APPLICATIONS AND CONSIDERATIONS OF SINGLE FAMILY DWELLING RESIDENTIAL SOLAR ENERGY SYSTEMS

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CHAPTER I

INTRODUCTION

Background and Justification

Consumers have always sought to blend current technology with the proven results of past technology to obtain greater savings within their limited budgets while hopefully contributing something that benefits society as a whole. One area where this may be feasible is in the use of solar energy. The average person considers solar energy as an exotic new source of energy requiring decades of further research and development before it will be practical for every day use. It has been documented that over 2,500 years ago, civilizations used solar energy to heat their homes, water, and make life more hospitable (Butti & Perlin, 1980). Throughout time, civilizations have attempted to harness the sun's energy for the same purposes we do today. Solar power, water heating, and home heating technologies have been evolving for thousands of years (Brinkworth, 1972). More recently, the energy crisis and environmental concerns of the 1970s and 1980s have renewed our interests in the area of solar energy. The emphasis in the use of solar energy has even become a national goal. In 1979, President

Carter committed the United States to a goal of meeting 20 percent of its energy needs with solar and other renewable resources by the year 2000 (Rosenblatt, 1982).

A quote by Dr. Richard Williams emphasizes the potential of solar energy: "Solar energy represents the only totally nonpolluting inexhaustible energy resource that can be utilized economically to supply Man's energy needs for all time" (Williams, 1977). Estimates based on various scientific calculations show that if we took all the world's reserves of coal, oil, and natural gas and burned them up at the same rate at which we receive the sun's energy, our whole supply would last less than three days (Lehrburger, 1976). With such a vast energy resource at our disposal, it is a wonder why we, as consumers, do not take a more active interest in the potential of solar energy in our homes. Certainly, energy costs represent a significant percentage of budgets in the average residential home. With rising energy costs and increasing pressure on household budgets, consumers and homeowners should explore the application of a technology that can possibly benefit them directly as well as reduce the amount of nonrenewable energy we consume as a nation. Alternative methods of heating and cooling residential buildings do exist. We are not necessarily locked into using the standard energy sources provided by builders. The consumer and society must make difficult decisions regarding investments in technology and the continued use of energy sources which are in short supply.

There exists a lack of awareness and knowledge of costs and benefits associated with solar energy on the part of consumers. Therefore, there is a need to educate residential homeowners and consumers on the benefits and drawbacks in the use of solar energy.

Purpose of Research

The purpose of this report is to examine the economic considerations related to the use of solar energy in family residences. Typical uses of solar energy will be described and explained to assist in developing a framework to examine costs. This report is a non-technical paper designed for basic consumer education and information. Concerns of consumer legislation, education, and protection in the field of solar energy will also be addressed. Since it is ultimately the consumer who will be affected by decisions regarding solar energy systems.

There are five objectives to this report: 1. To identify the two main categories in the use of solar energy and describe the various types of solar energy systems available to homeowners. 2. To describe a typical set-up (application) in an average residential home. 3. To discuss the economic considerations for an active solar system purchase. 4. To explain post-purchase considerations. 5. To identify future prospects for solar energy use for homeowners.

The emphasis of this report is on economic considerations. The economic feasibility of solar water and space heating has been the subject of a number of studies, which have often arrived at conflicting results (Bezdek, Hirshberg, & Babcock, 1979). Research results and other findings can help the consumer reach a decision on benefits and costs in the use of solar energy. Because continued use of nonrenewable resources will impact future generations, energy choices made in the U.S. in the near future are among the most important of any choices in its history. While the questions about energy sources may appear to be mostly economic, they are actually much broader. Concerns of air quality, health, and depletion of natural resources are just a few. They are related to the basic assessments of major priorities in our society today, as well as our attitudes towards future generations.

CHAPTER II

REVIEW OF LITERATURE

Residential Applications of Solar Energy

Most consumers lack a basic knowledge of how a solar system functions. In order to describe a basic solar system, there are some concepts which must be understood. In residential applications, solar energy is used both to generate heat and produce electricity. The more common use of solar energy is in the production of heat. Heat producing solar systems can be either passive or active. Both passive and active solar systems can be used to supply most of a home's heating (or cooling) needs, to supply part of the heating (or cooling) load, or to heat water. The distinction between passive or active systems is based on whether the system has major moving parts.

Passive solar energy systems rely on natural, non-mechanical means to collect, store, and deliver energy. These systems generally do not involve significant mechanical equipment. They typically make use of structural elements of a building to collect and store solar energy. They rely on ordinary air movement (convection) to circulate the heat. Gravity combined with a storage tank is used to heat water. This storage tank must be near and above the collectors. Commonly used components of a passive solar system include:

- large, south facing windows or glass enclosed spaces to collect heat.
- massive, heat-absorbing elements, such as brick walls or stone floors, to serve as storage.

Passive solar installations must increase the amount of solar heat admitted and decrease heat losses without affecting the input.

Active solar systems are generally more efficient and convenient (Meyer, 1986). They basically consist of the following:

- collector panels that absorb heat.
- a liquid (or air) that is passed through tubes in the panels in order to transfer the heat
- pipes or tubes through which the heated liquid or air moves to an insulated storage tank.
- pumps and pipes or fans and ducts to move heat from the collectors to storage and from storage to the rooms of the building (permit greater variation in placement of storage tanks because of the use of pumps).

Active solar water systems are either open-loop (direct) or closed-loop (indirect) types, depending on whether household water is piped directly from the collector or is heated indirectly via a heat exchanger.

The other application of solar energy is to produce electricity. To produce electricity, one can directly convert sunlight to electrical energy by means of a charge created in an array of photovoltaic cells. Currently, solar generated electricity has two somewhat limited residential applications. One is to power small electronic devices. The other is to provide power to homes in remote areas not often connected to power lines who rely heavily on expensive power from diesel generators or batteries (Meyer, 1986). Photovoltaics are generally too expensive for the average residential home that can rely on commercial sources for electrical needs. Photovoltaics are an ideal form of energy, no moving parts, non-polluting, and will last a lifetime. However, at this time, they can not compete in cost with conventional sources of energy (Corsi, 1985).

Solar System Example

Solar water heating refers to the use of solar radiation to heat water for domestic use - for showers, washing dishes, washing clothes, and so on. Solar space heating refers to the use of solar radiation to heat the building space. For technological as well as economic reasons, solar space heating systems are often designed to also provide domestic hot water, thereby combining the two heating needs (Bezdek, Hirshberg, & Babcock, 1979).

Typical systems that incorporate both functions are shown in Figures 1 and 2. These systems are general examples and not a technical discussion of how active solar systems perform.

The solar domestic hot water system (Figure 1) consists essentially of solar energy collectors, a water storage tank, a heat exchanger, a drain down tank, a circulating pump, a tempering valve, and a differential thermostat. In this example the back up system is a conventional domestic water heater using conventional sources of energy.

Whenever the temperature of the solar collectors is higher than the storage tank temperature, the differential thermostat starts the circulating pump. Water is circulated between the solar collectors and the storage tank, thereby heating the storage water. Cold city water is introduced into the storage tank, where it is heated by solar heated water. The tempering valve mixes solar heated water with cold city water, if necessary, to provide the desired water temperature. Heated water is supplied to faucets after passing through the conventional water heater and the tempering valve. However if solar heated water is not hot enough to provide the desired water temperature, the conventional water heater is turned on. Whenever solar energy is not available and the solar collector temperature is lower than the storage tank

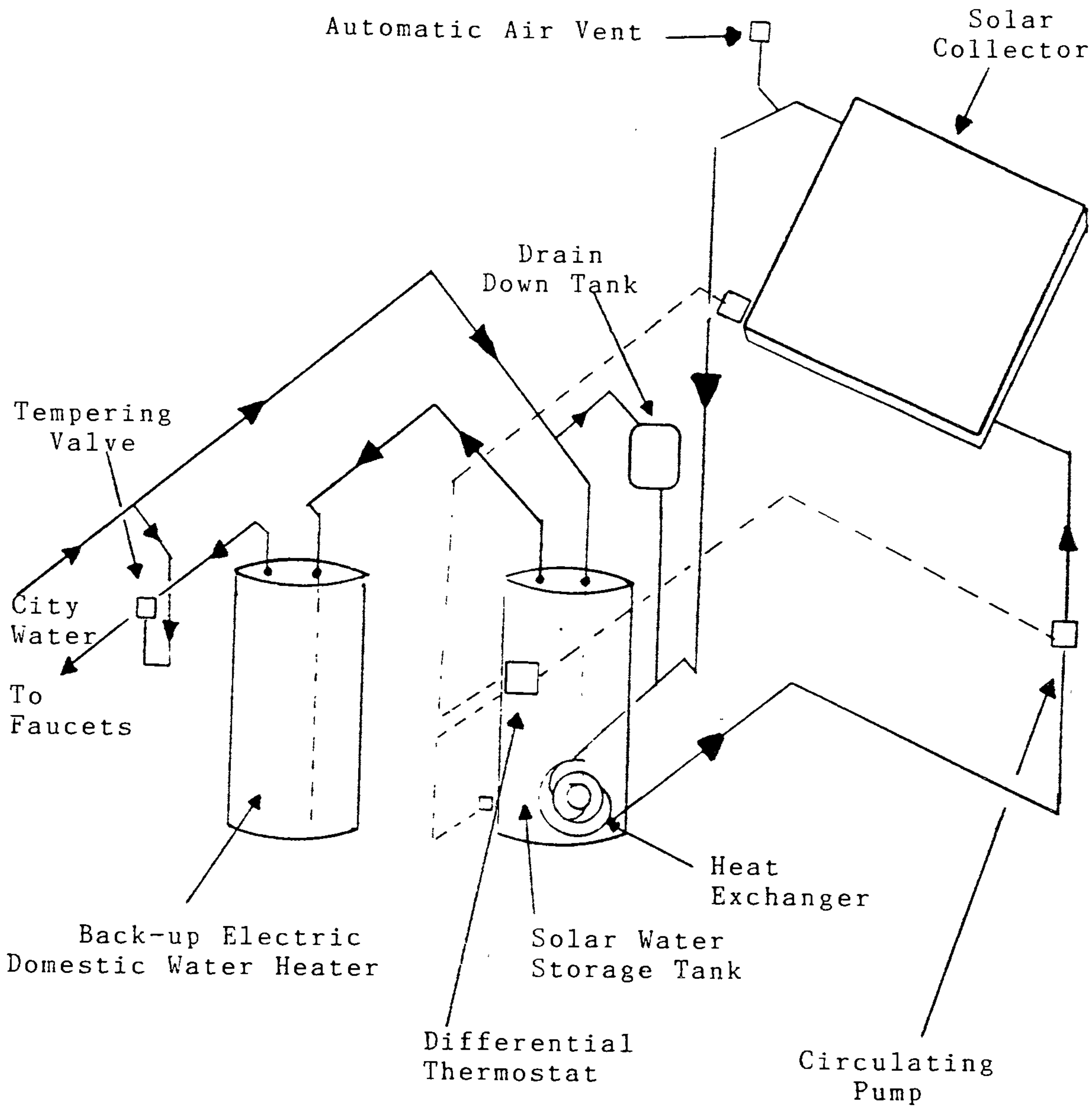

Figure 1. Example of an Active Solar Domestic Hot Water System (Adapted from Bezdek, Hirshberg, and Babcock, 1979).

temperature, the differential thermostat de-energizes the circulating pump and causes the water contained in the collectors to drain into the drain down tank, thus preventing energy losses from the collectors and freezing of components.

The combined solar water and space heating system (Figure 2) consists essentially of solar energy collectors, a water storage tank, a heat exchanger, two circulating pumps, a water heating coil, and a differential thermostat. The back up systems are a conventional domestic water heater and conventional forced-air furnance.

As in the case of the solar water heating system, whenever the temperature of the solar collectors is higher than the solar storage tank temperature, the differential thermostat energizes the solar collector loop pump, thereby heating the solar storage tank. Cold city water is introduced into the heat exchanger located in the solar storage tank, where it is heated by the solar storage tank water. Heated water is supplied to faucets after passing through a conventional water heater and a tempering valve. If the desired temperature of solar heated water is not available, the conventional water heater is energized.

Space heating is accomplished by means of a solar water heating coil located in the return airstream of the conventional furnace. Whenever the space calls for heat, the system pump is energized, causing solar heated tank water to circulate through the solar water heating coil. However,

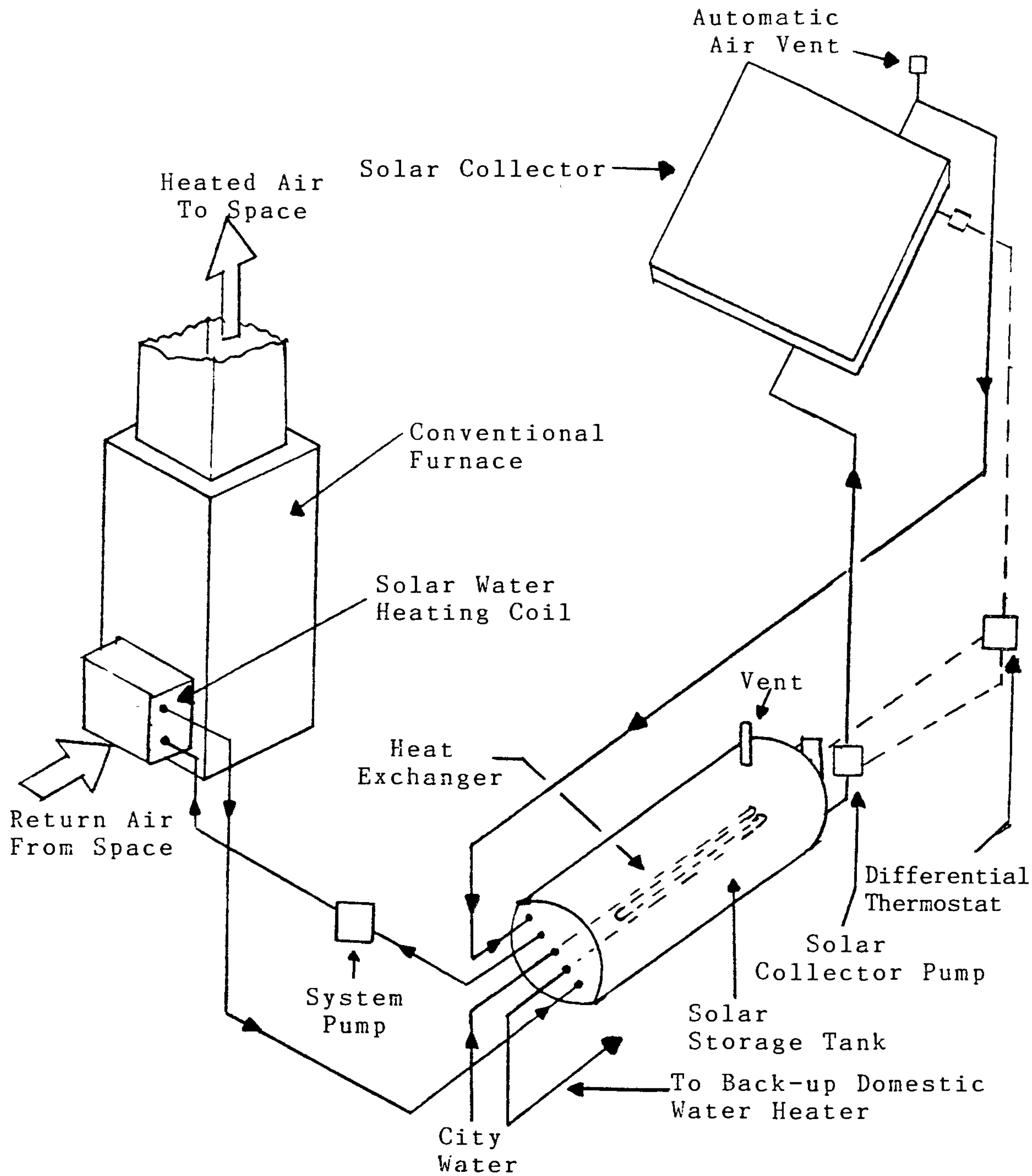

Figure 2. Example of an Active Solar Domestic Hot Water and Space Heating System (Adapted from Bezdek, Hirshberg, and Babcock, 1979).

if the space calls for heating and solar heated water is not available, the system pump is automatically de-energized and heating is provided by the conventional furnace.

Solar systems are generally not the only method of providing energy for the heating of water and space in most residential applications. Usually they assume a supplemental role. However, depending on region, climate, demand, efficiency, and other factors, they can provide up to 70 percent of the energy required for heating a residence annually (Browne, 1980). In almost all cases it is more economical to design a solar heating system to supply part of the annual heating load, not 100 percent, and provide an auxiliary heating system to supply additional energy as needed (McDaniel, 1983).

Whether building a house, remodeling, replacing an aging water heater, or just looking into the possibility of adapting to solar energy, there are many considerations the consumer must take into account.

Economic Considerations

The economic considerations in determining the use of a solar system are many. How much does it cost to purchase and install? How long will it take to pay for itself through savings in costs of other types of fuel or other heating systems? How much will it reduce utility bills? What incentives, in the form of tax credits, exist to help defray costs? What is the expected maintenance and service and their expected costs? What can be expected in terms of life span for the system? What additional factors, such as environmental concerns, must be included in making a decision about whether or not to purchase a solar energy system? These questions form the basis for a consumer to make an informed decision about solar energy systems.

Costs

The cost of a solar system can vary depending on the type and size of the system (water, space/water, etc.), the manufacturer, whether installed by a professional or by the homeowner, or other factors. The size of the system is directly related to cost and output. For roughly a 1,500 to 2,000 square foot home, most active solar water heating systems range from $2,000 to $6,000 to purchase and install (Meyer, 1986; Solar water heaters, 1984; Shama, 1981; & Anderson, 1985). Solar systems that combine both space and water heating can range from $3,000 to $15,000 to purchase and install (Solar water heaters, 1985; & Shama, 1981). In addition, systems that incorporate an active space/water system with passive measures can cost a homeowner up to $25,000 depending on whether these modifications must be made on an existing home or added to the cost of a home being built. Current costs can be affected by inflation or improvements in technology. Installation costs of an active system can be extensive if the existing home requires modification. It should be noted that it is considerably less expensive to adopt passive solar techniques than to install active solar equipment.

It is obvious that solar systems are initially expensive. Most homeowners do not have the resources to pay outright for such an expensive purchase and must rely on the use of some type of credit. Credit costs, in the form of second mortgages or consumer loans, will add to the cost of the system and must be calculated into the overall investment decision (Orsak & Younger, 1982). All solar systems require a large initial investment to realize a modest annual rate of return in terms of fuel savings. To be economical, the solar system must perform for many years, returning its initial costs plus interest over a long lifetime (Orsak, 1982; Hall & Morton, 1982).

Life-Cycle Costs

One way of examining economic feasibility is to determine the expected life-cycle cost of the system. Life-cycle costing evaluates all costs and savings of an item over its lifetime. It is perhaps the best way of analyzing solar energy systems against other heating methods (Life-cycle costing, 1986). For the consumer, life-cycle costing is an effective method for making a decision on the economic feasibility of solar energy systems. Other methods can include the net benefits method, benefit-cost method, and savings-to-investment method

(Orsak & Younger, 1982). The consumer should understand that this purchase, as an investment, should offer some type of return. How soon the consumer can expect a return on the investment in a solar energy system depends, besides tax breaks, on such factors as the price of the system, the price of conventional fuel, the efficiency of the system, the percentage of heating energy to be replaced by solar, and household demand.

Certain studies (Shama, 1981) have identified several problems with life-cycle costing methods. Such as:

- Americans move frequently. Since there is no existing resale market for solar systems, a homeowner planning to move may be concerned about being able to sell the house, since it may have to carry too high a price because of the solar system.
- Calculating energy savings and payback period, and thus using the life-cycle costing function, is very complex. It involves many variables: the system's efficiency, location, utility rates, and the homeownwers income tax bracket.
- It is hard to predict future fluctuations in the price of fossil fuels or to predict future solar incentives.

The variability of input factors must be taken into account by consumers as they estimate life-cycle costs of solar systems.

However, a method of estimating the return of a solar system is an integral part of making a purchase decision. The benefits of solar equipment can only be realized if the prospective owners compare solar and alternative systems on the basis of life-cycle costing (Orsak & Younger, 1982).

Savings

The average solar energy system is designed to provide heating for 50 to 75 percent of the household water demand. This productivity level usually yields the best return on investment.

There are numerous factors in determining an average annual amount of savings in fuel costs, such as whether the alternative method of heating is based on gas or electric. Estimates range from $200/year for solar water systems (Solar water heaters, 1984) to $500/year for active water/ space systems (Anderson, 1985). More current data would be affected by rising conventional fuel costs and improvements in system efficiency.

Tax Credits

Tax credits at the federal and state level for solar energy systems were at one time considered the principal reason, economically speaking, for the purchase of a solar energy system. These tax credits were brought into existence in the late 1970s, when Congress passed legislation titled the Energy Tax Act of 1978. The federal government perceived enough benefits in the potential of solar energy economies to encourage a program of rapid promotion. Consumers generally saw only the potential tax credit and evaluated little else. Federal tax credits, which expired in 1986, provided up to 40 percent of the system's cost. Up to $10,000 or a maximum credit of $4,000. State tax credit laws either expired, are under current extension, or still in effect, but also provided credits similar to those of the federal nature. It was not uncommon for the consumer to pay only 20 to 40 percent of the cost for their system. Much of the appeal of purchasing solar systems with the aid of tax credits has vanished with the expiration of many federal and state tax laws concerning the use of solar energy.

The intent of Congress and state agencies in giving tax credits for solar energy systems was to promote the solar industry (Seisler, 1984). Its most important advantage to consumers was the subsidizing of the relative high cost systems and to increase the cost effectiveness of a particular technology.

It is the opinion of quite a few studies and resources that without tax credits, solar systems provide little economic reason to purchase them. "Without tax credits, there would be little financial reason for installing a solar water heater" (Solar water heaters, 1984). "Tax credits offset the incentives given conventional energy sources and to create the so called 'level playing field'" (Morris, 1985). "There wouldn't be much of a solar industry without past federal aid " (Payne, 1985). The purpose of a study done by McDaniel (1983) was to analyze the effects of both federal and state income tax credits on the price competitiveness of solar energy in residential buildings. His findings were:

> Whether solar energy systems are economically competitive with conventional electric heating systems must be answered in terms of lif-cycle analysis. The longer the life cycle of the solar system, with the addition of tax credits, the more competitive. The shorter the life-cycle, the less competitive, even with tax credits.

In general, if the term of the life-cycle was 15 or more years, it greatly influenced positive worth; 10 to 15 years, impact was dependent on locale; less than 10 years, hardly any impact at all. Proctor and Tyner (1984) also studied the impact of solar legislation on the development of residential solar energy. They concluded that policy modification was needed, in essence either replace the credit, or enact other measures in addition to the credit. It was felt that reliance entirely on tax credits was not suitable for consumer acceptance nor promoting its use among homeowners. Heinze Fry (1986) added that household characteristics are almost as important as tax credits and fuel prices for the cost effectiveness of solar water heating. Overall, tax credits at the federal level are

are less relevant to the consumer at the present time. Credits at the state level may still exist and should be checked into by prospective purchasers.

Additional Factors

There are a number of other considerations in determining the feasibility of a solar energy system, such as added insurance costs on the dwelling to cover the value of the solar system. Local building codes or zoning rules may prohibit certain types of systems. Also, some states may increase the value of the residence, in effect increasing property taxes on the home. However, some states exempt a solar installation from raising the valuation of the residence (Solar water heaters, 1984).

Solar legislation affects consumers. Legal rights of solar energy users have also become an important issue (Beasley, 1986). Solar access, also known as "sunrights", of landowners is important to homeowners in certain crowded or developing areas. Maintaining the "solar easement" has been addressed in certain states legislation and is becoming an increasing part of title insurance. Rate discrimination by some utility firms is also of concern. Different rates may sometimes apply to those homeowners who use alternate sources of energy, such as solar energy. Depending on location, incentives and dis-incentives are offered by local utilities.

The direction the house faces, its design, material (type of construction), and location may render solar impractical. The family's use of hot water may exceed the capacity of solar to deliver it economically (Solar water heaters, 1985). Climate and geographical location are big factors in a solar energy decision. The farther north and cheaper your conventional fuel, the less you can expect to save with a solar system. Most studies are in agreement that solar water heating pays off best in the Southwest, Florida, Hawaii, and Southern California (Solar water heaters, 1985). A study conducted by Heinze Fry (1986) showed solar water heating only a little more competitive than did studies up to ten years ago. Projections showed solar energy heats water cheaper than electricity in 55 percent of the 69 cities studied, but cheaper than gas only in Hawaii and Arizona.

Actual energy costs, which vary from location to location, and to time of year also impact on the use of solar. Relying on back-up conventional energy during extended periods of cloudiness may decrease the effectiveness of the system. However, rising energy costs increase the value of a solar system over time (Solar water heaters, 1985). Utility rates play a significant factor in determining whether solar systems are economically desirable (Proctor & Tyner, 1984). Natural gas, while it maintains its least cost advantage, is the primary alternative to solar energy. However, because natural gas is in a state of rapid depletion, its price is expected to rise much faster than other energy sources, therefore electric might become the competing energy source (Ben-David, 1977). Ben-David also suggested that "Solar energy heating systems will become feasible when the cost of providing energy for either residential space heating or domestic hot water becomes economically competitive with alternative energy sources." With energy price decontrols or in areas which suffer natural gas curtailment, solar energy will become more feasible and possibly even more widespread.

Other studies confirm these findings as well. Hall and Morton (1982) concluded that cost/benefit analysis revealed that the optimum solar domestic hot water system represents at best marginal savings if the alternative fuel is gas. However, if the alternative fuel is electricity, solar systems are an economically attractive proposition that should be considered. The role of the price of alternative fuels is even more important with respect to solar buildings which not only compete with traditional energy sources but may also utilize these sources for auxilary supply. Krieth and West (1980) added "In many places solar heated domestic hot water systems are already competitive with electrically heated domestic hot water systems and they could compete with gas heating if the price of natural gas were to be placed at its marginal replacement value sometime in the future."

The economic considerations in determining whether to adopt solar energy are extensive. The consumer must evaluate these considerations and perhaps explore alternative decisions. Generally, active and passive solar water and space heating systems can be economically desireable if:

- electricity rates are higher than average and back up heating systems require electricity.
- alternative fuels for heating water are not available, or their prices have risen above the cost of the solar system.
- there is a suitable place to mount collectors and install storage tanks.

Studies are varied in their opinions on the economic impact of solar energy systems. Koral (1981) concluded that solar water and space heating is competitive with conventional methods and even advantageous if the initial costs of the systems and operating costs over the lifetime of the systems are compared. To the other extreme, Browne (1980) stated "I consider solar space heating through a liquid medium to be economically unsound and fundamentally flawed for efficient home use." He also concluded the homeowner should not expect a significant financial reward and only small savings will be realized over the long run. However, strong environmental and energy considerations make the move towards solar hot water highly desirable.

If the consumer has made the decision to purchase a solar system or has come to own a system through other means there are a number of issues to consider in addition to the economic considerations already mentioned.

Post Purchase Considerations

Once a system has been purchased, the consumer faces three important considerations. Installation, maintenance, and service. Installation can be performed by the homeowner who has a good working knowledge in plumbing, wiring, and carpentry. However, for the average homeowner, installation is best left to the professional. Many self-installations can void warranties. The use of a licensed contractor with local experience and with references to check on is recommended. Purchasing an existing system can avoid this trouble and offer an advantage of bypassing initial installation costs.

Maintenance can either be done by the homeowner or the contractor. Most systems will detail expected maintenance intervals. If the homeowner uses either the installer or another firm to provide maintenance, once again check on reputation. Most professional installations will offer maintenance contracts. The homeowner should confirm, in writing, all promises of services. Warranties on system parts are a common part of solar systems. Usually they offer limited and full warranties. Check on pass-on provisions or assumable warranties. Generally 5 to 10 years on major parts is the rule (Solar water heaters, 1984).

Service is another concern of the homeowner. National agencies such as the Solar Energy Industries Association

(SEIA), can recommend prospective firms for the homeowner to contact. In the past, it has not been unusual for firms to go out of business and leave the homeowner stranded. When left with an "orphan system" the homeowner can find assistance in dealing with existing problems (Best, 1986). Overall, the average consumer must consider maintenance and repair costs and add these to the expected payback period. Maintaining an efficient system is extremely important, it will add to the expected energy savings and possibly the expected life cycle of the system.

Future Prospects for Solar Energy

The future prospects for solar energy lie in the emphasis of design strategies for residential applications (Jaffe & Erley, 1982). The majority of applications in the past required adopting systems to existing homes. Both passive and active systems, to be fully efficient, required extensive modification, and therefore added costs, in their use.

Passive solar energy systems often require unconventional building design (Dubin-Bloom, 1982). Active systems require unsightly collectors and room for mechanical equipment such as large holding tanks. Integrating active as well as passive collectors and measures (such as concealment, position and axis, pitch of the roof, etc.) is known as designing a hybrid system (Jaffe & Erley, 1982). This type of system is best suited when designing a home from scratch and incorporated in the building of a new home. Their benefits can be substantial and in the long run can provide added savings. It should be noted that builders, not buyers usually make fuel decisions, and choose electric heat over gas for its low initial cost. If considering building a home, the use of solar energy should be investigated. Consumers should consult existing federal literature for recent developments in solar architecture designs.

Federal cutbacks in tax credits has curtailed the rate of expansion in the solar industry and the acceptance of solar systems by the consumer. With existing state credits in effect, the consumer may still find some type of tax advantage for their use. To date, the federal government has passed solar legislation that is limited to solar development funding. Congress provides generally for the development and demonstration of all types of solar heating and cooling, for the dissmination of information, and for certain federal assistance through mortgage loans. Beasley (1986) identified that the future trend in solar assistance to the consumer will come primarily from the individual states. Approximately 36 states have enacted some kind of solar legislation.

The technological advances made in solar energy design can change the economic equation drastically (Williams, 1977) and will probably lead to more acceptance by the consumer. Koral (1981) identified three things that are holding up the more widespread use of solar energy: 1. Most people do not know that solar energy can be converted into all the forms which we use in our daily life. 2. The equipment is not as readily available as conventional equipment. 3. The initial cost of solar equipment is higher although operating cost is very low. This study advanced the suggestion that solar energy design is still in its infancy and that advances in the field will lead to more widespread acceptance by consumers. The future certainly holds much in store and energy concerns should figure dramatically.

Solar advocates, such as Wilhelm (1980), have made many suggestions for promoting the use of solar energy in the future. Such as: legislation requiring the use of solar heating in all future construction, solar heating systems required for bank loans or special federal assistance for financing, tax breaks for builders incorporating solar systems, tax breaks to buyers (or lower interest rates), information on cost savings, government approved brands, do it your self plans, price part of all new construction and included in the mortgage, and government grants for local feasibility studies. In addition, the federal government could set minimum solar commercialization goals, requiring a certain percentage of energy needs to be met by solar technologies. State and local governments, in exchange for financial and technical assistance, would then be responsible for developing solar plans. State assistance would alleviate environmental concerns and reduce dependence on nonrenewable resources. Decisions based on purely economic reasons are not necessarily those desired by residents. It appears that more state and local interest and involvement is the key to a more succesful solar energy adoption by consumers. Studies have shown that those states that lead in solar usage, generally are more receptive in terms of state tax benefits and consumer assistance.

CHAPTER III

SUMMARY AND CONCLUSIONS

Most people put an active solar energy system in their home because they think they will save on costs and hence, money. Studies show these systems do in fact save on nonrenewable energy. Whether they actually save money, is less certain. Numerous factors affect the realization of savings. Equipment and installation costs, unless heavily subsidized, i.e., tax credits, are still too high to make the return, in the form of energy savings, attractive. Certain combinations of climate, conventional fuel prices, and tax credits however; may make solar water and space heating worth considering. There are also strong motivations other than economic ones that suggest consumers are willing to purchase solar systems. They might have environmental concerns, want to attain a degree of energy independence, or become an innovator and become the first on the block to own one. Even when consumers are faced with the higher cost of solar energy services, some of them would simply prefer them (Shama, 1981). McDaniel (1981) agreed, stating: "Solar energy can provide society with an important alternative energy source to help meet the U.S. energy requirements. It may also provide the opportunity for development and expression of values and expansion of individual choice."

Conclusions regarding active solar systems that are national in scope are difficult to reach and support for numerous reasons:

- important cost and performance factors vary among published studies.
- system performance varies with local climates, weather, and building insulation.
- the economics of solar heating systems are strongly affected by the unique thermal characteristics of each type of building.
- today's conventional fuel prices and electric rates, which determine immediate cost savings, vary across the nation and will vary during the life of the solar energy system.
- vital solar system characteristics, such as useful lifetime and operating costs, are not known with certainty.
- the specification of fuel price escalation rates has a substantial effect on economic results.
- the method of financing the solar investment varies between users.

At present, the comparatively high costs of producing solar energy restrict its spread. Similarly, the considerable expense of a domestic active solar system - and of retrofitting existing houses in particular -

militates against its widespread use. Moreover, these costs will probably diminish only over a long time span (Meyer, 1986). A system that is correctly installed and reasonably efficient can augment hot water needs economically and continue to do so even if fuel costs rise. Generally speaking, solar water heating is economically competitive with electric water heating in some regions. It does not compete favorably against fuel oil or natural gas.

The effect of rising fuel costs can alter the economics of the solar energy equation. It is estimated by 1995, with increased cost of electricity and increased development of technology, that photovoltaics will be competitive with conventional sources of electricity (Corsi, 1985). Improvements or delays in technology may make this estimate be revised. However, this will provide consumers with yet another alternative to evaluate.

In the forseeable future, solar energy will not provide all or even most of the nation's energy needs. Fossil fuels will continue to provide the majority of our energy needs simply because they are cheaper and more convenient. It is simply economically irrational not to choose the cheapest form of energy. But not all decisions, in the use of solar energy, are purely economic in nature. Consumers and society as a whole must weigh concerns of pollution, the saving of natural resources, and reliance on foreign imports in their adoption of solar energy. Solar energy is abundant, it is free, it is relatively non-polluting, and helps preserve nonrenewable fossil fuels for future use. Successful and widespread applications of solar energy for heating of buildings and water depends ultimately on consumer acceptance (Orsak & Younger, 1982). Perhaps the transition to solar energy is just beginning. A quote by Dennis Hayes suggests that this may be true.

> The entire world stands at the edge of an awesome discontinuity in its production and use of energy. The range of possible energy options is narrowed by factors other than the scarcity of certain fuels .... The growing demands of an expanding population push traditional energy systems past their carrying capacity .... Thus the world has begun another great energy transition. In the past, such transformations have always produced far-reaching social change. For example, the substitution of coal for wood and wind in Europe accelerated and refashioned the Industrial Revolution (No nukes, 1982).

Alternatives exist for consumers. Techniques that may lower energy bills are through conservation methods. Such as improved building design and adoption of passive solar energy measures. Studies agree, Feldman and Wirtshafter (1980) stated: "Investments in active solar energy systems do not appear to be economical compared to either passive solar energy or energy conservation."

Consumers must also realize that the current system which supplies homeowners with heating methods is not entirely supportive. We are set up to use natural gas, electric, coal, etc., but not necessarly solar. The means to adopt solar may require going against the norm in regards to heating homes and water.

The consumer must make the final decision regarding the use of solar energy. "The decision as to what type of energy source should be utilized must, in each case, be made on the basis of economic, environmental, and safety considerations" (Williams, 1977).

Two outcomes face the use of solar energy. Waiting until the consumer accepts solar energy based on a market change in the economic competitiveness of solar energy, or from a realization of the noneconomic benefits of solar energy. The effect of these individual decisions might be to eliminate a potential industry that collectively would be deemed desirable by society. Whatever the decision by the consumer on the acceptance of a solar energy system in a residential application, either for economic or social reasons, solar energy is part of the future. The variables are numerous, but solar energy can work to our advantage. We should all take a closer look at this potential energy source and make a decision on its present or future use in our lifestyles.

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