TECHNICAL
REPORT

TEXAS REAL ESTATE
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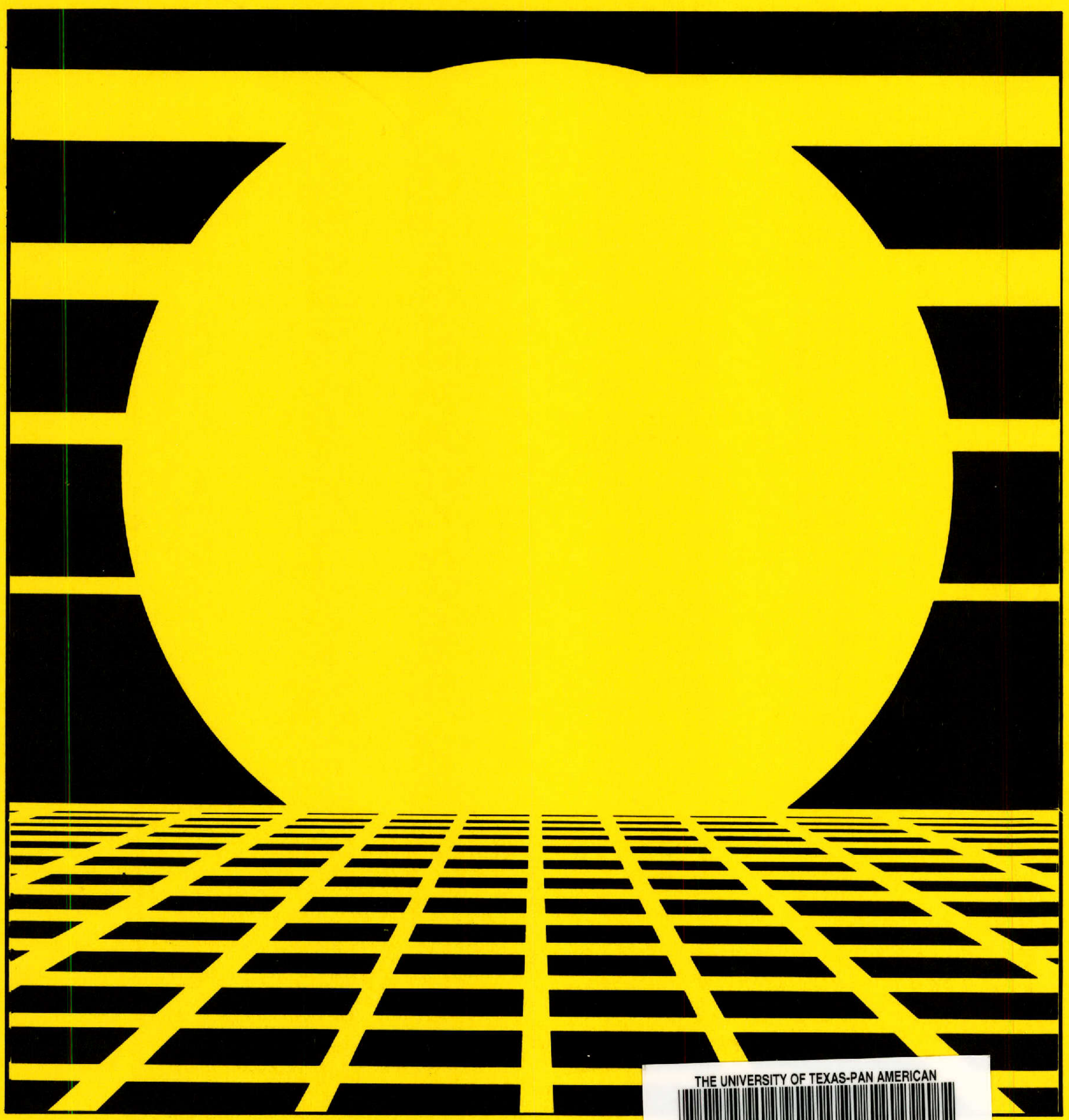
Considering the Solar Alternative



CONSIDERING THE SOLAR ALTERNATIVE

by

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Considering the Solar Alternative

I. INTRODUCTION

Solar Energy as a Viable Alternative for Domestic Use

In 1973 energy prices began to rise rapidly. Oil which cost $3.50 a barrel in 1973 was more than $30 in 1982. Similar price increases have occurred in other fuels. Many are concerned about the United States' increased dependence on other countries for basic fuels as well as the inflationary pressures exerted by rapidly rising energy prices.

One hope is that new technology will help to reduce future reliance on traditional energy sources. Sources such as coal gasification, coal liquidfication, shale oil extraction, nuclear breeder reactors, nuclear fusion and various forms of solar driven systems are presently being researched. Many of the sources are already technically feasible but are yet too costly to compete with established fuel sources.

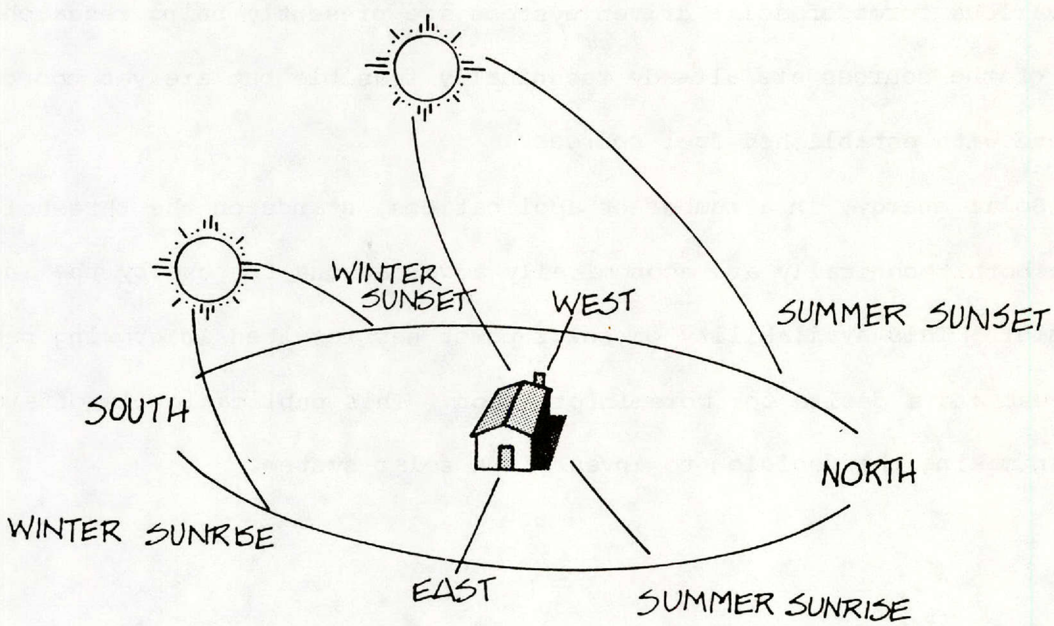
Solar energy, in a number of applications, stands on the threshold of being both technically and economically advantageous for use by the individual consumer. This availability of solar power has resulted in growing public interest and a desire for more information. This publication is offered as an aid in making the decision to invest in a solar system.

History of Solar Energy Application

Solar energy is not a new discovery. Excavations of ancient Greek cities indicate periods when the use of solar energy flourished. Entire cities have been found that were planned for solar access. These early Greeks were also the first to use solar powered weapons--called "burning mirrors"--to destroy Roman ships.

Solar energy use in America can be traced back as early as the 11th Century. Examples may be viewed today at Longhouse Pueblo, Mesa Verde, Colorado and Acoma Pueblo, New Mexico. Dwellings were designed and oriented to prevent the higher summer sun from penetrating into the structure. In the winter, the lower sun angle allowed the sun to penetrate into the dwelling and warm the home. The figure below illustrates this effect.

Sun Angles



Source: Citizens' Solar Guide, Texas Energy and Natural Resources Advisory Council, Austin.

In addition the thick adobe walls of the dwelling served as a passive collection and storage unit or what we might refer to today as an "indirect gain" system.

It was not until the 16th Century that the use of glass windows for trapping heat became widespread. The first applications were greenhouses for exotic plants brought from Asia, Africa and the new world. These small greenhouses eventually evolved into the lavish conservatories of the upper class. Use of greenhouses slowly filtered down to the middle class but on a smaller scale. A common sight was a window garden on the south side of a building and roof top greenhouses on multi-storied buildings.

In the 1800's Pasteur's germ theory of disease focused attention on the need for frequent hot water bathing. This concern resulted in an increased demand for hot water. Heating water at this time was a laborious and time consuming task. The majority of the people relied on wood, gas or coal stoves to accomplish this task. The development of solar hot water heaters led to an easier, safer and cheaper means of obtaining hot water.

The early solar water heaters were simply metal water tanks painted black and placed in the sun. These early heaters took all day to heat the water and once the sun went down the uninsulated tanks rapidly lost heat. Clarence Kemp, a Baltimore inventor, patented in 1891 a way to increase the tanks' ability to collect and retain heat. He combined the practice of exposing the bare metal tanks to the sun with the scientific principle of the hot box. Additional improvements in 1909 resulted in the Day and Night Solar Water Heater. This device supplied hot water not only while the sun was shining but for hours after dark and the following morning. This system consisted of an insulated storage tank and a separate collector.

In the early 1930's and 40's solar domestic hot water heating units were a common sight in Florida, Arizona and Southern California. Additionally, in the 1940's and early 1950's, solar homes were built in several areas of the country. The heating systems of these homes were based on an expanded version of the solar domestic hot water technology of the 1940's. As a result of errors in design and installation most of these homes were later converted to conventional systems.

The interest and excitement about solar energy in the early 50's led the Truman administration to predict that by 1975 there would be 13 million operating solar units in the United States. These units would satisfy 10 percent of the nation's overall energy needs. Such a solar boom never materialized. Rather, solar use declined in the late 1950's, due to abundant supplies of cheap natural gas and electricity.

Attention and interest in solar energy at this point turned to producing electricity directly from the sun. Bell Labs announced in 1954 the discovery of a photovoltaic cell which turned sunlight into electric current. Research in solar cells expanded as a result of their application in the growing space program.

Widespread concern over the "energy crisis" following the 1973 oil embargo has resulted in renewed interest in solar applications. Approximately $2 billion has been invested by the federal government since 1975 in research and development on renewable energy resources. Current research and development has had a strong emphasis on domestic uses of solar energy. State governments and private industry have also joined in this effort to increase solar application. As a result many solar oriented companies are presently operating across the nation. Texas is no exception, almost every major city in Texas presently has several solar equipment manufacturers and a growing list of installers and designers.

Primary Applications

Domestic applications of solar energy are rapidly developing. The most currently accessible uses are space and water heating using active solar systems. An active system exposes water or air to sunlight and pumps it to a distribution and storage system. Systems are available to provide hot water only or to supply general heating needs within the house.

Of growing importance is the application of passive systems. Actually, a passive system is a collection of design features built into the structure to maximize the benefits of natural heating and ventilation. Since these features must be built into the structure, they are most applicable to newly constructed houses, whereas active systems may be readily added, or "retrofitted," to a conventional house. (An excellent presentation of the various types of solar systems is contained in the Citizens' Solar Guide available from the Texas Energy and Natural Resources Advisory Council, 200 East 18th St., Room 509, Austin, TX 78701).

Research and development may some day produce practical methods for solar cooling and electric generation. Further design break-throughs and production economies are needed to attain this objective. This report concentrates on active systems available in the current market and the economic feasibility of their application. The great variety of passive solar designs makes any generalizable analysis impractical.

II. APPLICATION FEASIBILITY

The feasibility of a solar system in a specific application depends on many variables. The user may have direct control over some of these factors such as orientation to the sun, and type and scale of construction. Other variables such as cost of conventional fuels, tax credits, available financing cost and solar access are generally beyond the control of the user.

This report is designed to give an overall and general view of these and several other variables which will have a direct impact on solar use feasibility. Also contained within this report is an analysis of the financial feasibility of several different types of solar use applications. The analysis also involves a comparison for different conventional fuel types and projected solar system efficiency ratings.

A brief look at solar access laws is also included. Assured solar access is very important to solar use because of the need for a continuous supply of sunlight.

Installation Requirements and Costs

The economic attractiveness of the installation of a solar unit within a home varies with a number of factors. Among these are:

Orientation: The structure or collectors should be designed on an east-west axis, to facilitate the most effective collection of solar energy.

Site location: The effectiveness of solar heating units varies for different areas of the country. Some areas of the country have so little sunlight that only 40% of the heating needs may be provided by the most efficient solar system. Other areas have enough sun to provide 80% of heating needs.

Access & Sunlight: The sunshine available at the building site must be abundant. Surrounding vegetation and buildings must not obstruct solar access. Ideally, the possibility that future building will obstruct sunlight should be precluded.

Type of Construction: Solar systems may be built into existing buildings as well as new construction. In new construction all types of energy efficient techniques can be utilized in the design. In a retrofit, the techniques which may be adopted are somewhat limited.

Type and Scale of System: The system may be an active or passive type. Scale of the system determines the percentage of heating requirements provided by the system. This will directly influence energy savings to be recovered. Presently the majority of solar homes are designed to derive 50-80% of required energy from the sun. One hundred percent of the energy needed to warm a home may be provided by a solar system. However the cost of the additional collector area and storage capacity is often unreasonable.

Type and Cost of Conventional Fuels: Key variables in computing benefits of a solar system are the current prices of natural gas and electricity and their expected growth rates. In nearly all parts of the country it can be shown that over a number of years solar energy heating systems are less expensive than electricity but more expensive than gas or oil. A continual rise in conventional energy prices may increase the attractiveness of solar systems.

Retrofit of a Home for Solar Application

Retrofitting a home for solar use is the addition of solar heating, cooling or water heating equipment to an existing structure. The addition may be used to assist or to replace the original heating system.

When considering a solar retrofit it may be found that several existing design elements of the building are not compatible with solar use. These design elements are the shape of the structure, the site, the structure's orientation on the lot and the materials used in the construction. Short of reconstruction substantial alteration of these elements is not possible. Consequently, the retrofit design must take these factors into consideration and be directed toward aesthetic and effective placement of collectors.

There is a direct relationship between heat loss from a structure and the collector space needed to heat a home. Therefore, insulation is a key element in a retrofit design. An Energy Department slogan states "It is better to insulate before you insolate."

<u>Retrofit of Passive Indirect Gain System</u>. Thermal storage walls are easily added to the south wall of a structure. This wall needs a clear southern exposure to function effectively.

An attached greenhouse may be added to an existing structure without much difficulty. The greenhouse also needs a clear southern exposure.

<u>Retrofit of Active System</u>. The simplest and presently most popular retrofit is the addition of a solar domestic hot water heater. The amount of collector area needed is relatively small. To supply 75 percent to 85 percent of the annual hot water needs by solar, 15 sq.ft. of collector panel per person is required. Modest adjustments must be made in the structure's plumbing to accommodate the solar heater. The solar hot water storage tank must be placed in line ahead of the existing conventional water heater tank.

The addition of an active solar space heating unit is possible without substantial modifications if the existing structure has a forced air central heating unit. The solar heating system can work in conjunction with the traditional unit and use the same air ducts. A general rule of thumb is that one half the square footage of the area to be heated is needed in collector space.

Cost of Solar Energy Systems

In a 1976 HUD demonstration program, the price range for combined heating and hot water systems for single-family dwellings ranged in cost form $5,000 to $19,000. The cost for domestic hot water only range from about $1,500 to $2,500. Price quotes on collectors gathered from Texas Solar Constractors and Designers range from $15 to $30 per sq.ft. not installed, to $60 to $100 per square ft. including installation costs.

The purchase of a solar energy system reduces future expenditures on energy. Accordingly a solar energy system will prove less expensive than conventional systems if the present value of fuel savings over the life of the system is greater than the initial investment in solar equipment.

Thus the current price for fuel and the expected growth rates are key variables in predicting solar benefits. It is difficult, however, to accurately predict future fuel costs. Later in this section, the feasibility of solar systems will be tested under varying assumptions of future energy costs.

Life Expectancy and Obsolescence

The life expectancy of solar systems is generally longer than that of conventional equipment. Active systems have a life expectancy of approximately twenty years. Passive systems life expectancy is equal to that of the home itself.

A significant barrier to widespread solar use is fear of obsolescence due to technological advances. Solar is often viewed as a new technology, something that is still in its early development stages. Potential users hesitate to invest from fear of a major technological breakthrough which would severely reduce the value of their investment. This possibility exists in all investments of a technological or mechanical nature.

In the field of solar energy for space heating and domestic water heating this is not a potentially serious problem. Changes which will likely result in these systems will be minor improvements rather than basic advancements. More efficient absorption techniques will be applied and better insulation materials will be used. These and other techniques aimed at increasing efficiency should not result in system obsolescence.

Auxiliary Heating Requirements

One hundred percent of the energy needed to warm a home may be provided by a solar heating system. However, the majority of existing solar homes are designed to derive only 50-80 percent of their energy requirements from the sun. This is a direct result of the additional spatial needs and accelerating costs of the collector space and storage capacity required to supply over 80 percent of a structure's heating requirements.

Auxiliary heating units of various types are integrated into the original solar plan to complete the energy demand requirements. System efficiency can be increased by integrating the system with shared components of a traditional heating unit. Building codes in many states may require residential structures to be equipped with heaters capable of warming habitable rooms to specified temperatures. Therefore, in most applications, a conventional back-up system is required.

Government Solar Installation Incentives

Various incentives are offered to consumers to stimulate investments in solar energy systems through tax breaks aimed at reducing the cost of installation. Primary among those being offered are income tax credits and property tax exemptions. Incentive programs vary considerably from state to state. A 1978 state incentive inventory showed:

25 states have property tax exemptions

14 states have income tax credits

7 states have both

4 states exempted solar purchases from state sales taxes

3 states give refunds on sales taxes

3 states have a solar loan program for certain institutions

In addition, the federal government offers an income tax credit for use of renewable resource technology.

Texas Constitutional Amendment

The Constitution of the State of Texas was amended in 1978 to exempt solar and wind systems from all Texas taxation.

Texas Property Taxes

As a result of the constitutional amendment, and associated laws and guidelines that became effective on January 1, 1980, a tax assessor is prohibited from considering in his assessment of property value the value of any solar energy device installed or constructed on the assessed property. Guidelines were developed by the Texas Energy and Natural Resources Advisory Council for use by assessors in determining which devices qualify for exemptions. Systems to be exempted are active and passive solar energy systems, wind systems, geothermal and biomass installations whether residential, commercial, industrial or agricultural.

Texas Sales and Use Tax Exemptions

In March of 1979 a state statute became effective which exempted solar energy devices from all state and local sales taxes. This exempts all taxes on sales, lease, rental or use for such systems.

Devices defined as solar are systems involved in the heating of water and the heating and cooling of structures by solar collectors, heat pumps which are a part of an integral system designed to make the best combined use of solar energy and conventional heating, and photovoltaic systems.

Additional information concerning Texas Tax exemptions can be found in a booklet published by the Texas Comptroller's office, Texas Renewable Energy - Texas Tax Free. Included within the booklet is a through examination of this law and the guidelines associated with it. Call 1-800-252-5555 for a copy.

Federal Income Tax Credit.

Forty percent of the total cost of a residential solar system, up to a maximum of $4,000, may be taken as a credit on federal income taxes. Labor costs for on site preparation and assembly or installation of equipment are included in the credit.

New and existing residences are eligible for this credit if the system is installed after April 19, 1977. Additional restrictions on eligibility of a system are that it must be expected to last five years and must meet certain performance and quality standards set by the Secretary of the Treasury.

Credits are given for solar energy equipment which may be used for heating or cooling the home, for providing hot water, and/or for electricity use within the home. Active systems and some elements of passive design will qualify. For detailed information on a system's eligibility, contact the Internal Revenue Advisory Service at 1-800-492-4830. Note: this credit expires on December 31, 1985.

Financing Solar Applications

Conventional financing for solar applications has been hampered in the past due to the perception among lenders that solar housing is experimental and untried. Lenders have had concerns about the vulnerability of such houses to technological obsolescense and the possibility that the systems will prove impractical. In addition, the effect of solar equipment on market value is unclear.

The emerging economic feasibility of solar usage is changing the attitudes of private lenders, however. The vice president of a commercial bank in Cleveland, Ohio states:

> It is clear that rising costs of other energy sources impels me to learn more about what solar can do and how to evaluate the various ways in which it can be incorporated into a structure.

As lenders learn more of solar system benefits, loan opportunities will be enhanced, much as the condominium concept had to become familiar before loans became widely available.

One practice which may prove favorable to solar system loan applications is the inclusion of energy costs in loan qualifying calculations. Thus, the energy saving potential of solar systems reflected in the calculation of principal, interest, taxes and insurance may help applicants qualify for the higher loan amounts necessary to install solar equipment.

Solar Access

As solar energy systems become more popular, the potential is increased for conflicts among property owners over access to sunlight. At typical urban building densities, solar collectors are vulnerable to being isolated from a continuous supply of sunlight by surrounding buildings and vegetation. Therefore, interest exists in legal protection for solar access.

Thousands of collectors have been installed in the United States without the benefit of access laws. The Solar Energy Intelligence report estimated that there were 40,000 solar buildings in the United States in 1978. Legal conflicts have been avoided by careful placement of collectors. The Department of Energy has predicted there will be 2.5 million solar buildings by 1985. Such an increase in the number of solar applications would create difficulties in assuring access and undoubtedly increase conflicts which arise as a result of the shading of collectors.

The following is a brief description of several means of protecting solar access now in use in some parts of the country.

Solar Energy Zoning

The primary effect of solar envelope zoning is to create an area of air space over a landowner's property which may not be encroached. This space in effect creates a solar envelope that defines the largest possible structure which can be constructed on a piece of land without shading neighborhood properties during specified sun times. The solar envelopes are created by height and width limitations established by the use of a map of the changing daily and seasonal positions of the sun. The shape of the envelope may vary over different portions of the lot. The size of the solar envelope would vary with the size, shape, slope and orientation of the lot.

Solar Easements

Easements are defined as the right of a specific nonowner, a neighbor, government or the general public to use part of a parcel of land in a particular way. A solar easement describes the solar space or airspace through which the passage of sunlight may not be obstructed, thus describing to the property owner granting the easement the ceiling above which he may not build or let trees grow. Easements are created by contractural agreements among landowners.

Solar Covenants

A frequent practice of subdivision developers is to impose land use restrictions on developed lots as a means of assuring buyers of the quality of surrounding development. These restrictions take the form of a covenant, which is a written promise, agreement or restriction found in the deed.

Covenants to protect solar access work much like solar access easements. Covenants are used to assure homeowners that buildings, fences and /or trees from adjacent property will not be allowed to cast shadows on solar systems during critical sun hours of the day.

Financial Feasibility

To determine if owning a solar system is more cost effective than owning a conventional system, the differences in each system's costs must be analyzed. This feasibility analysis is frequently referred to as life cycle analysis. In a life cycle analysis a comparison is made of the initial purchase and operating costs of a solar system to the purchase and operating costs of a conventional system over some time frame. Only after comparing all the initial and future costs and benefits of each system can a decision be made regarding the feasibility of a proposed solar investment. Generally, as long as the life cycle benefits of a solar system exceed the life cycle costs over the analysis period, the investment will be determined feasible in terms of direct monetary gain to the investor. Life Cycle Cost depends on:

1. Initial construction costs.
2. Maintenance costs.
3. Interest payments on loan taken out to pay for system (or the opportunity cost of invested cash).
4. Possible property tax or other tax increase because of the addition of the system.
5. Federal and state use incentives.

Life Cycle Benefits depend on:

1. Amount of energy expected to be saved over the useful life of the system.
2. Current price of conventional energy.
3. Expected growth rate in the costs of conventional energy.

Feasibility Analysis

The following is a feasibility analysis of adding a solar energy system to a 1300 sq. ft. Texas home. The feasibility of adding solely domestic hot water, active space heating or combined water and space heating shall be examined. For each solar alternative the feasibility will be compared to using a conventional all electric house and combined gas/electric house.

Assumptions for this analysis are:

1. 1300 sq. ft. home that is very well insulated and has double pane windows.
2. Retrofit application
3. The home is located in Texas where it can expect to receive sufficient solar energy to provide a large portion of heating needs.
4. The expected life of the solar system is 20 years with zero salvage value.
5. Annual maintenance costs are $100 (in constant dollars).
6. All analysis is done in terms of real dollars. The rate of inflation is set at 0 and all growth and discount rates are adjusted relative

to the inflation rate. (Thus a growth rate of 5 percent means 5 points above the inflation rate.)

The feasibility of each alternative is analyzed in terms of its net present value after 20 years of use.

The net present value (NPV) is the most complete and accurate method of determining investment feasibility. The NPV is the sum of all costs and benefits discounted to reflect the time value of money. A NPV equal to zero means that benefits equal costs; also the investment return is equal to the discount rate.

Acceptance criterion for net present value is determined by whether or not the NPV is equal to or greater than zero. A positive NPV indicates the investment will yield a return greater than the user's required discount rate. Profitability Index (PI) of a project is the present value of future net cash flows divided by the initial cost of the investment. PI provides an idea of the relative magnitude of net benefit or cost. If the PI is greater than or equal to one, the proposed investment is acceptable. The greater the value of PI, the higher will be the investment yield relative to the user's discount rate.

Inputs to the analysis are:

1. Cost of system, which is determined by type and efficiency of system.
2. Percent of utility bill to be saved by installation of solar system.
3. Average current monthly utility bill which is determined by type of conventional system.
4. The expected annual growth rate of the utility bill in real terms.

In this analysis, separate runs are made for 0, 2 and 5 percent growth rates.

5. User's discount rate in real terms. This is the discount rate that reflects the costs of the money invested in solar equipment, either the interest income lost or cost of borrowed funds. Discount rates applied are -2%, 0% and 2%.

6. Type of System - Space Heating
Domestic Water
Combined System

Space Heating Only. Table 4 presents the feasibility of solar space heating for various applications and under varying assumptions.

Table 4

Solar Space Heating System

System	Conventional System	Expected Utility Growth	PI at Discount Rate -2%	0%	2%
High Efficiency	Electric	0	3.3	2.6	2.2
		2	4.3	3.4	2.8
		5	6.5	5.0	4.0
	Gas	0	2.0	1.6	1.3
		2	2.8	2.2	1.8
		5	4.6	3.5	2.8
Low Efficiency	Electric	0	0.7	0.6	0.5
		2	1.1	0.9	0.7
		5	2.0	1.5	1.2
	Gas	0	0.1	0.1	0.1
		2	0.4	0.3	0.2
		5	1.1	0.8	0.6

The high efficiency system is a feasible investment under all assumptions for all users. The extra expense (approximately 40 percent) of the higher efficiency appears worthwhile for these systems. The low efficiency system proves feasible only when utility costs are expected to increase substantially.

<u>Water Heating Only.</u> See Table 5

Table 5

Solar Water Heating System

System	Conventional System	Expected Utility Growth	PI at Discount Rate -2%	0%	2%
High Efficiency	Electric	0	0.6	0.5	0.4
		2	1.3	1.0	0.7
		5	2.6	2.0	1.5
	Gas	0	-1.0	-0.8	-0.7
		2	-0.8	-0.7	-0.6
		5	-0.4	-0.4	-0.3
Low Efficiency	Electric	0	-0.4	-0.3	-0.2
		2	0.5	0.3	0.2
		5	2.3	1.7	1.2
	Gas	0	-2.5	-2.8	-1.6
		2	-2.2	-1.8	-1.5
		5	-1.6	-1.3	-1.1

Under the assumptions used in this analysis, solar water heating systems are feasible investments only in comparison to electric hot water heating and only for high rates of utility cost growth. This result is due to the small proportion of utility cost savings (6-10%) achieved by use of the solar system.

<u>Water and Space Heating</u>. See Table 6

Table 6

Solar Space and Water Heating System

System	Conventional System	Expected Utility Growth	PI at Discount Rate -2%	0%	2%
High Efficiency	Electric	0	1.3	1.0	0.9
		2	1.7	1.4	1.1
		5	2.7	2.0	1.6
	Gas	0	1.0	0.1	0.1
		2	0.3	0.2	0.2
		5	0.6	0.5	0.4
Low Efficiency	Electric	0	1.5	1.2	0.9
		2	2.0	1.6	1.3
		5	3.3	2.6	2.0
	Gas	0	-0.1	-0.1	-0.1
		2	0.1	0.1	0.1
		5	0.6	0.4	0.3

The combined solar system is feasible when compared to all electric systems but not to gas systems. The currently favorable costs of gas heating makes it the best alternative even at rapidly rising prices.

<u>Conclusion</u>.

From the investment feasibility analysis, it appears the use of an active solar system for heating purposes in central Texas is cost effective only under certain circumstances. Specifically:

- High efficiency space heating systems are feasible under all circumstances while low efficiency systems require the assumption of rapid increases in the cost of conventional energy.
- Solar hot water heaters are only feasible as an alternative to electric hot water heating and only under the assumption of rapidly increasing electricity costs.
- Combination space and water heating systems are feasible only as an alternative to all-electric conventional systems.

These conclusions are based on representative installation costs and utility bill experiences. To test the feasibility of a particular system, the following rule may be used. Any system is feasible if after tax installation costs are less than the net annual savings multiplied by an annuity factor. Annuity factors at selected interest rates may be found in the following table.

Expected Life of System in Years

Nominal Opportunity Cost		10	15	20	25	30
	6%	7.36	9.71	11.47	12.78	13.76
	8%	6.71	8.56	9.82	10.67	11.26
	10%	6.14	7.61	8.51	9.08	9.43
	12%	5.65	6.81	7.47	7.84	8.06
	14%	5.22	6.14	6.62	6.87	7.00
	16%	4.83	5.58	5.98	6.10	6.18

The limited fesibility of solar heating systems is due primarily to the relatively small proportion of the total energy bill associated with heating in central Texas homes. The development of solar cooling systems promises a much greater potential for energy savings in Texas. In addition, incorporation of passive solar elements in new home construction could significantly impact air conditioning costs and prove extremely effective in this climate. As these developments progress, solar applications should become more common in Texas.