority similar to his own. In short, by introducing the technology through someone of Adams' status, solar thermal might not have appeared as something strange or risky, but instead, as a highly plausible if not altogether reasonable technology to use.

Adams' potential for mediating and legitimating the use of solar thermal was undoubtedly augmented by his professional status as well. For not only is Adams trusted on a personal level as a member of the local community and the Cathedral Square parish, but as an architect, he is particularly trusted and respected in matters relating to building and design. He has a proven competence and experise in these areas. As noted, Adams had been involved in the siting and design of the new church facility in 1972. Further, that the Board sees Adams in this way is evidenced by their selection of him as project architect.

Thus, on the basis of his personal and professional attributes, it seems that suggestions from Adams on matters concerning the physical structure would likely have been seriously considered. In a sense, because of such statuses, Adams was able to translate or interpret the information received from the ERDA publication and deliver it to the potential user in a form more in keeping with their routines; from the perspective of the Board, Adams was both a credible and reliable source of information with motiviations that could not have been too different from their own, suggesting the use of a new building material, as any architect might do. For these reasons, it would appear to have been safe for the Board to follow Adams' advice, safe, that is, to try solar thermal.

Another interesting aspect concerning Adams' professional status is his role as innovator or risk taker. This was, in fact, the predominant view Adams, generally, and more specifically, in the context of his role as an architect. As one board member explained, "Perhaps we can't always get him to a meeting, or to deliver plans on time, but ideas, we can always count on him for that; he's one of those innovative types, always in the vanguard, on top of new ideas . . ." This too likely had a mediating influence on the Board as it was altogether in keeping with tradition for Adams to be the one to suggest trying something new. For Adams to have suggested that they use solar thermal instead of a conventional hot water heating system was not only in keeping with his customary ("institutionalized") role as architect, but also, in keeping with his role as innovator, the initiator of new things and ideas.

Likely, these factors would have been sufficient to gain the Board's approval to use solar, but what also seems to have been important was the manner in which Adams presented the possibility to the Board, in other words, the meaning he attached to solar in introducing it. Importantly, Adams did not just inform the Board of the technical aspects of the technology or the operations of the HUD SHAC Program, but instead, whether or not intentional, he presented the idea in a manner entirely in keeping with the Board's overall disposition as well as their newly institutionalized roles and routines. That is, Adams emphasized the normative aspects of the innovation; given solar thermal's present status and current energy circumstances, use of the technology was presented as the proper, civic-minded thing to do. As a non-profit developer, the Cathedral Square Corporation was in general motivated more by ideals than by profit and thus likely to have been attracted to the normative dimensions of the technology. What seems of particular importance, though, is the new image desired by the Church, as Viele pointed out, the Church's desire to become "more civic-minded and outward-looking, . . . to take on projects that would serve the public good"-- in short, tasks precisely fitting the bill of solar as presented by Adams.

Considering both Adams' personal and professional statuses and the manner in which he introduced solar thermal, it is now more understandable why the Cathedral Square Corporation agreed to participate in the HUD SHAC Program, why solar thermal was, all of a sudden, "worth a try." Indeed, with all such factors, it would seem, in retrospect, more than a little suprising had the Board rejected Adams' idea. Of course there were still negative aspects to be reckoned with. For example, participation in the program would require the planning and preparation of another lengthy application. Yet here the Board could rely on Adams; he would take charge of all planning-related matters having to deal with solar as with other aspects of the physical design. As for possible organizational problems in using the new technology, likely, the Board was not aware, having had so little experience with housing development. To the extent that such difficulties were anticipated, however, they could again assume that they would be handled by Adams; he was, after all, the project architect, with full responsibility for project design and supervision during the housing production process.

Interestingly, in spite of Adams' abilities to convince the Board and generally serve mediating and legitimating functions, Adams was himself not altogether sold on solar. He was certain of the overall worthiness of the effort; he feels a serious commitment to furthering the development of solar, as he said, "someone has to try it . . ." However, as noted, he was not entirely convinced on the technological and economic aspects nor entirely certain of what a project of this scale would entail. And unlike the Board, Adams likely had a focused view of the uncertainties and potential problem areas; in other words, where the Board might not have fully known of uncertainties regarding technical or organizational aspects, one might expect an architect like Adams to have been well aware of the possibility of such problems.

Thus far we have described Adams as the innovator, the one willing to take risks for worthy causes, as a way of explaining his willingness to use solar in this case. But what seems important to recognize, and adds another dimension to the issue, is the fact that the risk Adams is so willing to take in this instance is not entirely his own. True, Adams' reputation is at stake, and his competence and expertise as an architect might be questioned should anything go wrong. But clearly, it is the Cathedral Square Corporation that will suffer should any major difficulties develop, whether resulting from the solar aspects of the project or simply on account of the complications in dealing with another branch in the federal bureaucracy and thus an additional set of regulations and operating procedures.

Insofar as Adams likely felt a responsibility to protect his client--it is one thing to gamble with ones own funds but clearly, he did not want to put them too far out on a limb--it seems reasonable to suspect that there were other factors convincing Adams that this was not the case, and that solar was, after all, "do-able." In again going back to the project chronology, the reasons why Adams was willing to assume such risks on behalf of his client seem more clear.

As noted, when Adams read about the HUD SHAC Program, one of his first steps was to contact someone he knew from the local building community having expertise in this area, Bob Wheeler of Yankee Solar Systems, Inc. In the discussions between the two that followed, Wheeler performed an important function, acting as a sort of sounding board for Adams, a fellow collaborator in the case. He also served as a conveyor, providing information on solar, generally, and the particular solar components which he distributed. Insofar as Wheeler was respected in the local building community and seen as a credible and reliable information source, he likely had a general mediating influence as well.

Perhaps of even greater significance, though, was Wheeler's role as a connector or linking agent; on the basis of personal and professional associations he was able to connect their efforts to two additional resources, both of which appear, in retrospect, to have been altogether critical to the case. The first resource, the Daystar Corporation, played a central role in helping to determine the overall feasibility of the idea, in providing detailed information on different solar components, and in providing general technical assistance on matters relating to systems design and integration with the site. In these capacities, Daystar served as the all-around expert, the ultimate technical advisor, providing technical information just at the times when it was needed. The importance of the Daystar connection was a point underscored by Adams himself, "Quite simply, we did not have complete information on other solar products; Daystar products seemed perfectly reasonable to us on the basis of the available data. One thing was for certain; if we hadn't gone with Daystar, we would not have gone with anyone."

While Daystar was thus critical to the project, simply by virtue of its accessibility, it is important to recognize why Daystar was so readily seen as a reliable and credible information source (in contrast to the vendor with a bias toward his/her particular product), why, in other words, the offer of assistance was immediately so appealing. First was the introduction through Wheeler, then a trusted colleague. A second and perhaps even more important reason, was Daystar's previous experience with the HUD SHAC Program; as noted, Daystar had been involved in both Cycles 1 and 2, the obvious implication being that they had the competence and expertise to plan and participate in the HUD SHAC Program. In short, Daystar knew just what would be required in terms of a system and the application, and they were there to assist, on both counts.

The second resource brought in by Wheeler was engineer James Brown. Also locally based, known and respected by both Adams and Wheeler, he too was a trustrworthy information source, another generally mediating force to join the team. Importantly, Brown approached the technology strictly from the perspective of mechanics, in other words, his area of expertise. As one colleague summed up ". . . he (Brown) seemed not the least bit ruffled by the fact that this was 'solar' . . ." With this approach to the technology, Brown not only served a general mediating influence, but in a very real sense, was able to translate the innovation from the state of something novel and uncertain to something more routine.

It is this cast of supporting individuals that took away some of the riskiness from solar thermal, and in doing so, convinced Adams of the feasibility of the idea. While Adams was obviously hoping to proceed with solar, in other words, predisposed to favoring the idea, certainly solar could not have been viewed as so risky or potentially uncertain with commitments for assistance and confirmation of its feasibility by two trusted and respected colleagues and access to the resources of an organization like the Daystar Corporation.

Together then, on the basis of a sense of mutual trust and compatability, both personal and professional, this group formed a sort of self-reinforcing network, in general, performing the critical mediating and legitimating functions and helping the individual participants to maintain a "forward-looking" attitude throughout. Of course there were uncertain moments, and complications did arise, e.g., the need to redesign the roof area, the incidents with the roofers. Yet by means of this "forward-looking," supportive network, it was possible for the group to work its way through such problems, "to piece things out, step by step." As one participant summed up: "Solar was something new to us, something of a challenge. At times we could certainly have benefitted from even further assistance; however, we knew we could make sense of it collectively; we were determined to make this thing work."

Thus we see how a network of interpersonal affiliations and generally supportive institutional contexts helped to make solar thermal a more acceptable technology. As a non-profit developer the Cathedral Square Corporation was likely more favorably disposed to solar thermal than the average industry participant. But this was not sufficient to induce the Corporation to participate in the HUD SHAC Program on its own. The critical force in bringing this about was Adams, who, on the basis of personal and professional attributes, his role as an architect in the local community, membership in the Cathedral Square parish, and the manner in which he presented the innovation to the Corporation, was able to mediate the newness and uncertainty inherent in the new technology and generally, legitimate its use. Coming from Adams, in the form presented, the suggestion to use solar thermal in the Cathedral Square Project seemed like an altogether reasonable thing to do.

Though Adams was himself regarded as an innovator, one predisposed to taking risks of this type, because of the risks that this entailed for his client, it is not clear that he would have done so altogether on his own in this case. What prompted his decision was the encouragement and support provided by two trusted and respected colleagues and access to the all-around technical expert and consultant, the Daystar Corporation. Brought together by Wheeler, the linker, this self-reinforcing network performed the critical mediating and legitimating functions for and among themselves, and in this way, helped to move the technology from the stage of novelty to something more routine. In sum, solar was neither too unusual nor too risky when it entailed a close collaborative effort among colleagues performing in their usual roles, and access to the resources of an outside (but also trusted) expert.

Chronology

Cathedral Square

1970

February	Original building of the Cathedral Church of St. Paul, of Burlington, burns.

1972

Fall	New church building completed at Cathedral Square.
1973	National Episcopal Church applies to HUD for funding of $50 million to sponsor the development of housing. Funds denied due to federal moratorium on housing subsidies.

1976

September	National Episcopal Church notified of availability of $10 million in HUD Section 202 funds; asks Church of Cathedral Square if they are still interested in sponsoring a housing development; Church accepts the offer. Cathedral Square Corporation established under the direction of James Viele; Anthony Adams AIA, of Burlington, contracted as project architect. Cathedral Square design stage begins.

1977	
January	Adams learns of the HUD SHAC Program; contacts Robert Wheeler of Yankee Solar Systems, Inc.; approaches the Corporation's Board of Directors with the idea of using solar.
February	Board and Adams agree to investigate the HUD SHAC Program. Wheeler begins development of proposal with technical assistance from the Daystar Corporation; Wheeler contacts James Brown; Brown agrees to join Adams and Wheeler on the project team.
February/March	Components selected; preliminary system design developed;
March	system design completed. Grant application drafted; submitted to HUD.
Spring	HUD awards Cathedral Square Corporation grant of $91,000. Project redesigned by Adams in order to comply with local zoning ordinance; solar system also redesigned.
Fall	Cathedral Square design stage completed; construction begins.
1978	
Summer	Installation of solar system begins.
Fall	Installation of solar system completed; solar system operationalized.
Winter	Construction of building completed.
1979	
February	Cathedral Square occupied.

CHAPTER 5: CONCLUSIONS

Introduction

This chapter reviews the propositions under investigation in this study and summarizes the study's major findings and implications regarding solar thermal acceptance and program design. The chapter is divided into two main sections. The first reviews the case studies and identifies institutional forces common to the solar thermal acceptance process. The second section presents the implications of the study for the design of future programs and measures aiming to facilitate acceptance of solar thermal technologies in the homebuilding industry.

The Major Institutional Forces

This study began by describing institutions and the institutional context in which innovation acceptance takes place. We then utilized this framework to assess the likely response of the homebuilding industry to a new energy technology like solar thermal. Finally, we considered three cases in which solar thermal was used in housing, attempting to assess the factors that contributed to the acceptance of the innovation.

Though at times this approach likely appeared somewhat abstract, perhaps overly theoretical, it is important to once again point out that the primary purpose of the study is to illustrate something that is, in essence, very simple. That is, we try to understand new things in relation to things that we already know, things we already understand. Thus, innovations are more likely to be accepted if they are connected or associated with things already accepted. In short, we connect the new to the old, use the old, the familiar, to give meaning to the new.

As explained in Chapter 1, such manipulation was possible first, because as new things innovations cannot be objectively seen and understood; it is almost definitionally impossible to fully comprehend an innovation in an objective manner. Moreover, the attributes of an innovation are not altogether fixed, intrinsic to the innovation, but instead, are developed by association and interchange with entities in the existing institutional environment. Innovations are always introduced into an existing institutional environment, a world of regularized relationships and common assumptions about behavior in different contexts. Thus, at least to some extent, an innovation can be expected to take on a meaning consistent with the context in which it is encountered. A builder, for example, seeing a technology like solar thermal always installed and associated with the HVAC trades might, upon cursory inspection, assume that it was a product having to do with plumbing or heating, perhaps, another heating system. By contrast, the technology might be taken to be something else if it was always installed by and associated with the roofing trades. In a similar vein, one might respond differently to a product or process that came highly recommended by ones most trusted colleague as opposed to one used by an individual considered "not too bright."

In short, an innovation is not evaluated on the basis of its intrinsic characteristics alone; there is almost always some middle ground, an area for malleability of its meaning. An innovation must, of course, have some minimal degree of compatability with existing institutional routines if it is even to be considered initially. However, after such initial consideration, acceptance of an innovation depends largely on the process through which it is encountered and the extent to which it acquires meaning compatible with existing institutional meanings and routines.

Understanding the existing institutional environment is of further importance in that it enables the definition of a means of mediating the uncertainties and risks involved in innovation acceptance. By connecting the innovation to existing institutional entities, and/or presenting it in institutionally supportive contexts, the innovation is given a framework within which it can be understood. In short, it become less novel, less strange.

In reviewing the major activities and events in the three case studies, it appears that this perspective on innovation acceptance has been confirmed. Though the cases differ, each involving a distinct developer type and therefore, different a priori dispositions toward the innovation, there are many common themes throughout. In spite of their varied operational modes and constraints, each developer had good reason to oppose the use of solar thermal. In each case there appears to have been limited prospects for the builder/developers to have chosen to use solar thermal on their own, that is, without the facilitating effects of institutional forces.

For example, one obvious constraint, shared by all three builder/developers was cost, in particular, the high front end cost of solar thermal equipment. In each case, this constraint was mitigated by the same factor, this being the subsidy provided by the HUD SHAC

Program. In each case, the subsidy was critical; the builder/developer would not have utilized the technology without the grant. However, for a variety of reasons, some particular to each case, but in general, owing to the uncertain status of the technology at the present time, the subsidy itself could not alter the innovation to make it adequately compatible with existing routines of the builder/developers. In other words, though the subsidy was necessary in each case, it was not sufficient to induce the builders to use the technology.

Rather, as revealed in the project analyses for each case, the decision to participate in the HUD SHAC Program, to use solar thermal, and the ability to undertake the many activities that this entailed, resulted from a variety of supporting institutional factors. As shown in each of the three cases, this was due to the workings of a wide range of individuals and organizations, who, because of their personal and professional statuses and capabilities (that is, their institutionalized roles and functions) were able to perform in a variety of supporting roles, mediating the uncertainties of the technology and generally legitimating its use. These institutional entities made solar thermal seem less risky and less new, and endowed it with a more positive status. Similarly, acceptance of the technology was facilitated by the institutional contexts in which it was encountered, that is, contexts in keeping with existing institutional meanings and routines. In short, the institutional forces made use of solar thermal seem both a worthwhile and realistic thing to do.

Facilitating Institutional Entities

The first factor common to each case is the importance of one or more facilitating institutional entities. In each instance, solar thermal was accepted because its entry was mediated by one or more significant institutional entities. For example, in the 924 West End Avenue Case the public interest organization CAN served as a linking institution, using its established organizational base together with its wide range of personal and professional affiliations to prompt solar thermal acceptance by the 924 Co-op Board. CAN's ties to prominent researchers and practicioners in the solar field coupled with its general organizational skills and work procedures, enabled the organization to identify and coordinate neded resources in an effective and timely manner throughout the case. CAN enlisted the support and assistance of two individuals, Richard Napoli and Arthur Weinstein, who, because of their personal and professional capabilities were able to serve in centrally supporting roles, the former on administrative and technical issues, the latter on housing and finance issues. As shown, Arthur Weinstein performed an altogether critical function in presenting the idea of the project to the 924 Co-op Board and in making solar thermal appear less uncertain and less risky, by contrast, a reasonably positive thing to do. Interestingly, it was through a similar process, (i.e., the mediating and legitimating effects of the experts linked by CAN, e.g., Napoli, Ehrenkrantz, Daystar and Crane) that Weinstein himself became convinced of the value of the project; though as we concluded at the end of the case, Weinstein played the part of the risk-taker i.e., the innovator, as well.

Though the names and circumstances are different in the other two cases, the importance of facilitating institutional entities is undeniable. In Burlington, there was Anthony Adams. In a manner similar to Weinstein, Adams was able to mediate and legitimate the technology for the Cathedral Square Corporation's Board of Directors. This ability derived from his personal and professional roles, for example, his expertise as an architect, his position in the local community and his membership in the Cathedral Square parish. As a consequence, solar thermal seemed like something worth investigating from the start. Like Weinstein, Adams was himself characterized as an innovator. He too was aware of the uncertainties, the personal and professional risks involved. Similarly, his final support of the project was the result of the influences and support of other individuals and organizations, notably, two trusted colleagues in the local building community, Robert Wheeler and James Brown. These three, were, in turn, supported by the Daystar Corporation who limited uncertainty regarding not only the technology but also, the HUD SHAC Program.

Project Solar for Indiana provides another variation on the theme. Here the HBAI assumed the critical legitimating, mediating and linking roles. The HBAI is the organizational focus of the state's building community and a credible and legitimate source of information for the builders. As such, it has access to experts in every aspect of the housing field and operates routinely to make links among its many resources. Thus, it is easy to understand why, at the HBAI's suggestion, solar thermal went from the category of something altogether unthinkable to something at least plausible. And in ways similar to CAN in the 924

West End case, the HBAI effectively marshalled the forces necessary to carry out the project, assembling the group of seven builders and the network of individuals and organizations (e.g., Puller, Moulder, Kennedy, Vandermeer) who were able to serve further mediating, legitimating and generally facilitating functions.

Facilitating Institutional Contexts

While we thus see how in each case a cast of individuals and organizations in institutionally facilitative roles helped to reduce the uncertainty and risk of solar thermal, in general, making it appear an attractive and worthwhile technology, it is also necessary to recognize the importance of facilitating institutional contexts. In each case, the builder/developers encountered the innovation not only through institutional entities themselves known and understandable, but also, in contexts that were known and understandable, thus engendering further mediating and legitimating effects.

For example, in the Cathedral Square Development case, Adams' ability to influence the Board resulted not only from the fact that he was highly respected, both professionally and personally, or simply from the fact that he was a member of the Cathedral Square parish. The ability was enhanced because Adams was perceived as fulfilling a routine role for the developer--conveying information about new products and techniques. The Burlington homebuilding industry routinely accepted and relied on information from such sources. Moreover, Adams was known as an innovator long before his involvement in the Cathedral Square Project. It was thus altogether in keeping with accepted routine in this institutional context for Adams to suggest the use of new product. Further, Adams was known to be concerned and committed to the development of alternative energy resources, solar energy, in particular. Thus it was in keeping with the institutional context that the new product suggested by Adams be a solar one.

Similarly, the 924 West End Avenue case is an example of routinized response to innovation and innovation prompters. Like Adams, Weinstein was known to be something of an innovator. It had been his idea to convert the building from rental to co-op, and it had been under his direction that the conversion was carried out. Thus it was altogether in keeping with the institutional context for Weinstein to initiate the idea and then serve in a supervisory role. Further, like Adams, Weinstein was known to have an interest and strong commitment to furthering the use of alternative energy resources, as well as an expertise in these areas. Thus it was altogether understandable in terms of the existing institutional context for Weinstein to be suggesting the use of new energy technology like solar thermal.

Such contextual mediation is even more apparent in the Project Solar for Indiana case. As the case analysis suggests, though the technology was different, for the seven builders involved in the project, it was, more or less, "business as usual." Most important in this regard was the introduction of the technology through the HBAI. As the focus for the state's builders and building related professionals, it is the place industry members customarily turn to hear of new developments in the field. Information about new products and practices of potential relevance to the Indiana homebuilding industry routinely flows to and through the HBAI. Builders expect to be informed of new developments in this way. Moreover, it is customary for the HBAI to sponsor group projects of this type; this is, in fact, the primary purpose of the many standing committees within the HBAI. Similarly, it is typically under the direction of individuals like Puller that such group projects, committee work, and other joint efforts are carried out. As a member of many HBAI committees, active in the organization's affairs, Puller is an individual of the type expected to lead the organization's projects. Further, the actual planning and implementation of the project was carried out in a manner consistent with the builders routines, matching the stages of the housing production process. In essence, these were not "solar houses" they were planning, but rather, "houses with solar." The only difference from totally routine development was that the HVAC product was solar thermal instead of conventional heating systems.

The Creation of Meaning for Innovation

In addition to the facilitating function of both supporting institutional entities and supportive institutional contexts, the particular meaning given to an innovation, when first presented to potential users, is also an important factor. Here too, it is apparent that existing institutional meanings were maintained in an effort to make the technology more comprehensible. In the 924 West End Avenue case, for example, Weinstein's presentation of the idea of the project to the Co-op's Board of Directors emphasized the financial aspects of the technology. Given the purpose behind the cooperative form of tenure, and the particular function of a Co-op Board of Directors, these were the aspects of the technology most compatible with the co-op's routines. Though appealing on political, environmental and philosophic grounds, the distinguishing characteristic of the technology in Weinstein's presentation was its financial appeal. In essence, solar thermal provided a means for the co-op to achieve cost savings in operation, a reduction in the co-op's annual operating budget. As explained in the project analysis, it was on this aspect that the 924 Co-op Board was finally convinced of the projects desirability, including a willingness to invest co-op resources.

In Indiana, the novelty aspects of the technology were emphasized in the initial presentation. Though a new product with environmental bonuses and potential future utility, in Indiana, solar is something so out of the ordinary that it could serve as a calling card, a means of attracting attention to subdivisions as Moulder's solar house had done. Obviously, considering the competitive conditions of local housing markets, this was a matter of importance to the builders.

In Burlington, the normative aspects of the technology were emphasized in the initial presentation. Considering the current energy situation, use of a technology like solar thermal, even in its underdeveloped state, was nothing less than the civic-minded thing to do, an effort consistent with the Corporation's normative motivations. Solar thermal was a technology that not only promised significant environmental benefits but symbolic bonuses as well. As Adams put it, "A solar array makes a public spirited type feel warm, . . . that the government is actually doing something about our energy circumstances." While is it clear that such normative aspects would have appealed to most non-profit developer types, this was particularly attractive to the Cathedral Square Corporation. After all, the motivation behind the entire project was to "better serve the community," the public good. It was in this spirit that, as Viele recalled, the Board had decided "solar was worth a try."

Caveats

While the three case studies thus clearly illustrate the less objective, "softer" dimension in the innovation acceptance process and underscore the importance of institutional forces hertofore ignored (or at least, vastly understated) it is necessary to offer certain qualifications. While it is evident that such institutional forces can and do help in the acceptance of innovation, it is important to realistically assess the potentials of such forces. One cannot conclude that innovations will invariably be accepted if they are encountered in supportive institutional contexts, conveyed by favored institutional entities or connected with existing institutional meanings. Innovation Q will not be acceptable just because trusted source M says it is a good thing and it is encountered in familiar institutional context Y. Obviously, this would be a rather simplistic interpretation. For in some cases it is clear that all the institutional support possible will not be able to make an innovation acceptable to potential users. For example, solar thermal may be technically uncertain and risky at the present time, its claims for efficiency, durability, reliability, and so on, unproven. However, one can be sure that if solar thermal proves in time, to be, in fact, inefficient, or unreliable, it will not stand a chance at gaining acceptance in the homebuilding industry. Such technical attributes are objective facts which cannot be mediated. (It is also likely, however, that if such inefficiency or unreliability are true, it would not be possible to assemble such sweeping institutional support).

Similarly, supportive institutional forces cannot overcome a lack of economic feasibility. The builder/developers in the three cases would not have utilized solar thermal had it not been for the grants from the HUD SHAC Program. In the 924 West End Avenue case, solar thermal was entirely out of the question without the grant; as Weinstein put it, it amounted to "selling the building out." Similarly, both small to medium-sized speculative builders and non-profit developers have obvious resource constraints. Neither the seven Indiana builders nor the Cathedral Square Corporation would have made the financial commitment to solar thermal without the grant from the HUD SHAC Program.

But while the HUD SHAC grant was critical in each case--in essence, it brought the technology to the middle ground, the area where the meaning of the innovation can be manipulated--it was not, as noted earlier, sufficient to induce the builder/developers to use solar thermal. As explained, the decision to participate in the HUD SHAC Program, to use solar thermal technology was the result of a range of institutional forces, the introduction of the innovation by facilitating institutional entities, in supportive institutional contexts, the connection with favored institutional meanings and routines, together with the HUD grant. The facilitating institutional factors made possible the initial consideration of solar thermal. Then, the HUD grant (itself having routine attributes in terms of entity, context and meaning) made the financial considerations possibile, in essence, making possible the means for compensating for the most blatant incompatability of the technology, i.e., product cost. Finally, the supporting networks (including the HUD financial support) made possible a continuing commitment to installation and ongoing use. In short, acceptance and adoption is a continuing process, requiring explicit positive response at each decision point. It is the result of a long chain of causes and conditioning factors, dependent on both the intrinsic characteristics of the innovation and the process through which it is encountered in the existing institutional environment.

Implications for Future Program Design

It is clearly beyond the scope of the present study to make elaborate recommendations on how solar thermal might be made a more acceptable technology to homebuilding industry members. Nor is it possible to fully address the broader dynamics relating to institutionalization of the technology in the industry overall. However, the major events in the three case studies and the experiences of the many individuals involved in these projects do present a number of common themes which have important implications for future program design efforts.

Issues with a Problematic Technology

This study confirms the view of solar thermal as a highly problematic technology, problematic in its inherent engineering and other "technical" attributes as well as in its match with major homebuilding industry routines. Both engineering and industry routine mismatch problems must be resolved before the technology is accepted in the homebuilding industry. In its present form, solar thermal is incompatible with a number of critical routines of the builder/developer; thus, there is good reason for resistance if not lack of serious interest on the builder/developer's part. Cost is likely the most serious obstacle at the present time. Quite simply, the payback period is too long, the front end cost too large. While this appears the most pressing issue, it is clearly not the only factor currently deterring the use of technology. Solar thermal is directly incompatible with industry design and aesthetic standards. It is at odds with major industry norms, most importantly, the homebuyer's traditional view of what a house should be. Moreover, as a new technology just making its introduction into the industry, solar thermal entails major uncertainties in nearly every activity in every stage in the housing production process, from preparation through distribution and service. Finally, and equally important, are the uncertainties inherent in the technology itself; basic questions about product reliability, efficiency and durability, in both design and performance, have yet to be resolved.

Based on this review, it is clear that solar thermal must resolve many substantive issues before it will be widely used in the industry. And it is clear that program efforts designed to facilitate such ends must account for both the uncertainties inherent in the technology, that is, questions of technical adequacy, as well as the instances of incompatibility with industry routines; obviously, a product that matches routines, but does not work (or entails many uncertainties and high risks in these regards) wil not be accepted. Similarly, a product that works, technically, but does not match industry routines e.g., cost, design and aesthetic considerations, among others, can be expected to meet stiff resistance.

The Innovation Introduction Process

Beyond reaffirming such substantive problems and grounds for resistance, and the general problematic nature of the technology, this review of solar thermal has, at the same time, identified several forces which facilitate the acceptance of innovation in the homebuilding industry. Central to the analysis is the view that an innovation is not likely to be accepted simply on the basis of an objective evaluation of its intrinsic characteristics. Rather, innovation acceptance is partly a function of the process in which it is introduced and encountered in the institutional environment, its connections with existing institutional entities and routines. An institutionally sensitive innovation introduction process will not compensate for blatantly incompatible intrinsic characteristics of an innovation. However, such a process can significantly enhance the acceptance of any plausible innovation. As shown in the three case studies, an institutionally sensitive process was both necessary and effective in inducing the builder/developers to use solar thermal and participate in the HUD SHAC Program. In short, presentation of an innovation though an institutionally sensitive process, can have a significant effect on the rate and extent of innovation acceptance.

Given such potentials, there appear obvious implications for enhancing the acceptability of solar thermal technologies and facilitating more widespread use in the homebuilding industry. That is, to utilize an institutionally sensitive approach(s) in conjunction with measures aimed at making the solar thermal a more plausible technology, measures, that is, that will correct or compensate for the blatant incompatibilities of the technology and bring it within the range of malleability noted earlier. In essence, the existing institutional structure would be used to its fullest advantage in order to heighten the potentialities of programs and measures addressing substantive problem areas.

Utilization of the institutional structure to its fullest advantage is, of course, a rather broad directive which may take any number of forms. However, the essential thrust of the approach is very simple; it entails an examination of the existing institutional structure, that is, an identification of the existing institutional entities, their functions, activities and roles, the relationships between and among them, the channels or mechanisms, through which they interact, the medium typically used, and so on. Who, for example, typically performs what functions, under what circumstances, to what advantage? Which entities are likely to be taken as credible information sources, in which contexts? Further, which entities are likely capable of providing support and assistance of the type needed? An examination of this sort will enable program development efforts which take the appropriate institutional forces into account--in short, forces that may be used to facilitate the acceptance of the innovation. (By the same token, forces detrimental to the acceptance of the innovation, e.g., institutional entities likely to oppose the innovation, contexts which might, for whatever reason, give the innovation a negative image, can also be identified and taken into account in program development efforts.)

For example, a more institutionally sensitive approach to the HUD SHAC Program might have tried to identify potentially facilitating organizations beforehand, and deliberately utilzed them in the program implementation strategy, if not in the design of the program itself. For example, in Indiana, even a cursory examination of the state's homebuilding community would have revealed the centrality of the HBAI, the organization's role as a reliable and credible information source, as well as its access to a wide range of resources and expertise. HUD might have targeted its approach at the HBAI more directly, rather than having the HBAI become involved in the haphazard way it did. Similarly, a review of the New York City housing market would suggest that co-ops were ideal initial accepters, and that environmental groups like CAN could be effective in project initiation and implementation. Whether or not environmental groups like CAN would be used directly in program implementation strategies, given their institutionalized roles as organizational facilitators and/or linking institutions, it would, in any event, appear advantageous for such organizations to be kept well informed of program efforts, such that they might pass on the information and perform their usual linking and facilitating functions. In a similar vein, given the role of the architect in the housing production process, the architect's institutionalized role as a conveyor of information about new products and building techniques, an institutionally sensitive program design approach would take explicit measures to ensure that architects are informed of program efforts, if not involved in a more direct way, such that they might suggest the use of solar thermal to potential users, and generally, facilitate the use of the technology.[1]

It is important to recognize that utilization of an institutionally sensitive approach can also help to prompt appropriate resolution of intrinsic characteristics that presently deter the use of the technology. For example, as the preceding examples suggest, and as shown in the three case studies, existing institutional forces can compensate for some of the uncertainties presently confronting the technology, importantly, uncertainties both real (i.e., concerning "technical matters") and symbolic (i.e., definitional uncertainties of an innovation). For example, in connecting solar thermal with an organization like the HBAI, it was possible to assemble the resources and expertise needed to actually plan and implement a solar project, while at the same time, because of the familiarity of the organization and its procedures to the builders (i.e., the HBAI's attributes of routine and stability), some of the more symbolic uncertainties were lessened.

---

[1]Why, for example, an individual like Anthony Adams, an architect with an unusually strong commitment to alternative energy resources, solar in particular, and moreover, an individual noted for awareness of new developments in the energy field, should have had to wait until he was more than three months into the design of a housing project before learning about the availability of subsidies from the HUD SHAC Program seems a bit suspicious. This one incident is not necessarily representative of the HUD SHAC program strategy as a whole. But it is clear, in any event, that had HUD been more sensitive to the institutional context of the industry, to the roles and functions of the architect in particular, HUD program efforts might have been publicized through channels of the type that Adams (and other architects) customarily rely on to learn about new developments in their field, e.g., architectural journals, periodicals, publications of the American Institute of Architects, and the like. In so bypassing the institutional structure, it is possible that HUD missed out on important program opportunities.

Further, by virtue of the organization's credibility and high standing in the homebuilding community, the technology was given a more positive image, as well as a more specific meaning compatible with the builders' institutional routines. Similarly, in the Cathedral Square case, Adams was able to serve mediating and legitimating functions by virtue of personal and professional attributes, while at the same time, by virtue of his connections to individuals like Wheeler and Brown and in turn, Wheeler's connections to the Daystar Corporation, it was possible to amass the technical skills and expertise needed to carry out the project, thus lessening the actual uncertainties and risks that use of the technology entailed.

It is important to point out that while an institutionally sensitive innovation process can thus reduce some of the uncertainties currently confronting the technology, a continued sensitivity to such institutional processes, how, for example, the innovation is being used, to what effect, by which entities, and so on, will yield useful information on emerging meaning(s) attributed to the innovation. To the extent that such meaning reveals problems with the intrinsic characteristics, either technical limitations such as engineering problems, or instances of incompatability with homebuilding industry routines, the innovation disseminators can then make possible appropriate modifications of the innovation or modifications in program strategies. If, for example, program monitoring reveals technical problems with a given solar system, a particular manufacturer, or any flaws affecting product performance, reliability or cost effectiveness, appropriate action might be taken such that these limitations do not engender negative meanings for solar thermal and further deter its use. In the 924 West End Avenue case, for example, the Daystar Corporation responded to evidence of technical complications, thus retaining a positive view of both its activities and products and solar thermal in general. By comparison, HUD, as shown, did not systematically monitor the institutional context, thus likely missing opportunities to build off its program successes in each of the three cases.[2]

Summary of Implications

Thus there are many reasons to use an institutional approach to innovation acceptance, rather than relying exclusively on measures and incentives relating to substantive issues, as exemplified in the HUD SHAC program strategy of technical development and financial subsidy. Quite simply, the traditional market approach to inducing change in the homebuilding industry does not seem to be sufficient in the case of a replacement technology of the intrinsic characteristics of solar thermal. Though an institutional approach will not overcome an

---

[2]Though the case studies are highly suggestive in these regards, the objective at this point is not to critique or even analyze the HUD SHAC Program in terms of its "institutional sensitivity" or its approach to substantive issues. For further discussion and analysis of program objectives, strategies and accomplishments, see "National Solar Heating and Cooling Demonstration Program, A Roundtable Discussion with the Solar People at HUD and ERDA," Solar Age, December 1977, pp. 9-16; Oversight Hearings before the Subcommittee on Energy, Research, Development and Demonstration, the House Committee on Science and Technology on Solar Heating and Cooling Demonstration Act of 1974, 94th Congress, 1st Session, May 13, 14, 15, 1975; and Thomas H. Stanton et al., "Clouded Progress: An Evaluation of the HUD Residential Solar Energy Program," Washington, D.C.: Housing Research Group of the Center for Study of Responsive Law, 1976.

inadequate technology, we have seen evidence that such an approach can significantly facilitate innovation acceptance, even in the face of very real engineering problems and examples of incompatability with major industry routines. Use of existing institutional forces can help to compensate for such negative intrinsic attributes of the innovation, in addition to providing leveraging potential needed to overcome the more symbolic, i.e., definitional uncertainties and resistance to innovation.

Needless to say, given the structure of the homebuilding industry, the general disposition of industry actors, and the many examples of solar thermal's mismatch with homebuilding industry routines, solar thermal technologies will not be institutionalized in the homebuilding industry overnight. Further, given the complexity of the issues involved and the number of different interests at stake, it is clear that no single piece of legislation, no single program or activity can possibly be expected to resolve the many problematic aspects of the technology. However, given the evidence provided in these three case studies, it is clear that soundly conceived strategies with institutional dimensions, that is, programmatic strategies that utilize the existing institutional structure in a sensitive and imaginative way, can do much to enhance the probability of successful introduction of solar thermal technologies.

APPENDIX

Exhibit A: Interview Schedule

[Note: Use actual name of organization instead of "your organization."]

We are first interested in understanding the role of your organization in this housing market.

1. In general, what role does your organization assume in this housing market?

2. What activities does your organization pursue in carrying out its role in the housing market?

[Note: Here pursue information on the organization viewed internally, and in relation to the overall market.]

3. What are your duties and responsibilities in the organization?

   (a) How long have you been in this position?
   (b) How long have you worked in the organization? in housing?

4. (a) How large is the organization?
   (b) How long has the organization been in existence?
   (c) What is the make-up of the staff?

We are interested in how innovations are accepted in the housing sector, and how your organization relates to that process. In particular, we would like to discuss your organization's experience with solar thermal forms of heating and cooling.

5. Can you recall when and how your organization first learned about solar thermal?

6. In what way was your organization involved with solar thermal?

[Note: Questions 7 and 8 are prompting questions. Respondent should be answering 5 and 6 in the time and sources/information-orientation mode. Use 7 and 8 to be certain ground is covered.]

7. Time-orientation

   (a) What did your organization do first?
   (b) What did you do then? and then? . . .

8. Sources/information-orientation

   (a) What sources of information did you rely on?
   (b) How did that information get to you?
   (c) What kinds of information did you get from these sources?
   (d) How important was (name each source) in making your decision?

[Note: expands on data from 8.]

9. (a) How did the actions of other organizations influence your organization's actions?
   (b) What aspects of solar thermal did your organization examine?

We have focused on the specific aspects of your organization's use of solar thermal in residential settings. Before we move on, can we briefly summarize in a somewhat broader context.

10. As you think back, then, what were the key factors in determining your organization's adoption of solar thermal?

11. Have you now made solar thermal a part of your routine activities in the housing market? (Pursue reasons for answer.)

12. Thinking about the housing market more generally, which organizations have favored solar thermal? Which opposed it? Which participated? Which did not?

13. In carrying out your organization's present role in the housing market, what other organizations do you deal with?

14. Which of those organizations would it be useful for us to see in studying acceptance of solar thermal?

   (a) Why do you think these people and/or organizations are important?

Exhibit B: Thesis Interviewees

Project Solar for Indiana:

Chaille, John. Director of Information and Education, Conservation Department, Indiana Department of Commerce, Indianapolis, Indiana.

Kennedy, Lee. Director of Sales and Marketing, The Hedback Corporation, Indianapolis, Indiana.

Kibler, Thomas. Director, Indianapolis Energy Office, Indianapolis, Indiana (formerly Director of the Indiana Energy Office).

Laycock, Thomas. President, A.H.M Graves, Inc., Builders & Developers, Indianapolis, Indiana (formerly President of the HBAI).

Moulder, Stephen. President, The Moulder Corporation, Greenwood, Indiana.

Puller, Kenneth. President, Puller Mortgage Associates, Inc., Indianapolis, Indiana.

Reilly, John. President, R&R Builders, Cumberland, Indiana.

Shure, Patricia. Designer, Hutchcraft Associates, Architects, Indianapolis, Indiana (formerly Energy Director of Puller Mortgage Associates, Inc.)

Steinkeamp, Harold. President, Steinkamp Builders, Batesville, Indiana.

Vandermeer, Albert. Director of Sales and Marketing, Davidson Industries, Indianapolis, Indiana.

Weiss, Robert. Associate Director, The Home Builders Association of Indiana, Indianapolis, Indiana.

924 West End Avenue

Hunt, Irmgard. Director, Consumer Action Now, New York, New York.

Napoli, Richard. Deputy Director of the Center for Regional Technology and the Solar Energy Application Center, Polytechnic Institute of New York, Brooklyn, New York.

Weinstein, Arthur. Attorney, New York, New York (formerly Deputy General Counsel for the New York State Energy Research and Development Administration).

<u>Cathedral Square</u>

Adams, Anthony. Anthony Adams AIA Architect, Burlington, Vermont.

Brown, James. President, Jennison Engineering, Inc., Consulting Engineers, Burlington, Vermont.

Viele, James. President, Cathedral Square Corporation, Burlington, Vermont.

Wheeler, Robert. President, Yankee Solar Systems, Inc., Burlington, Vermont.

REFERENCES

American Savings and Loan Institute. Lending Principles and Practices. Chicago: American Savings and Loan Institute Press, 1971.

Anderson, Bruce. Solar Energy: Fundamentals in Building Design. New York: McGraw-Hill, 1977.

Balcomb, Douglas. "The Department of Energy Solar Program: A Question of Balance." Solar Age (May 1978): 13-17.

Barnett, H.G. Innovation: The Basis of Cultural Change. New York: McGraw-Hill, 1953.

Barrett, David; Epstein, Peter; and Haar, Charles M. Financing the Solar Home. Lexington, MA: Lexington Books, 1977.

__________. "Home Mortgage Lending and Solar Energy." Prepared for the U.S. Department of Housing and Urban Development. Washington, D.C.: U.S. Government Printing Office, (023-000-00-387-2), February 1977.

Berger, Peter, and Luckmann, Thomas. The Social Construction of Reality. Garden City, New York: Doubleday and Company (Anchor Books), 1967.

Dietz, Albert G.H., and Cutler, Lawrence S. eds. Industrialized Building Systems for Housing. Cambridge, MA: MIT Press, 1971.

Filmer, Paul; Phillipson, Michael; Silverman, David; and Walsh, David. New Directions in Sociological Theory. London, England: MIT Press, 1973.

Foster, Howard G. Manpower in Homebuilding: A Preliminary Analysis. Philadelphia, PA: The Wharton School, University of Pennsylvania, 1974.

Frank, Allan. "Flat Plate Collector Manufacturing: Up Again, and Steadying." Solar Age (June 1978): 36-37.

Furlong, Michael, and Nutt-Powell, Thomas E. "Institutional Analysis of Research and Socialization in Housing: A Preliminary Exploration." Cambridge, MA: MIT Energy Laboratory, March 1979.

Havelock, Ronald G. ed. Planning for Innovation through Dissemination and Utilization of Knowledge. Ann Arbor, Michigan: Center for Research on Utilization of Scientific Knowledge, University of Michigan, 1970.

Landers, Stewart. "The Effects of Institutions on Innovation: The Case of Center-Pivot Irrigation." Master in City Planning Thesis, MIT, 1978.

Little, Arthur, D. Inc. "Patterns and Problems of Technical Innovation in American Industry: Report to National Science Foundation." Cambridge, MA: Arthur D. Little, Inc., September 1963.

Maisel, Sherman J., and Roulac, Stephen E. Real Estate Investment and Finance. New York: McGraw-Hill, 1976.

Mills, Daniel Quinn. Industrial Relations and Manpower in Construction. Cambridge, MA: MIT Press, 1972.

Myers, Sumner, and Marquis, Donald G. Successful Industrial Innovations: A Study of Factors Underlying Innovation in Selected Firms. Washington, D.C.: National Science Foundation, 1969.

NSF/NASA Solar Energy Panel. "An Assessment of Solar Energy as a National Energy Resource." Washington, D.C.: U.S. Government Printing Office, (NSF/RA/N-73-001), 1972.

"National Solar Heating and Cooling Demonstration Program; A Roundtable Discussion with the Solar People at HUD and ERDA." (Ronald D. Scott, ERDA, Assistant Director, Heating and Cooling; Joseph Sherman, Director, HUD Division of Energy and Building Technology; David Moore, HUD, Program Manager Solar Heating and Cooling Demonstration Program; and Fred Morse, ERDA, Chief Research and Development Branch), Solar Age (December 1977): 9-16.

Nelkin, Dorothy. The Politics of Housing Innovations: The Fate of the Civilian Industrial Technology Program. Ithaca, N.Y.: Cornell University Press, 1971.

Nutt-Powell, Thomas E., with Landers, Stewart; Nutt-Powell, Bonnie R.; and Sorrell, Levi. "Toward a Theory of Institutional Analysis." Cambridge, MA: MIT Energy Laboratory, April 1978.

Nutt-Powell, Thomas E. "Research Design for Institutional Analysis of HUD's Solar Heating and Cooling Demonstration Program." Cambridge, MA: MIT Energy Laboratory, May 1979.

Nutt-Powell, Thomas, E.; Furlong, Michael; McDaniel, Patricia; Parker, Barbara; and Reamer, Andrew. "Solar Heating and Cooling of Housing: Five Institutional Analysis Case Studies." Cambridge, MA: MIT Energy Laboratory, June 1979.

Nutt-Powell, Thomas E., and Wagner, Judith. "Solar Heating and Cooling Standard Setting: An Institutional Analysis Case Study." Cambridge, MA: MIT Energy Laboratory, August 1979.

Oversight Hearings Before the Subcommittee on Energy, Research, Development and Demonstration, House Committee on Science and Technology on Solar Heating and Cooling Demonstration Act of 1974. 94th Congress, 1st Session, May 13, 14, 15, 1975.

Reiger, Arthur J. "Marketplace Realities and Solar Economics." Washington, D.C.: Residential Solar Heating and Cooling Demonstration Program, U.S. Department of Housing and Urban Development, June 1978.

Report of the President's Committee on Urban Housing (The Kaiser Committee). A Decent Home. Washington, D.C.: U.S. Government Printing Office, 1969.

Reuyl, John S.; Harman, Willis, W.; Carlson, Richard C.; Levine, Mark D.; and Witwer, Jeffrey G. "Solar Energy in America's Future: A Preliminary Assessment." Menlo Park, California: Stanford Research Institute for the Energy Research and Development Administration, 1977.

Rogers, Everett M, and Shoemaker F. Floyd. Communication of Innovations: A Cross-Cultural Approach. New York: The Free Press, 1971.

Schoen, Richard; Hirsberg, Alan; and Weingart, Jerome. New Energy Technologies for Buildings: Institutional Problems and Solutions. Cambridge, MA: Ballinger, 1975.

Schon, Donald A. Technology and Change. New York: Delacorte Press, 1967.

Silverman, David. The Theory of Organizations. New York: Basic Books, 1971.

Stanton, Thomas H.; Gabriel, Stuart; and Maier, Peter L. "Clouded Progress: An Evaluation of the HUD Residential Solar Energy Program." Washington, D.C.: Housing Research Group of the Center for Study of Responsive Law, November 1976.

Stobaugh, Robert, and Yergin, Daniel, eds. Energy Future: Report of the Energy Project at the Harvard Business School. New York: Random House, 1979.

Sumichrast, Michael A.; Ahluwalia, Gopal, and Sheehan, Robert T. Profile of the Builder and His Industry. Washington, D.C.: National Association of Home Builders, 1979.

Swetky, Carole, and Nutt-Powell, Thomas E. "Institutional Analysis of Housing Production: A Preliminary Exploration." Cambridge, MA: MIT Energy Laboratory, March 1979.

U.S. Congress, Office of Technology Assessment. "Application of Solar Technology to Today's Energy Needs." Washington, D.C.: Office of Technology Assessment, (OTA-E-66), June 1978.

U.S. Department of Energy. "Domestic Policy Review of Solar Energy: A Response Memorandum to the President of the United States." Washington, D.C.: U.S. Department of Energy, (DOE-TID-22834), February 1979.

U.S. Department of Energy. "National Program for Solar Heating and Cooling of Buildings: Annual Report." Washington, D.C.: U.S. Department of Energy, (DOE/CS-0007), July 1978.

U.S. Department of Energy. "Solar Energy: A Status Report." Washington, D.C.: U.S. Department of Energy, (DOE/ET-0062), June 1978.

U.S. Department of Housing and Urban Development. "Solar Heating and Cooling Demonstration Projects: A Descriptive Summary of HUD Cycle 3 Solar Residential Projects." Washington, D.C.: U.S. Department of Housing and Urban Development, (HUD-PDR-230-1), 1977.

U.S. Department of Housing and Urban Development. "Residential Energy from the Sun: A Brief Description of HUD's Residential Solar Demonstration Program." Washington, D.C.: U.S. Department of Housing and Urban Development, (HUD-PDR-351), 1978.

U.S. General Accounting Office. "Solar Demonstrations on Federal Residences--Better Planning and Management Needed." Washington, D.C.: U.S. Government Printing Office, (EDM-78-53), April 1978.

U.S. National Commission on Urban Problems (The Douglas Commission). Building the American City. Washington, D.C.: U.S. Government Printing Office, 1968.

"Utility Involvement: A Roundtable Discussion." (Roger Bezdek, Department of Energy, Chief, Barriers and Incentives Branch; Ronald Doctor, member of the California Energy Commission; Alan S. Hirshberg, Principal, Booz, Allen & Hamilton; and Ajit Ratra, Washington Gas Light Company, Director of Corporate Planning, Solar Age (December 1978): 12-17.

Ventre, Francis T. "Social Control of Technological Innovation: The Regulation of Building Construction." Ph. D. dissertation, MIT, 1973.

_________. "Innovation in Residential Construction." Technology Review, vol. 82 (November 1979): 50-59.

Williams, Robert H. ed. Toward a Solar Civilization. Cambridge, MA: MIT Press, 1978.

Williams, Robin M. Jr. American Society: A Sociological Interpretation. New York: Alfred A Knopf, 1970 (3rd edition).

Zaltman, Gerald; Duncan, Robert; and Holbek, Jonny. Innovations and Organizations. New York: John Wiley and Sons, 1973.