LOW-INTEREST LOANS FOR RESIDENTIAL SOLAR HEATING AND COOLING EQUIPMENT

HEARING

BEFORE THE

SUBCOMMITTEE ON HOUSING AND COMMUNITY DEVELOPMENT

OF THE

COMMITTEE ON BANKING, CURRENCY AND HOUSING HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

FIRST SESSION

ON

H.R. 3849

A BILL TO ESTABLISH IN THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT A DIRECT LOW-INTEREST LOAN PROGRAM TO ASSIST HOMEOWNERS AND BUILDERS IN PURCHASING AND INSTALLING SOLAR HEATING (OR COMBINED SOLAR HEATING AND COOLING) EQUIPMENT

H.R. 8524

A BILL TO AMEND THE SMALL BUSINESS ACT TO ESTABLISH WITHIN THE SMALL BUSINESS ADMINISTRATION A NEW DIRECT LOW-INTEREST LOAN PROGRAM TO ASSIST HOMEOWNERS AND BUILDERS IN PURCHASING AND INSTALLING SOLAR HEATING (OR COMBINED SOLAR HEATING AND COOLING) EQUIPMENT

NOVEMBER 5, 1975

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LOW-INTEREST LOANS FOR RESIDENTIAL SOLAR HEATING AND COOLING EQUIPMENT

WEDNESDAY, NOVEMBER 5, 1975

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON HOUSING AND
COMMUNITY DEVELOPMENT,
COMMITTEE ON BANKING, CURRENCY AND HOUSING,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:10 a.m. in room 2128, Rayburn House Office Building, William S. Moorhead presiding.

Present: Representatives Moorhead, St Germain, Boggs, Spellman, Rousselot, Wylie, and Conlan.

Mr. MOORHEAD. The Subcommittee on Housing and Community Development is in order.

The subcommittee meets today to consider legislation to authorize financial incentives for the installation of solar heating and cooling equipment in residential buildings. The hearings today will focus primarily on H.R. 3849, a bill introduced by Congressman Gude, who is with us this morning. This bill authorizes HUD to make direct loans at below-market interest rates to homeowners and builders who plan to install solar energy equipment in single and multifamily residences.

The bill before us today proposes one method to encourage the acceptance of presently available solar technology for residential purposes. I hope the hearing will clarify several important questions. First, does solar energy have the potential for economically meeting a substantial part of residential energy needs? Second, is the equipment as it is presently available effective, reliable and cost-effective? Third, is Federal support necessary to encourage the acceptance of the technology? Finally, is a direct loan program to homeowners and builders as proposed in this bill the most effective method to use?

I am pleased that two of my distinguished colleagues, who are most expert in the field of solar energy applications, are appearing before us today. The Honorable Gilbert Gude is the author of the legislation we will consider, and the Honorable Richard Ottinger, who has co-sponsored H.R. 8524, a similar proposal to be administered by the Small Business Administration, will join us later this morning.

[The text of H.R. 3849 and H.R. 8524 follows:]

94TH CONGRESS
1ST SESSION

H. R. 3849

IN THE HOUSE OF REPRESENTATIVES

FEBRUARY 27, 1975

Mr. GUDE introduced the following bill; which was referred to the Committee on Banking, Currency and Housing

A BILL

To establish in the Department of Housing and Urban Development a direct low-interest loan program to assist homeowners and builders in purchasing and installing solar heating (or combined solar heating and cooling) equipment.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

FINDINGS AND PURPOSE

SECTION 1. (a) The Congress finds that the heating and cooling of private homes accounts for a significant portion of our national energy consumption, and that the expected substantial increases in the cost of oil, gas, and electricity will significantly and adversely affect millions of American homes. The Congress further finds that, with technologies for solar heating having developed to the point of commercial application and improved solar heating units becoming increasingly available, and with technologies for solar cooling expected to reach the point of commercial application within a relatively few years, a program of Federal assistance in purchasing and installing solar heating equipment or combined solar heating and cooling equipment can provide a new opportunity for the efficient heating and cooling of homes despite the energy shortage.

(b) It is the purpose of this Act to provide a source of financial assistance for homeowners and builders so as to enable them to purchase and install solar heating equipment or combined solar heating and cooling equipment while substantially reducing energy use.

AUTHORIZATION OF LOANS

SEC. 2. (a) In order to carry out the purpose of this Act, the Secretary of Housing and Urban Development (hereinafter referred to as the "Secretary") is authorized to make loans as provided in this section to individuals and families owning and occupying one- to four-family residential structures, and to persons engaged in building residential structures of any kind, to assist them in purchasing and installing qualified solar heating or solar heating and cooling equipment (as defined in section 3) in such structures.

(b) A loan made under this section with respect to any residential structure shall—

(1) be in such amount, not exceeding 75 per centum of the cost of purchasing and installing the equipment involved, and not exceeding—

(A) $6,000 in the case of a one- to four-family structure,

(B) $5,700 per dwelling unit in the case of a multifamily structure containing five or more but less than twenty-five such units,

(C) $5,400 per dwelling unit in the case of a multifamily structure containing twenty-five or more but less than one hundred such units,

(D) $4,800 per dwelling unit in the case of a multifamily structure containing one hundred or more but less than two hundred such units, or

(E) $4,500 per dwelling unit in the case of a multifamily structure containing two hundred or more such units,

as may be necessary to enable the owner or builder of such structure to purchase and install qualified solar heating or solar heating and cooling equipment which is suitable and appropriate for such structure, including the cost of any necessary modifications in the structure itself, taking into account the climatic, meteorological, and related conditions prevailing in the region where the structure is located, as established by the Secretary in regulations prescribed by him and in effect at the time of the loan;

(2) bear interest at a rate equal to the average market yield (computed as of the end of the calendar month preceding the month in which the loan is made) on all marketable interest-bearing obligations of the United States then forming a part of the public debt (with such average yield, if not a multiple of one-eighth of 1 per centum, being adjusted to the nearest such multiple), plus one-half of 1 per centum for administrative costs;

(3) have a maturity not exceeding—

(A) eight years in the case of a one- to four-family structure, or

(B) Fifteen years in the case of a multifamily structure,

except that if the loan is made to the builder of a structure which is sold to another person for occupancy, rental, resale, or any other purpose, the maturity of the loan shall not extend beyond the date of the sale to such other person; and

(4) be subject to such additional terms, condi-

tions, and provisions as the Secretary may impose in order to assure that the purpose of this Act is effectively carried out.

(c) Each application for a loan under this section shall be accompanied by detailed plans for the purchase and installation of the proposed equipment and an estimate of the costs involved. No such application shall be approved unless the Secretary finds that the proposed equipment is suitable and appropriate and will be effective, that the costs will not be excessive, and that the purchase and installation of the equipment will not involve elaborate or extravagant design or materials.

(d) In making loans under this section, the Secretary shall impose such standards and take such actions as may be necessary or appropriate to assure that both one- to four-family structures and multifamily structures share equitably in the funds provided for such loans under section 7.

QUALIFIED SOLAR HEATING OR SOLAR HEATING AND COOLING EQUIPMENT

SEC. 3. (a) For purposes of this Act—

(1) the term "qualified solar heating equipment" means equipment which utilizes solar energy to provide heating for a residential structure (including all necessary fittings and related installations) and which is certified by the Secretary—

(A) as being designed to meet more than 40 per centum of the total heating needs (including domestic hot water) of the type of structure for which it is intended, or substantially all of the needs of such a structure for domestic hot water (where its remaining heating needs are met by other methods), and

(B) as meeting minimum standards (as developed under the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93–409)) with respect to durability of parts, efficiency, ease of repair, availability of spare parts, acceptability of cost, technical feasibility of design or proven workability, and such other matters as the Secretary may consider relevant or appropriate; and

(2) the term "qualified solar heating and cooling equipment" means equipment which utilizes solar energy to provide both heating and cooling for a residential structure (including all necessary fittings and related installations) and which is certified by the Secretary—

(A) as being designed to meet both the heating needs of the type of structure for which it is intended, to the extent required by paragraph (1) (A) of this subsection, and substantially all of the cooling needs of such a structure, and

(B) as meeting minimum standards (as developed under the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409)) with respect to the matters specified in or under paragraph (1)(B) of this subsection.

(b) In carrying out its functions under the Solar Heating and Cooling Demonstration Act of 1974 and in support of the objectives of this Act, the Energy Research and Development Administration shall—

(1) establish a mechanism or procedure (or both) for the inspection and evaluation of each type or model of solar heating and solar heating and cooling equipment, making provision for dealing with applications received from manufacturers and for the consideration of comments received from homeowners already using such equipment,

(2) review each new solar heating or solar heating and cooling unit, system, or component entering the market,

(3) periodically (no less often than once every three years) review all outstanding certifications granted with respect to solar heating or solar heating and cooling equipment, and recommend the prospective rescission of such certifications (or appropriate modifications in the equipment involved) whenever it finds that such

equipment no longer meets applicable standards or criteria,

(4) periodically transmit its findings and recommendations under this subsection to the Secretary for use in the performance of his functions under subsection (a) of this section, and

(5) take such other actions, and impose such other conditions and requirements, as will promote the objectives of this Act.

DISSEMINATION OF INFORMATION

SEC. 4. The Secretary shall provide to any person upon his or its request (without regard to whether or not such person is making or proposes to make application for a loan under section 2) full, complete, and current information concerning recommended standards and types of qualified solar heating or solar heating and cooling equipment appropriate for use in residential structures of varying sizes and types and in various regions of the country.

ADMINISTRATIVE PROVISIONS

SEC. 5. In the performance of, and with respect to, the functions, powers, and duties vested in him by this Act, the Secretary shall (in addition to any authority otherwise vested in him) have the functions, powers, and duties set forth in section 402 (except subsections (a) and (c)(2)) of the Housing Act of 1950.

PENALTIES

SEC. 6. Any person who makes any false statement or misrepresents any material fact for the purpose of obtaining a loan under this Act, or who violates any provision of this Act or of a loan contract entered into under this Act, shall be fined not more than $1,000 or imprisoned not more than one year or both.

APPROPRIATIONS; REVOLVING FUND

SEC. 7. There is authorized to be appropriated the sum of $100,000,000 to provide an initial amount for the program under this Act, and such additional sums thereafter as may be necessary to carry out such program. Amounts appropriated pursuant to this section shall be placed in and constitute a revolving fund which shall be available to the Secretary for use in carrying out this Act.

EFFECTIVE DATE

SEC. 8. The authority of the Secretary to make loans under this Act shall become effective six months after the date of the enactment of this Act, and shall expire ten years after such date.

94th CONGRESS
1st Session

H. R. 8524

IN THE HOUSE OF REPRESENTATIVES

July 10, 1975

Mr. Gude (for himself and Mr. Ottinger) introduced the following bill; which was jointly referred to the Committees on Small Business and Banking, Currency and Housing

A BILL

To amend the Small Business Act to establish within the Small Business Administration a new direct low-interest loan program to assist homeowners and builders in purchasing and installing solar heating (or combined solar heating and cooling) equipment.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

FINDINGS AND PURPOSE

Section 1. (a) (1) The Congress finds that the heating and cooling of residential structures accounts for a significant portion of our national energy consumption, and that the expected substantial increases in the cost of oil, gas, and electricity will significantly and adversely affect millions of

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American homes. The Congress further finds that, with technologies for solar heating having developed to the point of commercial application and improved solar heating units becoming increasingly available, and with technologies for solar cooling expected to reach the point of commercial application within a relatively few years, a program of Federal assistance in purchasing and installing solar heating equipment or combined solar heating and cooling equipment can provide a new opportunity for the efficient heating and cooling of homes despite the energy shortage.

(2) The Congress recognizes that small business concerns have already demonstrated their ability to participate effectively in the assembly and marketing of solar heating equipment and are increasingly engaging in commercial operations in this field, and declares that it would be in the national interest to place special emphasis upon the small business segment of the economy in any program of Federal assistance of the kind described in paragraph (1).

(b) It is the purpose of this Act to provide a source of financial assistance for homeowners and builders so as to enable them to purchase and install solar heating equipment or combined solar heating and cooling equipment, primarily through the small business segment of the economy, in order to substantially reduce energy use.

SEC. 2. Section 7 of the Small Business Act is amended by adding at the end thereof the following new subsection:

"(l) (1) In addition to its other functions under this Act, the Administration is authorized to make loans as provided in this subsection to individuals and families owning and occupyng one- to four-family residential structures, and to persons engaged in building residential structures of any kind, to assist them in purchasing and installing qualified solar heating or solar heating and cooling equipment (as defined in paragraph (4)) in such structures.

"(2) A loan made under this subsection with respect to any residential structure shall—

"(A) be in such amount, not exceeding 75 per centum of the cost of purchasing and installing the equipment involved, and not exceeding—

"(i) $6,000 per dwelling unit in the case of a one- to four-family structure,

"(ii) $5,700 per dwelling unit in the case of a multifamily structure containing five or more but less than twenty-five such units,

"(iii) $5,400 per dwelling unit in the case of a multifamily structure containing twenty-five or more but less than one hundred such units,

"(iv) $4,800 per dwelling unit in the case of a multifamily structure containing one hundred or more but less than two hundred such units, or

"(v) $4,500 per dwelling unit in the case of a multifamily structure containing two hundred or more such units,

as may be necessary to enable the owner or builder of such structure to purchase and install qualified solar heating or solar heating and cooling equipment which is suitable and appropriate for such structure, including the cost of any necessary modifications in the structure itself, taking into account the climatic, meterological, and related conditions prevailing in the region where the structure is located, as established by the Administration in regulations prescribed by it and in effect at the time of the loan;

"(B) bear interest at a rate equal to the average market yield (computed as of the end of the calendar month preceding the month in which the loan is made) on all marketable interest-bearing obligations of the United States then forming a part of the public debt (with such average yield, if not a multiple of one-eighth of 1 per centum, being adjusted to the nearest such multiple), plus one-half of 1 per centum for administrative costs;

"(C) have a maturity not exceeding—

"(i) eight years in the case of a one- to four-family structure, or

"(ii) fifteen years in the case of a multifamily structure,

except that if the loan is made to the builder of a structure which is sold to another person for occupancy, rental, resale, or any other purpose, the maturity of the loan shall not extend beyond the date of the sale to such other person; and

"(D) be subject to such additional terms, conditions, and provisions as the Administration may impose in order to assure that the purpose of this subsection is effectively carried out.

"(3) (A) Each application for a loan under this subsection shall be accompanied by detailed plans for the purchase and installation of the proposed equipment and an estimate of the costs involved.

"(B) No such application shall be approved unless—

"(i) the Administration finds that the proposed equipment is suitable and appropriate and will be effective, that the costs will not be excessive, and that the purchase and installation of the equipment will not involve elaborate or extravagant design or materials; and

"(ii) the proposed equipment is being purchased from a small business concern (as defined by the Administration under section 3) and, unless installed by the applicant, will be installed by a small business concern (as so defined); except that the requirement of this clause may be waived by the Administration in any case upon a specific finding that there is no small business concern within two hundred and fifty miles of the structure involved which is engaged in marketing or installing solar heating or solar heating and cooling equipment that would meet (with respect to such structure) the requirements of clause (i).

"(C) In making loans under this subsection, the Administration shall impose such standards and take such actions as may be necessary or appropriate to assure that both one- to four-family structures and multifamily structures share equitably in the funds provided for such loans.

"(4) For purposes of this subsection—

"(A) the term 'qualified solar heating equipment' means equipment which utilizes solar energy to provide heating for a residential structure (including all necessary fittings and related installations) and which is certified by the Administration—

"(1) as being designed to meet more than 40 per centum of the total heating needs (including domestic hot water) of the type of structure for which it is intended, or substantially all of the needs of such a structure for domestic hot water (where its remaining heating needs are met by other methods), and

"(ii) as meeting minimum standards (as developed under the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93–409) and modified by the Administration to the extent appropriate for application under this subsection) with respect to durability of parts, efficiency, ease of repair, availability of spare parts, acceptability of cost, technical feasibility of design or proven workability, and such other matters as the Administration may consider relevant or appropriate; and

"(B) the term 'qualified solar heating and cooling equipment' means equipment which utilizes solar energy to provide both heating and cooling for a residential structure (including all necessary fittings and related installations) and which is certified by the Administration—

"(i) as being designed to meet both the heating needs of the type of structure for which it is intended, to the extent required by subparagraph (A) (i) of this paragraph, and substantially all of the cooling needs of such a structure, and "(ii) as meeting minimum standards (as developed under the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93–409) and modified by the Administration to the extent appropriate for application under this subsection) with respect to the matters specified in or under subparagraph (A) (ii) of this paragraph.

"(5) In carrying out its functions under the Solar Heating and Cooling Demonstration Act of 1974 and in support of the objectives of this subsection, the Energy Research and Development Administration shall—

"(A) establish a mechanism or procedure (or both) for the inspection and evaluation of each type or model of solar heating and solar heating and cooling equipment, making provision for dealing with applications received from manufacturers and for the consideration of comments received from homeowners already using such equipment,

"(B) review each new solar heating or solar heating and cooling unit, system, or component entering the market,

"(C) periodically (no less often than once every three years) review all outstanding certifications granted with respect to solar heating or solar heating and cooling equipment, and recommend the prospective rescission of such certifications (or appropriate modifications in the equipment involved) whenever it finds that such equipment no longer meets applicable standards or criteria,

"(D) periodically transmit its findings and recommendations under this paragraph to the Administration for use in the performance of its functions under paragraph (4), and

"(E) take such other actions, and impose such other conditions and requirements, as will promote the objectives of this subsection.

"(6) The Administration shall provide to any person upon request (without regard to whether or not such person is making or proposes to make application for a loan under this subsection) full, complete, and current information concerning recommended standards and types of qualified solar heating or solar heating and cooling equipment, available from small business concerns, which is appropriate for use in residential structures of varying sizes and types and in various regions of the country.".

SEC. 3. (a) Section 4(c)(1) of the Small Business Act is amended by striking out "and" immediately before "(B)", and by inserting before the period at the end thereof the following: "; and (C) a solar heating and cooling loan fund which shall be available for financing functions performed under section 7 (l) of this Act, including administrative expenses in connection with such functions".

(b) Section 4 (c) (2) of such Act is amended by striking out "and" immediately before "(B)", and by inserting before the period at the end thereof the following: ", and (C) pursuant to section 7 (l) of this Act, shall be paid into the solar heating and cooling loan fund".

(c) Section 4 (c) (4) of such Act is amended by striking out "and" immediately before "(D)", and by inserting before the period at the end thereof the following: "; and (E) under section 7 (l) of this Act, shall not exceed $600,000,000".

SEC. 4. (a) The authority of the Small Business Administration to make loans under section 7 (l) of the Small Business Act (as added by section 2 of this Act) shall become effective six months after the date of the enactment of this Act, and shall expire ten years after such date.

(b) Prior to the date on which its authority to make loans under section 7 (l) of the Small Business Act becomes effective under subsection (a) of this section, the Small Business Administration shall promulgate and publish the regulations necessary to carry out its functions under such section 7 (l).

Mr. MOORHEAD. After Mr. Gude speaks, a panel of experts involved in solar energy research and application will present their testimony. At the conclusion of the panel's testimony, we will be pleased to hear from Mr. Claude Barfield, the Deputy Assistant Secretary of the Department of Housing and Urban Development in charge of the Office of Research and Demonstration.

Mr. Gude, will you come forward? I particularly welcome you because we do serve together on the Subcommittee on Conservation, Energy, and Natural Resources. So, we have duplicating interests in this legislation.

Mr. WYLIE. Mr. Chairman, thank you. I too want to welcome Mr. Gude. I appreciate your coming here, and I commend you for your interest in solar energy development. I have long had an interest in solar energy development, as you know, and a lot of the initial research has been done by the Battelle Memorial Institute, which is located in my congressional district.

Although I have some reservations about a Government loan program—added bureaucracy and replacement of a portion of the private sector—I do agree that a solar heating and cooling incentive is necessary to our overall energy struggle.

Maximum impact initially will be in the above-average income groups regardless of incentive, unless that incentive were to be extremely large, simply because the solar energy technology is still today largely a custom process and very expensive. Thus, even with incentives, the cost would be prohibitive to the low and lower-middle income groups. As the incentives increase demand, which will in turn encourage mass production and lower unit costs, lower income groups will be brought in.

The point I am making is that a tax incentive is a better incentive from a standpoint of simplicity and from a standpoint of impact on the affected group.

But, there is a strong argument for the Committee on Banking, Currency and Housing acting on an incentive for solar that Mr. Gude does not make. That is the tax incentive package that is included in H.R. 6860. Despite the Senate Finance Committee's receptivity to the solar provisions—they maintained all of the tax credits, increasing several—the bill overall is in limbo. It is unlikely to see any further committee action soon. A clean solar bill should pass much more quickly, and the House Ways and Means Committee is bogged down in tax reform.

Thank you, Mr. Chairman.

Mr. MOORHEAD. You may proceed, Mr. Gude.

STATEMENT OF HON. GILBERT GUDE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MARYLAND

Mr. GUDE. Thank you, Mr. Chairman and Congressman Wylie. As you have suggested, the question of solar energy and what it means in today's economy is the other side of the coin when we consider conservation. I must say I am delighted this subcommittee has shown interest in our national energy conservation efforts, and solar energy in particular. Energy conservation is espeically relevant to housing concerns, since some 25 percent of our total energy consumption currently goes into heating, cooling, and hot water heating.

It is my goal today to take up a number of different questions relating to solar heating and cooling in residential structures, and I hope to convince subcommittee members of three things.

First, lasting and meaningful energy conservation in heating and cooling can only be obtained through large-scale conversion to alternative, renewable energy sources, particularly solar energy.

Second, the technology necessary to build efficient solar heating equipment is available today, and in many parts of the country it is already economical to install, particularly when compared to electric heat on a life-cycle cost basis.

And third, the nature of the energy crisis makes it imperative that we accelerate the process of conversion to solar. Declining solar prices due to mass production and further technological development and increasing fossil fuel prices make the good economics of solar inevitable. The time it takes to reach that point on a national scale represents wasted fuel. A sound national energy policy demands Government incentives to speed up the inevitable process of conversion to solar through overcoming resistance to change.

I ask unanimous consent that my entire statement be included in the record, and I will just address myself to portions of it.

Mr. MOORHEAD. Without objection, your entire statement will be made part of the record.

Mr. GUDE. There is no need for me to repeat for you statistics on the depth of the energy crisis we face. It and its various ramifications are behind much of the legislation we have considered this year, as we attempt to deal with both our shortrun vulnerability to an OPEC embargo and the longrun certainty that our conventional sources of energy—and indeed, our whole way of looking at energy and energy use—must change.

Today's hearing is particularly relevant to the latter, as we face the absolute certainty of the eventual exhaustion of fossil fuels, particularly oil and natural gas, the two most widely used home heating fuels. Existing natural gas reserves are projected to run out before the end of this century at present consumption rates. The oil picture is marginally less bleak, though our continuing dependence on foreign sources of supply is an added factor of concern. A third alternative, heating by electricity, is not only a relatively inefficient method, but the bulk of our electric generation today is dependent on those same fossil fuels, with large-scale conversion to nuclear plants some years away, even assuming current problems and controversies about nuclear can be resolved.

To my mind, the obvious answer is solar. It is available now. Its energy source is inexhaustible. It is clean and nonpolluting. It does not depend on power or pipelines or central transmission stations. It is relatively maintenance-free. We have the equipment now to reduce current fossil fuel consumption for heating by a substantial amount, and to insure the same level of reduction in future construction. A General Electric phase 0 study for the National Science Foundation indicates the magnitude involved:

> Of the 60 million buildings to be constructed in the United States in the next 5 years, approximately 40 million were found to be viable cost-effective candidates

for solar systems . . . If all these buildings were so equipped, the yearly equivalent electric power savings would be approximately 1,500 billion kilowatt hours . . . by the end of the century—equivalent to the total electrical generating capacity of the United States in 1970.

What does this mean in total energy terms, using today's popular standard, the barrel of oil? According to a 1974 Atomic Energy Commission study, assuming building heat represents 20 percent of energy use, and that a solar unit saves 50 percent of heating in each unit, both reasonable assumptions; if 60 percent of buildings had solar systems, the annual savings would be 720 million barrels of oil. If all buildings were solarized, the annual savings would be 1.2 billion barrels. This latter figure, of course, is an extreme, but more practical figures from other sources are also impressive.

ERDA estimates, for example, that solar heating and cooling could have a maximum energy input in the year 2000 equivalent to more than 1 billion barrels of oil. Additionally, the TRW phase 0 study for NSF predicts a solar market of more than a billion dollars per year by 2000, assuming an incentives program. This level is nearly twice the projected market with no incentives program. Moreover, the rapid development of solar is already showing the conservatism of most estimates. As Senator Gaylord Nelson pointed out on the Senate floor on May 8, 1975, NSF now estimates that by 1985, we can reach the level of solar use that GE and Westinghouse predicted for the year 2000. This, of course, is a 15-year improvement.

The nature of the energy crisis demands that we continue to accelerate the pace and bring solar on line as a major heating alternative sooner. Doing just that is uniquely within the purview of this subcommittee, as it is not primarily a technological problem, but rather a marketing problem. Important aspects of it include the following: First, the wariness of consumers to what they perceive as an untested technology, plus their tendency to consider only initial costs; second, the reluctance of financial institutions to risk money on a new technology with an uncertain demand; and third, the desire of builders to have a low-risk, high-return heating system that they can obtain as a standardized unit at a small initial cost.

Some solutions to these difficulties are already under development. HUD has been working on its definitive performance criteria for solar, which will help provide standards of quality and uniformity. Those will not be ready for some time, though minimum property standards which can be used to qualify solar for FHA financing will be finished sooner. These and other current activities will help to make solar an accepted alternative perceived as normal.

Further efforts are needed, however, to make it perceived as sound in economic terms as well as technological terms, and it is here that Government incentives will inevitably play an important role. As FEA's Project Independence Blueprint report stated,

The Federal program is designed in good part to reduce the first costs of solar energy systems. However, first costs higher than for conventional systems will continue to constrain widespread adoption, since the building community is extremely sensitive to first cost. Tax relief, loan and interest incentives and special depreciation policies will probably be required to overcome this constraint.

Such incentives will work in two areas. First, in reference to consumer and bank resistance, solar installations will benefit from a Government stamp of approval that an incentive program will signify. Second, incentives will help to make the economics of solar more favorable, or favorable sooner, depending on conditions; and the table on the center of page 4 of my prepared statement indicates this point.

We face the certainty that, while the economics of solar may be marginal now in some areas, they will not be in a few years as fossil fuel prices rise and solar prices come down. Under normal circumstances, one could simply permit these market forces to operate and watch the solar heating industry grow, albeit slowly. The additional factor of the energy crisis, however, argues against letting the market take its course; and the Office of Technology Assessment's evaluation of ERDA's energy program verified that there is a great potential of savings in the immediate-term development, not following the slow pace of ERDA's solar heating and cooling plans. I quote from the Office of Technology Assessment's evaluation of ERDA's energy program:

> There is abundant evidence that solar heating and cooling applications offer a large potential for energy savings in the immediate and near term—to 1985—and beyond this to 2000, than any other solar applications. Indeed, ERDA's figures verify this statement; yet, solar heating and cooling is categorized at the third level of priorities as an "under-used mid-term technology", and one which "may provide an energy 'margin' in the event of RD&D failure in other areas." These statements in the ERDA document project a significant potential for solar heating and cooling, yet underemphasize the development and actual impact of solar heating and cooling on our energy economy . . .
>
> The prime objective of the demonstration program should be to accelerate consumer acceptance of solar energy as a heat source, so that substantial fuel savings can be achieved at a considerable earlier date than would otherwise result. The plans set forth in ERDA-48 do not appear to be oriented to achieve these purposes . . .
>
> The overall goal of the program should not be the development of technology or of hardware, but rather the development of consumer markets.

Now, to incentives. I am far from alone in my emphasis on the need for a government incentives program. Almost every major analysis of solar markets cites the same need for significant expansion of Federal monetary incentives to encourage solar purchases. There, for example, is the recommendation by the Senate Select Committee on Small Business, which I quote on page 5 in the center there, where the recommendation is,

> Congress should enact tax incentives and consider low-interest loan and loan guarantee programs for the development of solar energy for heating and cooling residences and other buildings, wherever possible and as quickly as possible.

And also, we have the testimony of George Löf, director of the Solar Energy Applications Laboratory at Colorado State University, before the Ways and Means Committee in March of this year.

Clearly, in the short run, such incentives will be necessary both to bring the costs of solar down to competitive levels—though in many cases they are already competitive—and to break down psychological barriers to the use of new technology. Additionally, we should keep in mind the fact that corporate producers of fossil fuels have for some time enjoyed incentives through such tax breaks as the depletion allowance, depreciation allowances, and investment tax credits. The solar homeowner, an energy producer as well as a consumer, currently enjoys none of these advantages.

At this point, the relevant question is, what kind of incentives will best achieve our objectives? Major proposals thus far have been in two categories: Tax incentives and loan—or loan guarantee—incentives. Each has certain advantages of its own. A tax incentive, for example, has proved easier to deal with legislatively and administratively. It would require no cumbersome bureaucracy or large administrative costs. In a society conscious of taxes, it is easy to quantify and therefore easy for the consumer to understand. Its application through the tax code gives its users a high degree of flexibility.

Tax incentives also have certain disadvantages when compared to loan programs. First, it is important to recognize the major distinction between solar and conventional heating equipment—different initial costs. A conventional heating system is inexpensive to buy and install, but solar initial costs are relatively high. The advantage of solar lies in its extremely low ongoing costs compared to the constantly rising costs of conventional fuels.

Loan incentives are able to deal with this high front-end cost problem by providing capital at the time it is needed—the time of initial purchase. In contrast, tax incentives provide relief after the fact. One could not claim the incentive until one's tax return was filed. Of course, anticipation of the tax break would have some effect on one's financial planning, and tax credits no doubt serve as an incentive to look into solar. They do not always, however, solve the financing problem, nor deal with the likely situation of homeowners or builders with cash flow limitations who need the funds in advance and would be receptive to borrowing it at favorable terms.

There are also other advantages to loan incentives from the point of view of Government policy. First, from the point of view of equitable tax policy, it may not be desirable to promote this kind of progress through the tax code. Tax reform efforts in recent years have been directed toward neutralizing the tax code by repealing this kind of incentive, on the assumption that incentive policies are better carried out through direct programs.

Second, a tax incentive program is inevitably a more circuitous approach than a loan program. In general, it is easier to control and if necessary limit a direct program. In the case of a tax credit, the Government would not know that solar equipment had been purchased until some time after its installation. No tax program could contain the kind of advance protections against the purchase of inadequate or fraudulent equipment that a loan program could institute, because a tax program is essentially self-policing. The fraction of cases audited would be examined by IRS agents who are not necessarily skilled in judging the eligibility of solar heating equipment. In a situation like this, precertification is clearly more rigorous than postcertification.

Third, a loan program will in the long run cost the Federal Government less money, if only because a tax credit is essentially a gift, while loans will be repaid. Given our current budgetary situation, cost factors must be an important part of our consideration.

Listing the advantages and disadvantages of both loan incentives and tax incentives is really to argue that they both are appropriate policy tools. The House has already passed, as part of H.R. 6860, a

25-percent solar tax credit, sponsored, I might add, by a member of this subcommittee, Mr. Wylie. Coincidentally, the loan program in H.R. 3849 would complement the 25-percent tax credit perfectly by providing loans for 75 percent of the cost. Taken together, these two incentives would permit an individual to finance three-fourths of his costs with a loan, and then essentially be reimbursed through the tax credit for the one-fourth down payment he made. The two do not necessarily have to be mutually exclusive.

My purpose here today is to argue for a loan incentive approach, as I have indicated. But at the same time, I think we have to support a broad package of incentives to accelerate the pace of solar development. A tax credit will be the most appropriate incentive for some, a direct loan for others, a loan guarantee for still others. All these approaches have their place.

Now, as to H.R. 3849 and H.R. 8524; in turning to our specific loan incentive proposals, let me make clear that I am not wedded to the precise details of the bills that are a subject of this hearing. The two bills, however, do raise some basic questions about loan incentives that need to be discussed. In brief, both bills provide for a direct loan program to homeowners and homebuilders for the purchase and installation of solar heating and cooling equipment. The bills impose certain limits on the amount which can be borrowed, the interest rate, and the amortization rate. Only solar equipment tested and evaluated by ERDA would be eligible for purchase with loan funds. Some specific observations follow.

First, as to the interest rate. Since our proposals are designed to provide incentives effectively reducing the cost of solar equipment, the interest applied to the loans is an important factor. In both bills, we have proposed a formula rate linked to the monthly average rate on Treasury bonds. This "cost of money" approach, plus the one-half of 1 percent for administrative costs, is designed to provide a rate lower than existing market rates without at the same time creating a substantial cost to the Government. Obviously, a better incentive would be a subsidy rate of 3 or 4 percent, but that would significantly increase Government costs.

As to amortization, one issue which has engendered some controversy is the amortization schedule. The bills presently provide for an 8-year payoff plan for homeowners and a 15-year payoff for builders of multifamily structures, with the proviso in the latter case that the loan is due if the entire property is sold. Our logic in choosing this more rapid rate was that the prospect of a time in the future when the homeowner would have only minimal heating payments—when the loan is paid off—would be an attractive incentive. Given the mobility of the population, we felt that 8 years was a suitable figure.

It has been suggested, however, by a number of those who have examined the bills that lengthening the amortization period to 20 years, or tying it to the homeowner's mortgage payments, would be a better incentive. Of course, in the case of builders, the price of the equipment would be subsumed into the purchase price of the home, thus effectively tying it to the homeowner's mortgage. In the case of retrofits, a longer amortization period would result in substantially lower payments. Tying the loan to the mortgage is a neater approach, one which lowers the monthly payments and ties the loan to established financial channels, an important factor if we are to encourage the private sector to move more fully into financing solar equipment. Comparisons of the annual loan payment with the fuel savings involved also reflect the advantages of the longer amortization period. Assuming a maximum $6,000 loan and equipment which cost $8,000, meaning a $2,000 downpayment, the larger payments required by an 8-year amortization schedule would prevent a homeowner from really being ahead on energy savings until the eighth year, at which point the annual savings would begin to be very substantial, the loan having been paid off. A 20-year amortization, on the other hand, would permit the homeowner to move ahead on savings as early as the fifth year. The annual savings would not be as great, since the loan payments continue, but the immediate payoff is quicker.

As to solar equipment standards, the two bills contain significant protections against the purchase of improper equipment. Money obtained from the loans may be used only for the purchase of qualified equipment. Hardware is certified as qualified by HUD after testing and evaluation by ERDA. In our view, this two-agency process is necessary, because ERDA is uniquely qualified to perform testing and evaluation, while HUD will really be setting the appropriate standards and, as the originator of the loans, should retain final authority on what the funds can be used for.

In conclusion, Mr. Chairman, let me return to the three points I made in the beginning. First, if we are to achieve meaningful energy savings in residential heating and cooling, then conversion to nonfossil fuel energy sources is essential. Second, the obvious choice in that case is solar energy. The technology exists; solar houses exist and have been functioning for years. Solar is already cost-competitive with electric heat on a life cycle basis in most parts of the country, and changing fuel prices make it only a matter of time before it will match oil and gas nationwide as well.

Third, this process of conversion is an inevitable one, given the increasingly favorable economics and the growing awareness of the limitations of fossil fuels. The energy crisis has made it the policy of this Government to accelerate the process of conversion to solar and other energy alternatives as part of our conservation effort. The relevant question for this subcommittee is how best to assist that acceleration; specifically, what incentives would be most appropriate and most effective? While I believe in and am committed to a direct loan program, I hope the effect of my testimony and that of those who follow me will be to stimulate the members of this subcommittee to undertake a thorough study of the incentives question, which will lead to the rapid development of meaningful incentives legislation.

Thank you, Mr. Chairman.

[The prepared statement of Congressman Gude follows:]

STATEMENT OF THE HONORABLE GILBERT GUDE BEFORE THE HOUSING SUBCOMMITTEE, COMMITTEE ON BANKING, CURRENCY, AND HOUSING. November 5, 1975

SOLAR LOAN INCENTIVES

Mr. Chairman, members of the committee, it is a privilege to be here today. I must say I am delighted this committee has shown interest in our national energy conservation efforts and solar energy in particular. Energy conservation is especially relevant to housing concerns since some 25 percent of our total energy consumption currently goes into heating, cooling, and hot water heating.

It is my goal today to take up a number of different questions relating to solar heating and cooling in residential structures, and I hope to convince committee members of three things:

1) Lasting and meaningful energy conservation in heating and cooling can only be obtained through large-scale conversion to alternative, renewable energy sources, particularly solar energy.

2) The technology necessary to build efficient solar heating equipment is available today and in many parts of the country it is already economical to install, particularly when compared to electric heat on a life-cycle cost basis.

3) The nature of the energy crisis makes it imperative that we accelerate the process of conversion to solar. Declining solar prices due to mass production and further technological development and increasing fossil fuel prices make the good economics of solar inevitable. The time it takes to reach that point on a national scale represents wasted fuel. A sound national energy policy demands government incentives to speed up the inevitable process of conversion to solar through overcoming resistance to change.

As I will explain later, I do not intend to tie myself irrevocably to the particular bills that led to this hearing. I do, however, firmly believe in the underlying concept of both bills -- a direct loan program for the installation of solar equipment for both builders and homeowners. If the testimony here today is convincing, then I hope to see the committee ultimately consider for approval either H.R. 3849 or H.R. 8524 or begin the process of drafting its own version which will achieve the same objectives. The importance of moving forward on solar incentives now cannot be underestimated, and I don't believe there is anyone familiar with the industry who would not agree with that statement or go on to point out how quickly this process could begin.

I. The Need for Action

There is no need for me to repeat for you statistics on the depth of the energy crisis we face. It and its various ramifications are behind much of the legislation we have considered this year as we attempt to deal with both our short run vulnerability to an OPEC embargo and the long run certainty that our conventional sources of energy and indeed our whole way of looking at energy and energy use must change.

Today's hearing is particularly relevant to the latter, as we face the absolute certainty of the eventual exhaustion of fossil fuels, particularly oil and natural gas, the two most widely used home heating fuels. Existing natural gas reserves are projected to run out before the end of this century at present consumption rates. The oil picture is marginally less bleak, though our continuing dependence on foreign sources of supply is an added factor of concern. A third alternative, heating by electricity, is not only a relatively inefficient method, but the bulk of our electric generation today is dependent on those same fossil fuels, with large scale conversion to nuclear plants some years away, even assuming current problems and controversies about nuclear can be resolved.

To my mind the obvious answer is solar. It is available now. Its energy source is inexhaustible. It is clean and non-polluting. It does not depend on power or pipelines or central transmission stations. It is relatively maintenance free. We have the equipment now to reduce current fossil fuel consumption for heating by a substantial amount, and to insure the same level of reduction in future construction. The General Electric Phase 0 study for the National Science Foundation, as summarized in Solar Energy for Earth, an assessment by the American Institute of Aeronautics and Astronautics, indicates the magnitude involved:

> Of the 60 million buildings to be constructed in the United States in the next (2)5 years, approximately 40 million were found to be viable, cost effective candidates for solar systems....If all these buildings were so equipped, the yearly equivalent electric power savings would be approximately 1500 billion kilowatt-hours...by the end of the century -- equivalent to the total electrical generating capacity of the United States in 1970.

What does this mean in total energy terms, using today's popular standard -- the barrel of oil? According to a 1974 Atomic Energy Commission study, assuming building heat represents 20 percent of energy use and that a solar unit saves 50 percent of heating in each unit, both reasonable assumptions, if 60 percent of buildings had solar systems the annual savings would be 720 million barrels of oil. If all buildings were "solarized" the annual savings would be 1.2 billion barrels. This latter figure of course is an extreme, but more practical figures from other sources are also impressive. ERDA estimates, for example, that solar heating and cooling could have a maximum energy input in the year 2000 of 5.9 Quads (1 Quad = 1×10^{15} BTUs), equiavalent to more than one billion barrels of oil. Additionally, the TRW Phase 0 study for NSF predicts a solar market of more than a billion dollars per year by 2000, assuming an incentives program. (This level is nearly twice the projected market with no incentives program.) Moreover,

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the rapid development of solar is already showing the conservatism of most estimates. As Senator Gaylord Nelson pointed out on the Senate floor on May 8, 1975,

> In 1974, the General Electric Co., after making a half-million dollar study financed with public funds from the NSF, estimated that only 1.6 percent of all national energy requirements for building heating and cooling could be met by solar systems by 2000. Westinghouse Corp. and TRW, Inc., makers of similar studies on identical grants, thought it might be 3.04 percent and 3.56 percent, respectively. With a 25 percent tax credit incentive, TRW thought the solar contribution could reach 5.77 percent of all building heating and cooling energy by 2000.
>
> But NSF, early this year, estimated that we could be approaching 4 percent by 1985 -- some 15 years earlier than the year Westinghouse thought we could top 3 percent and GE thought we would still be under 2 percent.

The nature of the energy crisis demands that we continue to accelerate the pace and bring solar on line as a major heating alternative sooner. Doing just that is uniquely within the purview of this committee as it is not primarily a technological problem, but rather a marketing problem. Important aspects of it include the following:

1) the wariness of consumers to what they perceive as an untested technology plus their tendency to consider only initial costs;

2) the reluctance of financial institutions to risk money on a new technology with an uncertain demand;

3) the desire of builders to have a low risk, high return heating system that they can obtain as a standardized unit at a small initial cost.

Some solutions to these difficulties are already under development. The Department of Housing and Urban Development has been working on its definitive performance criteria for solar which will help provide standards of quality and uniformity. Those won't be ready for some time, though minimum property standards, which can be used to qualify solar for FHA financing, will be finished sooner.

Local governments are gradually becoming aware of and removing the various hurdles, zoning and building code problems for example, in their jurisdictions.

The development of standard complete systems rather than components is an entrepreneurial problem that has yet to be fully resolved. We need to learn more about why large companies seem to be concentrating on components, primarily collectors, rather than total systems, and we need to discover ways of dealing with this problem. There is no question that this is a major obstacle from the builder's point of view.

Current activities will help to make solar an accepted alternative perceived as "normal." Further efforts are needed, however, to make it perceived as sound in economic terms as well as technological terms, and it is here that government incentives will inevitable play an important role. As the Federal Energy Administration's Project Independence Blueprint, Solar Energy Task Force Report, stated, The federal program is designed in good part to reduce the first costs of solar energy systems. However, first costs higher than for conventional systems will continue to constrain widespread adoption, since the building community is extremely sensitive to first cost. Tax relief, loan and interest incentives and special depreciation policies will probably be required to overcome this constraint.

Such incentives will work in two areas:

1) In reference to consumer and bank resistance, solar installations will benefit from a government stamp of approval that an incentive program will signify. Lending institutions that will be called on to finance solar, both in the case of individuals and particularly in the case of homebuilders, can be expected to resist financing what they regard as a higher risk technology. It will be necessary for the government to intervene in this lending process to reduce the risk.

2) Incentives will help to make the economics of solar more favorable, or favorable sooner, depending on conditions. The following figures, prepared by the General Accounting Office, are illustrative of the differing economic calculations.

1973 Combined Heating and Cooling Evaluation Results Adjusted to More Nearly Reflect 1972 Solar and Conventional Energy Costs (Costs per million BTUs)

	Least Cost Solar Energy 25,000 BTU/DD		Conventional Energy		
Location	Low	High	Elec.cooling with gas heating	Elec.cooling with oil heating	All Electric
Albuquerque	$2.16	$2.93	$2.59	$3.29	$5.89
Boston (note a)	3.85	5.48	2.95	2.92	4.85
Charleston	3.07	4.41	1.78	2.06	2.31
Miami	2.67	3.85	3.19	3.20	3.34
Omaha	3.11	4.55	1.64	2.34	3.58
Phoenix	2.25	3.21	2.45	2.71	2.98
Santa Maria	3.07	3.81	1.54	2.33	3.93
Seattle	4.72	6.31	1.95	2.48	2.08

(a) Blue Hill Observatory in the Boston area, which, according to one source, "receives 23.5 percent more solar energy than Boston, enough to make a solar collector there perform about 35 percent better." (We did not attempt to determine whether similar variations existed for other cities.)

Figures in the attached table are based on 1972 fossil fuel prices, prices which have since risen and can be expected to rise further. As the numbers make clear, we face the certainty that while the economics of solar may be marginal now in some areas, they won't be in a few years as fossil fuel prices rise and solar prices come down. Under normal circumstances one could simply permit these market forces to operate and watch the solar heating industry grow. The additional factor of the energy crisis, however, argues against letting the market take its course. We have an opportunity here to save a significant amount of fuel permanently and to move the nation in the direction of more responsible energy consumption patterns through the encouragement of solar energy, at little long run cost to the government if a loan incentive program is adopted. Certainly if we wait a number of years, this will happen anyway, but those intervening years represent literally wasted energy when we should have been acting. The Office of Technology Assessment's evaluation of ERDA's energy program verified this in its criticism of the slow pace of ERDA's solar heating and cooling plans:

> There is abundant evidence that solar heating and cooling applications offer a larger potential for energy savings in the immediate and near term (to 1985), and beyond this to 2000, than any other solar applications. Indeed, ERDA's figures (ERDA-48, volume I, table 6-1) verify this statement; yet, solar heating and cooling is categorized at the third level of priorities as an 'under-used mid-term technology' and one which may 'provide an energy "margin" in the event of R,D&D failure in other areas.' These statements in the ERDA document project a significant potential for solar heating and cooling, yet underemphasize the development and actual impact of solar heating and cooling on our energy economy....
>
> The prime objective of the demonstration program should be to accelerate consumer acceptance of solar energy as a heat source so that substantial fuel savings can be achieved at a considerable earlier date than would otherwise result. The plans set forth in ERDA-48 do not appear to be oriented to achieve these purposes....
>
> The overall goal of the program should not be the development of technology or of hardware, but rather the development of consumer markets.

II. Incentives

I am far from alone in my emphasis on the need for a government incentives program. Almost every major analysis of solar markets cites the same need for significant expansion of federal monetary incentives to encourage solar purchases. In addition to the FEA analysis mentioned earlier, other comments include:

1) Recommendation #9 from the <u>Interim Report of the Senate Select Committee on Small Business on The Role of Small Business in Solar Energy Research, Development and Demonstration</u> (October 7, 1975).

> 9. Congress should enact tax incentives and consider low-interest loan and loan guarantee programs for the development of solar energy for heating and cooling residences and other buildings, wherever possible and as quickly as possible.

2) From the testimony of George Löf, Director of the Solar Energy Applications Laboratory, Colorado State University, before the Ways and Means Committee (March 11, 1975):

> The high initial investment requirement for a solar heating system is a deterrent to immediate wide public use, even though the life cycle cost of the system may be lower than the conventional alternative. This capital cost requirement is a problem for the builder, the purchaser, and all others in the chain of interests in the home building and commercial building industry. A great stimulus to the use of solar energy for heating of buildings would be the availability of capital for solar heating systems at moderate interest rates. Such an incentive would cause an immediate increase in the demand for these systems. With a minimal cash outlay, and moderate monthly payments, the home owner could thus afford this great new energy source. An incentive of this type has just been proposed by Senator Hart in his bill S.875. At no net cost to the government, the availability of federal loans should increase the rate of application from perhaps hundreds per year to the hundreds of thousands per year as soon as such funds are available.

(The bill referred to above is identical to H.R. 3849, which is under consideration today.)

Clearly in the short run such incentives will be necessary both to bring the costs of solar down to competitive levels -- though in many cases they are already competitive -- and to break down psychological barriers to the use of new technology. Additionally, we should keep in mind the fact that corporate producers of fossil fuels have for some time enjoyed incentives through such tax breaks as the depletion allowance, depreciation allowances, and investment tax credits. The solar homeowner, an energy producer as well as a consumer, currently enjoys none of these advantages.

At this point, the relevant question is what kind of incentive will best achieve our objectives? Major proposals thus far have been in two categories: tax incentives and loan (or loan guarantee) incentives. Each has certain advantages of its own. A tax incentive, for example, has proved easier to deal with legislatively and administratively. It would require no cumbersome bureaucracy or large administrative costs. In a society conscious of taxes, it is easy to quantify and therefore easy for the consumer to understand. Its application through the tax code gives its users a high degree of flexibility.

Tax incentives also have certain disadvantages when compared to loan programs. First, it is important to recognize the major distinction between solar and conventional heating equipment, different initial costs. A conventional heating system is inexpensive to buy and install, but solar initial costs are relatively high. The advantage of solar lies in its extremely low ongoing costs compared to the constantly rising costs of conventional fuels.

Loan incentives are able to deal with this high front end cost problem by providing capital at the time it is needed -- the time of initial purchase. This is particularly important if solar is to have an appeal to all economic strata. Obviously someone with an extra $6000 in his savings account would be relatively less concerned about obtaining incentive funds in advance, but realistically there are not many of us in this happy category, and even those with higher incomes are likely to find it difficult to make an expenditure of this magnitude all at once. Clearly any effort to encourage solar among homeowners of all income levels demands the supplying of the incentive when it is needed -- in the beginning.

In contrast, tax incentives provide relief after the fact. One could not claim the incentive until one's tax return was filed. Of course, anticipation of the tax break would have some effect on one's financial planning, and tax credits no doubt serve as an incentive to look into solar. They do not always, however, solve the financing problem, nor deal with the likely situation of homeowners or builders with cash flow limitations who need the funds in advance and would be receptive to borrowing it at favorable terms.

There are also other advantages to loan incentives from the point of view of government policy.

1) From the point of view of equitable tax policy, it may not be desirable to promote

this kind of progress through the tax code. Tax reform efforts in recent years have been directed toward "neutralizing" the tax code by repealing this kind of incentive, on the assumption that incentive policies are better carried out through direct programs.

2) A tax incentive program is inevitably a more circuitous approach than a loan program. In general, it is easier to control and if necessary limit a direct program. In the case of a tax credit, the government would not know that solar equipment had been purchased until some time after its installation. No tax program could contain the kind of advance protections against the purchase of inadequate or fraudulent equipment that a loan program could institute, because a tax program is essentially self-policing. The fraction of cases audited would be examined by IRS agents who are not necessarily skilled in judging the eligibility of solar heating equipment. In a situation like this, pre-certification is clearly more rigorous than post-certification.

3) Third, a loan program will in the long run cost the federal government less money if only because a tax credit is essentially a gift while loans will be repaid. Given our current budgetary situation, cost factors must be an important part of our consideration. The cost of a loan program is variable depending upon the amounts involved, of course, but also depending on the interest rate charged and the repayment periods authorized. As I will discuss shortly, my own bills authorize an interest rate that would not provide an interest subsidy.

Listing the advantages and disadvantages of both loan incentives and tax incentives is really to argue that they both are appropriate policy tools. The House has already passed, as part of H.R.6860, a 25 percent solar tax credit, sponsored, I might add, by a member of this subcommittee, Mr. Wylie. Coincidentally, the loan program in H.R.3849 would complement the 25 percent tax credit prefectly by providing loans for 75 percent of the cost. Taken together, these two incentives would permit an individual to finance three-fourths of his costs with a loan and then essentially be reimbursed through the tax credit for the one-fourth down payment he made.

My purpose here today is to argue for a loan incentive approach, as I have indicated, but at the same time I think we have to support a broad package of incentives to accelerate the pace of solar development. A tax credit will be the most appropriate incentive for some, a direct loan for others, a loan guarantee for still others. All these approaches have their place.

III. H.R. 3849, H.R. 8524.

In turning to our specific loan incentive proposals, let me make clear that I am not wedded to the precise details of the bills that are a subject of this hearing. The two bills, however, do raise some basic questions about loan incentives that need to be discussed. In brief, both bills provide for a direct loan program to homeowners and home builders for the purchase and installation of solar heating and cooling equipment. The bills impose certain limits on the amount which can be borrowed, the interest rate, and the amortization rate. Only solar equipment tested and evaluated by ERDA would be eligible for purchase with loan funds. Some specific observations follow.

1) Interest Rate. Since our proposals are designed to provide incentives effectively reducing the cost of solar equipment, the interest applied to the loans is an important factor. In both bills we have proposed a formula rate linked to the monthly average rate on treasury bonds. This "cost of money" approach, plus the one-half of one percent for administrative costs is designed to provide a rate lower than existing market rates without at the same time creating a substantial cost to the government Obviously a better incentive would be a subsidy rate of three or four percent, but that would significantly increase government costs.

Furthermore, I am not completely sure that a subsidy rate would be necessary, though it clearly would be desirable, other factors not intervening. I suspect that one of the major obstacles to the expansion of solar at this time is the lack of available financing at any normal rate, due to the reluctance of lending institutions to participate in the financing of what is perceived as a higher risk system. Thus the biggest attraction of a loan program would be the sheer availability of funds rather than the existence of a subsidy rate.

2) Amortization. One issue which has engendered some controversy is the amortization schedule. The bills presently provide for an eight year payoff plan for homeowners and a fifteen year payoff for builders of multi-family structures, with the proviso in the latter case that the loan is due if the entire property is sold. Our logic in choosing this more rapid rate was that the prospect of a time in the future when the homeowner would have only minimal heating payments -- when the loan is paid off -- would be an attractive incentive. Given the mobility of the population, we felt that eight years was a suitable figure.

It has, however, been suggested by a number of those who have examined the bills that lengthening the amortization period to 20 years or tying it to the homeowner's mortgage payments would be a better incentive. (Of course, in the case of builders the price of the equipment would be subsumed into the purchase price of the home, thus effectively tying it to the homeowner's mortgage.) In the case of retrofits, a longer amortization period would result in substantially lower payments. Tying the loan to the mortgage is a "neater" approach, one which lowers the monthly payments and ties the loan to established financial channels, an important factor if we are to encourage the private sector to move more fully into financing solar equipment. Comparisons of the annual loan payment with the fuel savings involved also reflect the advantages of the longer amortization period. Assuming a maximum $6000 loan and equipment which cost $8000 (meaning a $2000 down payment), the larger payments required by an eight year amortization schedule would prevent a homeowner from really being ahead on energy savings until the eighth year, at which point the annual savings would begin to be very substantial, the loan having been paid off. A twenty year amortization, on the other hand, would permit the homeowner to move ahead on savings as early as the fifth year. The annual savings would not be as great, since the loan payments continue, but the immediate payoff is quicker.

Recognizing these advantages, I am prepared to support language changing the bills to provide for a longer amortization schedule. The most preferable approach is clearly the longer rate integrated with the existing mortgage. Integration of a federal loan into an existing mortgage or a builder's construction loan, of course, presents complex administrative problems that are not dealt with in these bills. Suffice it to say that is the ideal approach, though not necessarily the most feasible.

3) Solar Equipment Standards. The two bills contain significant protections against the purchase of improper equipment. Money obtained from the loans may be used only for the purchase of "qualified" equipment. Hardware is certified as qualified by HUD after testing and evaluation by ERDA. In our view this two-agency process is necessary because ERDA is uniquely qualified to perform testing and evaluation, while HUD will really be setting the appropriate standards and, as the originator of the loans, should retain final authority on what the funds can be used for.

Though perhaps somewhat outside this committee's purview, we must recognize that maintenance of standards is a vital part of the bills, given the substantial amounts of money involved. The bills specify that an acceptable system for loan purposes is one which meets 40 percent of heating needs and/or substantially all of domestic hot water needs. Some systems on the market cannot meet that standard, or cannot meet it in all parts of the country. Our purpose in setting tight standards was to protect against phony claims and equipment, but also to move the program out of the "new toy" category and insure that any equipment purchased will make a substantial contribution to energy conservation.

IV. Conclusion

Let me conclude by returning to the three points I made in the beginning. First, if we are to achieve meaningful energy savings in residential heating and cooling, then conversion to non-fossil fuel energy sources is essential. Second, the obvious choice in that case is solar energy. The technology exists; solar houses exist and have baan functioning for years. Solar is already cost competitive with electric heat on a life cycle basis in most parts of the country, and changing fuel prices make it only a matter of time before it will match oil and gas nationwide as well.

Third, this process of conversion is an inevitable one, given the increasingly favorable economics and the growing awareness of the limitations of fossil fuels. The energy crisis has made it the policy of this government to accelerate the process of conversion to solar and other energy alternatives as part of our conservation effort. The relevant question for this committee is how best to assist that acceleration, specifically, what incentives would be most appropriate and most effecitve? While I believe in and am committed to a direct loan program, I hope the effect of my testimony and that of those who follow me will be to stimulate the members of this committee to undertake a thorough study of the incentives question, which will lead to the rapid development of meaningful incentives legislation.

Mr. MOORHEAD. Thank you, Mr. Gude, for an excellent statement, very thorough and well thought out. Let me say I agree with you that conversion is inevitable. I agree with you that we should do all we can to accelerate it. And I also agree with you that the question is how to do that.

Mr. St Germain, do you have any questions?

Mr. ST GERMAIN. Mr. Chairman, I would just compliment our colleague on a very, very detailed statement. Obviously a great deal of work and time has been put into this, and frankly, to the extent that I would not presume to ask any questions at this point.

Mr. GUDE. Thank you.

Mr. MOORHEAD. Mr. Wylie?

Mr. WYLIE. Thank you, Mr. Chairman.

I, too, want to compliment you, Mr. Gude, for the excellent statement you have given and the considerable amount of work that you have obviously put into this bill. And I do agree that solar heating and cooling incentives are necessary to our overall energy structure. There is no question about that, and we have discussed my tax credit proposal previously. Thank you for your support.

There was a fellow who was Secretary of Defense one time who established a policy of fly before you buy. And that is the whole theory behind my so-called tax credit proposal. In other words, a unit should be in place and an ascertainment made as to whether it does work, whether it will convert solar energy into heating and cooling systems. I for one think this is a better approach.

Do you not think there is something to recommend that approach? That the end product ought to be examined to see if it does work, since we are really in a premature state of the art as I see it.

Mr. GUDE. I think either with a tax incentive or loan program, we are in a position to certify the good units and to reject bad units that will come onto the market. There is no doubt about it, that the solar heating and cooling industry is going to attract a few fly-by-nights, along with the reliable manufacturers and researchers. But I think it can really work with both the tax incentive and a loan program.

And I recall that I supported your measure. I believe this is one way. With some builders and some people, this is an option. But I think there is a need for a loan program, too. Whether you would want to make them exclusive of each other, so that a person could not take advantage of both, that would be a good question.

Mr. WYLIE. You did support my tax credit measure, and I appreciate that. It is likely that I will support your bill. But I want to get into a couple of other questions.

First, I think my proposal recommends from the standpoint of simplicity and the fact that it does have a direct impact on the affected individual or group. Having said that, I go to your language on page 2 of your bill, which says that "the loan will be made available to individuals and families owning and occupying one- to four-family residential structures and to persons engaged in building residential structures of any kind."

Now, does that refer to the builder generally?

Mr. GUDE. Yes. That refers to the builder generally. And I think the economics of solar heating show that the greatest benefit and value will come in multifamily units.

Mr. Wylie. Well, let us assume for a minute that a builder obtains a construction loan for the construction of, say, 200 units. He decides that 50 of them will be equipped with solar energy equipment. Now, does he have to have two determinations made as to whether the houses equipped with solar energy equipment will qualify as far as a loan in your bill is concerned? How is the determination to be made as to the payoff amount on the whole project?

Mr. Gude. Well, the way this legislation is presently constructed, if he sells the units after construction, then he would have to pay the loan off. And this would be separate and apart from the other financing of the project. It would be a separate determination of his eligibility for a loan for the solar heating aspect of the units.

Mr. Wylie. That is the point, it would be a separate determination?

Mr. Gude. Yes.

Mr. Wylie. In other words, what I am saying is the contractor goes into a bank or to a mortgage lender and makes application for a construction loan on a project of, say, 200 units. Now, he wants to equip 50 of those with solar energy units. Is a separate loan determination to be made by the prospective lender? Does the builder have to go to HUD and get that approval first?

And then what about the payoff?

Mr. Gude. Under my bill, he would have to go to HUD for one of these solar loans. They would have to certify as to the technology.

Mr. Wylie. If a builder pays off his loan at the time he sells a house, what good is this loan incentive to him? It would be only for a short period of time.

Mr. Gude. Well, this incentive, I think, is going to give the technology the stamp of approval. The buyers of the units would be attracted by the fact that their utility costs over the years are going to be sharply reduced. And again, it gets to the matter of a marketing problem. I feel that such a program makes the marketing of his units a much more attractive job.

Mr. Wylie. But the builder would pay back a solar energy loan to HUD, wouldn't he? Your bill calls for a direct loan program, as I understand it, and the loan would come from HUD for the solar energy houses.

Mr. Gude. That is right.

Mr. Wylie. Would he pay HUD back when he sells a house, when a house is completed or when the total subdivision is completed?

Mr. Gude. At the time of the sale of the unit, he would have to pay HUD back. At that time he would have to pay off that part of the loan or loans which went to the solar heating unit.

Mr. Wylie. I think this is something we will need to consider as to the mechanics of it. Are there to be two separate loans; a separate loan arrangement with HUD for a loan on a solar energy house and a separate loan arrangement for construction of the whole subdivision? I have just been given a note that my time has expired.

Thank you.

Mr. St Germain [presiding]. Thank you, Mr. Wylie.

Mrs. Boggs?

Mrs. Boggs. Thank you, Mr. Gude, for your excellent testimony and I was so pleased to see that you feel that we do need to develop the consumer market. That is what needs to be done at this point. I also appreciate your detailed account of both approaches, the loan approach and the tax incentive approach.

I am told that the average turnover of a house, back in the 1960's, was about 8 years, and that now the new statistics reveal that the average turnover is 5½ years nationwide. I would deduce, then, that the loan approach on the mortage credit might be the better course for the people who do move often, even though they would not enjoy the advantages of a lower rate, particularly for their energy bills.

I do thank you very much and this should be very valuable information to all of us.

Mr. GUDE. Thank you.

Mr. ST GERMAIN. Mrs. Spellman?

Mrs. SPELLMAN. I too, Mr. Gude, want to thank you for what is excellent testimony. I am in full agreement with what you say. I think that this Nation has got to find some alternatives to fossil fuels and that we need to be moving very fast. I know in our own State, the FEA has just recently announced that some of our industries may have to shut down this winter because of a shortage of natural gas.

And I am sure Maryland is not the only State that is going to be affected that way. So we really have to have to seek and seek very quickly alternative methods of providing energy.

In Prince Georges County, I guess the greatest pioneer in the field of research on solar energy, Dr. Harry Thomason, has been heating his homes with solar energy for a long, long time. I can remember riding down the road and people would think that his house was sort of an oddity at the time. Now as I recall, he has heated his home for about 10 years primarily with solar energy for a full winter for $4.65. That was for 31 gallons of oil in those days.

Well, of course, that oil would cost more today. But that is certainly quite different from the costs of all electric homes that are being heated. My daughter in Columbia has an all-electric home and the cost has doubled in the few years she has been there to the point where their electric bill equals their mortgage payment, which was too large in the first place.

So I think what you are proposing is something that we really ought to be moving on and moving on very quickly. I just have a couple of questions. I agree with you that we ought to have various kinds of incentives. How would you view the feasibility of the loan guarantee versus the loan approach?

Mr. GUDE. The loan guarantee would leave the question of availability of money up to the banker, whereas the direct loan approach, I think, puts the government more squarely behind the program and is going to guarantee more money flowing into this program, in that a builder who thinks this is attractive and something that is very salable and interesting to the home buyer, can have the cash flow. He can get this money available quickly at the time he is building.

And then at the sale of his house—why, he does have to repay HUD—but it gives him liquidity and ability to move and take advantage of developing a market. So I think the direct loan is good and I might add that, of course, this legislation does not say that this direct loan program will go on forever. It terminates in 10 years, and so we are not underwriting forever a direct loan program.

But we do have a crisis. Just because the OPEC nations have been quiet lately does not mean that in a week or so we are not going to be right back into the soup. And I think we have really got to put it on the line. That is why I think the direct loan program is best. Certainly the guaranteed loan program is useful also, but not as good in my opinion.

Mrs. SPELLMAN. You are right. Unless we can find ways of taking care of our own energy needs, we are not going to be able to control our own destinies and this is, I think, one of the most important things that this Nation can be and should be working on.

I am personally familiar with those homes there in Prince Georges County. Has the art of using solar energy gone beyond the experimental stage in your estimation?

Mr. GUDE. In some sections of the county it is more advanced than others. There are several well engineered homes in my own district. Everett Jones, one of our former park and planning commissioners has built one in Damascus. There is a very good example of a solar heated home in Mt. Airy. And, of course, you mentioned Harry Thomason's excellent installation in your own district.

Mrs. SPELLMAN. I thank you very much. This is something I hope we will be moving on quickly. And you have done a great job of thinking it through.

Mr. GUDE. Thank you.

Mr. MOORHEAD [presiding]. Mr. Rousselot?

Mr. ROUSSELOT. Thank you, Mr. Chairman.

We appreciate very much your coming here and taking the time and also putting as much thought as you obviously have into your testimony, which I think will be very, very helpful to us as we consider ways that this subcommittee might take some appropriate action to accelerate the use of solar energy in either individual or multifamily homes.

And so we are very, very grateful for your taking the time to give it the obviously thorough study that you did.

Now, as a practical matter, most people are used to buying homes and paying off through a mortgage equipment, heating and cooling equipment that might be included. And FHA is in the process of developing a way that such equipment can be put in their mortgage. We are informed that the FHA minimum standards for the use of solar energy will not be completed until May, and I am sorry to hear that it is taking that long. But it is progressing, and presently you can get solar energy included in an FHA mortgage with FHA central approval.

So, this is now a reality. Now, is it not true, because most American people who buy either new or existing homes are used to including this type of equipment—heating and cooling—in their mortgage, and maybe this is the way to do it, rather than a direct loan program which would be a second loan that they would really have to pay off.

Why not include it in the mortgage?

Mr. GUDE. Well, the direct loan program, as I see it, would be an incentive to the builder. As I said, it gives him the liquidity to add this to the one or more units that he is building. It gives him the cash to do this and then in the sale of the house, the homeowner in effect folds this into his mortgage.

Mr. ROUSSELOT. Well, we have to be concerned about not just the incentive to the builder—and I realize that has to be present, although those incentives are beginning to appear because manufacturers of systems are beginning to appear generated—that we also have to be concerned on this subcommittee with the ultimate consumer, the buyer of either the individual home or the person who wants to include it in an existing home, or the person who may become an owner or a tenant in multifamily housing.

Now I am sure you are aware that there are projects now underway—in California we have one in a joint venture with the Jet Propulsion Laboratory in Orange County, which also involves the California Institute of Technology, the National Science Foundation, FEA, and ERDA. A solar heating system has been installed at Timbers Apartments located in El Toro, California. It has been in operation for 9 months and is operated in conjunction with Southern California Gas Company. And they have proven that they can save up to 40 percent by the use of the solar system that is part of the complex. Another project involving the same participants in a new, rather than in an existing apartment project is under construction in Upland, California, and is scheduled to be completed next year.

Now my question is would we not really be better off to try to find the ways to fold it in, as you say, to the mortgage system because that is the way consumers in this country are used to buying housing?

Mr. GUDE. Well, as I said, I think this legislation specifically approaches the problem of the builder in being able to get the necessary funds and the liquidity to move ahead. And then it seems to me it is folded into the mortgage at the time of the sale.

Mr. ROUSSELOT. But if the builder knows that he can pass on the cost to the consumer through the mortgage, and assuming he does, I think he may only need tax incentives. The thing that really basically moves a builder is the tax incentive to build it and to include it in the facility. And would we not really be better to concentrate on the tax incentive for the builder and the lending capacity through the mortgage for the equipment, just as we do presently with systems for air-conditioning and heating?

Would that not be the best way to go?

Mr. GUDE. For some people, yes. I think for some builders this would be an attractive incentive. I think the tax incentive is helpful to some, but not to all.

Mr. ROUSSELOT. You and I know builders well. We have them in our own areas.

Mr. GUDE. There are all kinds.

Mr. ROUSSELOT. Yes; there are. And, of course, that is one reason FHA makes an attempt to have standards to weed out those who would misuse the system. But is it not really, if the tax incentive is present to the builder, is that not really going to motivate him more to utilize existing or developing systems of solar energy?

Mr. GUDE. Yes; it is going to help. And that is why I supported it. But I think it is a question of degree. I think there are some that would be very attracted to this program. And, of course, in addition the original homeowner can get a loan through this program to retrofit his house, which I am sure is something some will do.

Mr. ROUSSELOT. You are really saying you think we need the combination of a direct loan program to the builder as well as the tax incentive.

Mr. GUDE. Yes. Or, as I said, I think if not the direct loan—I know that some people have problems with a direct loan program—a guaranteed loan program.

Mr. ROUSSELOT. Well, especially on the basis that the shape of our U.S. Treasury is in these days, where that money is going to come from, even—and I appreciate your legislation providing that it shall be at least, I think, one-half percent above the going market rate, where today Treasury bills are anywhere from about 7.4 percent. So, it would be up around 8 percent. I appreciate your building in that consideration.

Mr. GUDE. And also as I said, you stimulate something very important, building more consumer attractiveness into this program. But at the end of 10 years the program would be terminated.

Mr. ROUSSELOT. Mr. Chairman, I ask unanimous consent that my colleague's comment on some of the things that were in the Washington Post article on Sunday, November 2, 1975, relating to the solar system hit by a storm, relating to the concern about the people in the field selling systems that are clearly misrepresented, because I think that that is part of the problem we face as to how we can prevent utilization of any Government guarantees or moneys for systems which may not be effective.

Mr. MOORHEAD. You want him to comment for the record, after having opportunity to read this?

Mr. GUDE. I would be happy to. That is a problem, regardless of whether you use tax incentive, guaranteed loan, or direct loan. That is a problem and our people really have to be on top of it, so we do not have too many people that are bilked in the course of this.

[The article referred to by Congressman Gude entitled "Solar System Hit by Storm" from the Washington Post, dated November 2, 1975 and Mr. Gude's comments follow:]

[From the Washington Post, Nov. 2, 1975]

SOLAR SYSTEM HIT BY STORM

CRITICS CHARGE ISC OVERSTATES PERFORMANCE CLAIMS

(By Nancy L. Ross)

Into every solar heating salesman's life a little rain must fall, or so it is said. Of late, a few umbrellas have already been raised against an expected federal cloudburst.

An official storm signal was put up last week by Virginia Knauer's Office of Consumer Affairs. It announced it had turned over to the proper federal legal authorities for investigation and possible prosecution a number of allegedly exaggerated claims dealing with the anticipated performance of solar heating systems.

At the same time, Joe Dawson of the Knauer office, is putting the final touches on a consumer's guide to solar heating designed to alert the unwary, untrained public to the dangers presented by fastbuck operators in the field. Government agencies are readying technological standards for solar systems and the disturbed industry's trade group, the Solar Energy Industries Association, is drafting a code of ethics.

According to reliable sources, these actions are aimed at one company in particular, International Solarthermics Corporation (ISC) of Nederland, Colo., and its licensees and distributors who operate nationwide under different names. Some of the trade names are Sungazer, Sun Glow, Energy King, et cetera.

ISC advertises its system, built around an A-frame backyard solar furnace the size of a bathroom floor, can reduce annual heating bills up to 90 per cent in areas like California. ISC says it can provide 72 per cent of the heat requirements of a 1,000 square foot home (58 per cent of a 1,500 square foot house) in the Washington area through its solar collector, which comes in three sizes: 96, 128 and 160 square feet. The system costs between $4,500 and $6,000, although a Bowie, Md., franchise claims he can sell it for as little as $3,500.

ISC's claims do not jibe with currently accepted solar technology, a fact that has made it the center of a growing controversy among scientists and competitors. ISC's chief, John H. Keyes, a philosophy major turned solar inventor, asserts he is the victim of a conspiracy. In a recent interview with the National Observer, he alleged his files had been rifled a la Ellsberg's psychiatrist.

According to experts at the National Bureau of Standards, the Energy Research and Development Administration and in industry, the rule of thumb in determining the size of a solar heat collector—the honeycomb array of cups that captures the sun's rays—is one square foot per 2.5 square feet of house surface in this area. Thus a 2,000 square foot house would require an 800 square foot collector to provide 70 per cent of the space heat required in this climate.

The average price per square foot of collector for an "active" system (with pumps) ranges between $10 and $20. Cheaper prices may be quoted for a "passive" system or for parts without installation charges.

Here, too, experts say a high efficiency range—or the amount of the available solar radiation caught by the collector and put to use—is generally impossible to achieve. On sunny days the average runs about 55–60 percent; on cloudy days, 35–40 per cent.

According to Henry Anderson of Applied Solar Technology, a company which assesses homes' solar heating prospects but does not sell equipment, the average house in Washington needs 75 million BTUs of energy per year at a cost of about $9 per million (for electricity), or $657 annually. A 400 square foot collector system with 50 per cent efficiency would supply something over 30 million BTUs annually and save about $300 a year, or 40–50 per cent of one's fuel bill.

(Figures vary according to the design of the house, the tilt of the collector and many other factors. Also neither the amount of energy nor the efficiency rate increases in direct proportion to the size of the collector, so accurate comparisons are impossible for the amateur to figure.)

Reducing the equation to its simplest terms, Anderson calculates the average house would require a 400–500 square foot collector at $20 a square foot to supply 50 per cent of a home's needed energy. At this rate the investment would be paid off in 12 to 15 years, assuming 7 per cent inflation, but excepting finance charges on a loan to pay the initial costs.

Dawson's guide, "How to Buy Solar," discusses many of these measurements in easy-to-understand terms. It also raises and attempts to answer, legal, tax, insurance and other questions the prospective buyer faces. The book does not mention ISC by name, but it has a section on insulation which should offer a clue to those curious to know how Keyes' 60 square foot collector costing $6,000 can supposedly do the work of a 500 square foot one costing $10,000.

Keyes' model home has 18 inches of glass fiber insulation in the ceiling, 3.5 inches in the outer walls, double paned small windows, 1.5 inch thick wood doors with storm doors plus good weather stripping and caulking.

Few existing houses have more than four to six inches of attic insulation and two to three inches in the walls. Solar experts say it would probably be physically impossible and economically ruinous to put into an existing house the amount of insulation ISC requires. And building a new house designed around such a solar system would also be expensive if it works. ISC has not made test data public and consumer experience with the system is lacking.

According to the National Observer, ISC licensees pay $75,000 to produce the system Keyes designed, plus a royalty on each unit. Manufacturers sell franchises to distributors and dealers for between $5,000 and $10,000 each. Some licensees have invested as much as $300,000.

As Keyes told Paul C. Hood of the Observer, "This is not a fast-buck operation . . . It's not the kind of thing you can get in, get your money out, and leave for Rio."

COMMENTS BY HON. GILBERT GUDE ON ARTICLE IN THE NOVEMBER 2, 1975, WASHINGTON POST ENTITLED "SOLAR SYSTEM HIT BY STORM"

In regard to the contents of the article, I would make the following observations.

(1) In reference to complaints about solar equipment, the article mentions only one company, International Solarthermics Corporation (ISC). ISC uses a backyard A-frame solar furnace containing rock for heat storage. This approach is considerably different from the rooftop collector-hot water storage systems which are more widespread, and any allegations concerning the one cannot automatically be extended to the others.

Second, the allegations in question cover exaggerated claims not met by the technology, rather than the basic nature of the technology itself. In other words, if the charges are correct, the equipment works; it just does not work as well as is claimed. This, of course, is not an excuse, since sales will be made on the basis of claims, and exaggerated claims threaten to jeopardize the entire industry by destroying its credibility. Since the complaints in question, however, refer primarily to marketing and expectations, I don't believe the basic effectiveness of the solar heating idea is questioned, though we must all continue to guard against unrealistic predictions of what solar can do.

(2) Complaints against manufacturers exist in every industry, and while we must do everything we can to get phony equipment off the marketplace, it does not automatically follow from the presence of complaints that the entire industry is crooked. I would further point out that both H.R. 3849 and H.R. 8524, the subjects of this hearing, contain strict protections against unqualified equipment being purchased with loan funds. Equipment would have to be evaluated by ERDA and certified by HUD as meeting its performance criteria before it could be purchased with loan funds. This guarantees the marketing of quality solar products through a federal incentives program, and I believe strongly we have to have protections of this kind connected with any kind of incentive—loan programs or tax credits.

(3) At the same time, however, I think we also should guard against stifling innovation. This is, in many respects, an infant industry which still has room for further technological breakthroughs in some areas, although the basic concepts are well established. While we must protect the public against solar equipment which does not work or does not meet advertised claims, we must not be so hasty as to pounce on anyone with a new or different idea. Room for innovation remains, and it should be nurtured, leading to the conclusion that the most appropriate kind of federal standards are those in the area of performance criteria and advertising claims.

(4) Without question, improved insulation is an important part of energy conservation and can contribute a great deal to properly functioning solar equipment. Where claims about solar heating are derived from data on heavily insulated homes, those claims should so indicate. Solar manufacturers, however, can do the cause of energy conservation a great service by stressing the importance of insulation both in solar homes and conventional homes.

Mr. ROUSSELOT. Mrs. Knauer says she is producing a booklet to protect the unwary, but I have not seen it.

Mr. GUDE. I have met one developer who has a magic formula, which he keeps saying he is going to have patented, and you put this in a solar heating unit, and you just have a little tiny unit in your roof, and you can heat the whole house with no trouble at all. And we have

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not quite gotten to the bottom of these magical properties of this material. But some people are going to buy it before they are sure it really works. I will be glad to comment.

Mr. ROUSSELOT. Thank you.

Mr. MOORHEAD. Thank you very much, Mr. Gude.

The subcommittee would now like to hear from our distinguished colleague from New York, Hon. Richard L. Ottinger, who has also been very active in this field, and in the field of the environment.

STATEMENT OF HON. RICHARD L. OTTINGER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. OTTINGER. Thank you very much, Mr. Chairman.

And I would also like to express my appreciation to the Chairman of the subcommittee for being here today to help with this legislation. We are also jointly involved in other legislation to promote solar energy to be used on Federal buildings, where the Federal Government could create a market for solar equipment that I think is compatible with this.

As I will state in my formal statement, I am a member of the Science and Technology Committee, where we have been very active in trying to promote research and development and the standards for solar equipment, and I will speak to that a bit later.

Congressman Gude, who authored these bills, is to be congratulated for his work and commitment in getting solar energy technology into use now, by helping homeowners to be able to buy it and builders to be able to install it, and by helping the small businesses that have done the lion's share of solar equipment development get into production.

Your subcommittee now has the essential role to play in bringing solar technology out of the R.D. & D. stage and into Americans' homes, office buildings and factories. Your work in this subcommittee will be the pivotal thrust that will bring this essential source of clean, readily available and renewable power off the drawing boards and into reality. I am concerned that we move quickly and decisively to show the country that we in Congress are aware of the needs of builders and homeowners for assistance in solving some of the current financial problems associated with putting solar energy into operation; and that we are also aware of the special involvement of small businesses in the production and supply of solar equipment.

I am a member of the House Committee of Science and Technology and have been very involved and interested in the work of the Energy Research and Development Administration in both conservation and solar energy. The work of ERDA will be continually important in the development of solar energy, but let me emphasize to you that based on the many hours of testimony I have heard these past months, there is proven technology and technological expertise throughout the country for solar heating and cooling that should be put into practice right now.

The Office of Technological Assessments' analysis of the ERDA National Plan completed this October states that commercially acceptable equipment for solar space heating and water heating is available and price effective in today's market. The American Society of Heating, Refrigeration and Air-Conditioning testified last May before the Subcommittee on Energy Research, Development and Demonstration of which I am a member that the technology for heating and cooling is here for commercial buildings. Solar energy is in widespread use for hot water heating in much of the world. Japan has more than two million units in use, and widespread use also exists now in Australia, New Zealand, and Israel.

It has also been demonstrated rather dramatically during recent months that homeowners are ready to move with solar energy. Last fall, 7,000 individuals responded to a television program on solar energy asking for information about installing solar units. The Massachusetts Electric Co. had more than 5,200 customers respond to a solar water heating demonstration program that the electric company anticipated would serve only 100 customers. Both ERDA and the Housing and Urban Development Administration have been beseiged with individual requests for information about the Heating and Cooling Demonstration Act programs which will probably only involve 2,000 demonstration units.

Solar heating and cooling has the possibility of a very positive effect on our economy. As you are aware, the construction industry represents about 10 percent of the Nation's gross national product, second only to the food industry. The Sheet Metal Workers International recently commissioned a study prepared by Stanford Research Institute which forecast a potential $2 billion operation for a solar heating and cooling industry by the year 1990 if we push forward with a strong national commitment.

A further plus to be kept in mind is that solar energy technology is virtually free from environmental damage. It does not cause air, water or thermal pollution. It does not require solid waste disposal, fuel storage or pipelines, transmission lines or other forms of fuel transportation. Furthermore, solar equipment installed on a building's roof reduces land use associated with other energy producing methods.

Solar energy will help materially to advance the goals of energy independence, but only if we start installing it now. According to a study done by Fred S. Dubin of the Dubin-Mindell-Bloome Engineering firm, if energy used in all buildings could be reduced just 25 percent, we would be able to save 3 million barrels of oil a day. The Federal Energy Administration in its Solar Task Force report states that solar heating and cooling could save 1 million barrels of oil per day by 1985 and that solar energy could provide 10 percent of our national energy demand by 1990. And this, of course, would save us hundreds of millions of dollars in not having to import expensive oil, which we have to do at the present time.

To bring solar energy into use now, for all the above reasons, we need financial help for homeowners and builders. The Office of Technological Assessments' report states that

> There is a clear need for equitable treatment of the solar energy user. The individual user, turned energy producer, does not now receive the benefits of investment tax credits, depreciation allowances, depletion allowances and other incentives provided to corporate producers of fossil fuels. No incentive recognizes his contribution to society in reducing pollution, preserving fossil resources or reducing the nation's dependence upon imported fuel.

And that is a quote from OGA.

Although solar equipment can be economically advantageous on a first-cost basis for those areas of the country relying on electricity for space heating, it is more expensive initially than conventional systems using heating oil and gas. I urge you to recognize the importance of equalizing these costs and benefits for those who will now wish to use solar energy.

I also urge you to consider the special role that small businesses have and can continue to play in the development of solar technology, its distribution and servicing.

Solar systems for space heating and cooling are not technically complicated. Equipment can be easily brought to the site of construction and installed. Therefore, many local small manufacturers and workers now out-of-work could work making and installing solar equipment without lengthy or complicated training.

Small businesses throughout the country have really been the champions and inventors of many of the solar systems we have now. They are ready and waiting to go into production, but they lack the capital to do so, and the assurance of markets. At a recent meeting of ERDA on the Solar Heating and Cooling Demonstration Act, 64 out of 112 business representatives registered as small businesses.

I think it is important that this particular aspect of the development of solar energy not be overlooked and that you provide for small business participation through the loan program the legislation before you proposes.

The overriding issue is how can we get solar heating and cooling into homes and buildings across the country and do it rapidly. The bills before you today deal with the financial incentives which are so terribly important to accomplishing this goal.

I would like to, if I could, comment on some of the questions that were raised to Mr. Gude. One is the concern about the inadequate solar systems which are coming on the market, and there is very detailed provision in this legislation for certification of equipment that is available for these loans, both by ERDA and by the Secretary of the Department of Housing and Urban Development, who has to establish standards for this program which it receives from ERDA, and only qualified equipment that will satisfy 40 percent of the heating needs of a particular house will qualify. So that I think we have protection in this regard.

The question was raised, what is the relationship between loans and tax credits. I also supported Mr. Wylie's tax credit program, and I think both are very badly needed. The tax credit for a period of time covers the initial first cost of solar equipment, and it will give an actual incentive to make this equipment, while it is being perfected and gotten into mass production, more competitive than fossil fuel systems.

The loan is not subsidizing the equipment, as such, but is making it possible and for individual owners that may want to retrofit their homes to be able to do so, and to have the cash up front. And I think that is exceedingly important. At the present time, it is very difficult for a person to get a loan for solar equipment and builders are very hesitant to add solar equipment, even though it is a kind of sexy addition to their project, because they are having such difficulty in selling homes at any rate, and adding to the initial first cost is a factor which they do not want to undertake at this time. So that having this kind of financial assistance, I think, really will make a difference.

With respect to the FHA mortgage suggestion that Mr. Rousselot has suggested, a great many houses are not financed—are not available for financing with FHA. I think that an FHA program complementing this would be fine, but in my area of the country, very little of the housing qualifies for FHA financing, and the builders generally do not use that financing, so that I do not think that would solve your whole problem.

I do think that it is terribly important—and I know you will hear some people who will say, you know, let's wait. Let's get the solar equipment more perfected before we move. I was in Air Force procurement in my time in the Service, and I saw that time after time we would fail to get aircraft into the air because new developments would come along which would be insisted to be incorporated into the new model of the aircraft. It would get delayed and delayed, and expenses would be incurred as the designs were changed to accommodate the new equipment. I think that it was a very disadvantageous program for us.

I think we should go now, particularly in view of the tremendous energy crisis that we do face, and get the experience that providing the presently available adequate equipment for both hot water heating and for space heating and cooling of commercial buildings on the road and into place. As we get more perfected equipment, the building industry unquestionably will incorporate the more sophisticated equipment into their units.

Furthermore, as we get this equipment into use, it will be mass produced, and the need for this kind of financial incentive will be eliminated, because I am quite sure that once this equipment does get in mass production, it will be cost competitive in every way.

[The prepared statement of Congressman Ottinger follows:]

Prepared Statement of Congressman Richard L. Ottinger

I want to thank you for the opportunity to present a statement on these two vitally important pieces of legislation, H.R. 8705 and H.R. 4507.

Congressman Gude, who authored these bills, is to be congratulated for his work and commitment to getting solar energy technology into use now by helping homeowners to be able to buy it, builders to be able to install it, and by helping the small businesses that have done the lion's share of solar equipment development get into production.

Your committee now has the essential role to play in bringing solar technology out of the R.D. & D. stage and into Americans' homes, office buildings and factories. Your work in this committee will be the pivotal thrust that will bring this essential source of clean, readily available and renewable power off the drawing boards and into reality. I am concerned that we move quickly and decisively to show the country that we in Congress are aware of the needs of builders and homeowners for assistance in solving some of the current financial problems associated with putting solar energy into operation; and that we are also aware of the special involvement of small businesses in the production and supply of solar equipment.

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To bring solar energy into use now, for all the above reasons, we need financial help for homeowners and builders. The Office of Technological Assessments' Report states that "there is a clear need for equitable treatment of the solar energy user. The individual user, turned energy producer, does not now receive the benefits of investment tax credits, depreciation allowances, depletion allowances and other incentives provided to corporate producers of fossil fuels. No incentive recognizes his contribution to society in reducing pollution, preserving fossil resources or reducing the Nation's dependence upon imported fuel."

Although solar equipment can be economically advantageous on a first cost basis for those areas of the country relying on electricity for space heating, it is more expensive initially than conventional systems using heating oil and gas. I urge you to recognize the importance of equalizing these costs and benefits for those who will now wish to use solar energy.

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I think it is important that this particular aspect of the development of solar energy not be overlooked and that you provide for small business participation through the loan program the legislation before you proposes.

The overriding issue is how can we get solar heating and cooling into homes and buildings across the country. The bills before you today deal with the financial incentives which are so terribly important to accomplishing this goal.

Mr. MOORHEAD. Well, thank you very much, Mr. Ottinger, for an excellent statement. And you bring to this subcommittee the benefit of your experience on your Science and Technology Committee, which is a great help to us.

I have no questions at this time.

Mr. St Germain.

Mr. ST GERMAIN. I have no questions.

Mr. MOORHEAD. Mr. Wylie.

Mr. WYLIE. I would just like to ask a couple, if I may. Knowing that you have studied this problem, just as I have, and have spent a considerable amount of time on it—and I do feel that solar energy is the energy source of the future, and I am only attempting to hasten the day when it will be in use by the public all across the land on a mass produced basis. The problem I have, a little bit, with your bill, and you can help me with this, if you will—I am being the devil's advocate, if you please, by asking this question—how does this bill provide an incentive to produce a solar energy house? Would this not actually increase the cost to the ultimate purchaser or consumer?

Mr. OTTINGER. Well, no. At the present time, the consumers are finding it impossible to get bank lending or to get the solar equipment addition included in their mortgages.

Mr. WYLIE. Let me rephrase the question. Solar energy is a viable source for heating and cooling right now. There is a solar energy home in being in Columbus, Ohio. Solar energy has provided about 70 percent of all the heating and cooling needs in that house for a period of almost 10 months. The problem is that it costs so much to install solar energy equipment that few people can afford it, so I offered a tax credit proposal which simply stated that it would reduce the end cost to the person who ultimately buys the home.

I think we must reduce the cost if we are going to encourage people to build or buy solar energy homes, or we must determine a way to produce cheap solar energy units on a mass production basis. That is what HUD is up to right now, as I understand it; developing the research for development of a prototype program.

But does not the loan program which you have suggested actually increase the cost, in that there is a 0.5 percent additional interest rate for administrative costs. We really do not know how much cost that will add; plus the fact there would have to be at least two separate sets of books where a builder is building a solar energy home as a part of a subdivision where some of the homes would be conventional.

And I might, in that connection, ask you to comment on Mr. Barfield's statement, in his prepared statement in which he says:

In its present form, the proposed incentive program could result in windfalls to those homeowners and others who could economically justify the use of solar energy based on current energy costs.

Mr. OTTINGER. I do not see, considering that most homeowners do borrow money to finance their homes, that providing a loan program which will still be at a below-the-market rate, though not a below-the-market rate for Government securities, but certainly a below-the-market rate for mortgages, is going to be any discouragement to use solar energy. Quite the contrary, I think it is going to enable the use of solar energy.

To the argument that this is a program which is likely to be more helpful to affluent homeowners or middle-income and upper-income homeowners than it is to low-income howeowners, I would say it is probably so, though there are a group of homeowners in New York City, slum dwellers, who are rehabilitating their own homes, that are putting solar energy in a slum dwelling, with financing for the solar addition coming from HUD in a demonstration program, so that may not be universally so.

But I think that there is an overriding national importance here of getting solar equipment into use and getting it mass produced and providing the oil savings and the pollution savings that the installation of solar equipment would provide, so that while my own personal record would indicate that I have a general bias toward programs that are of particular help or at least treat the poor segment of our population on an equitable basis, I do not really think that is the thrust of this legislation. Whether or not it helps the poor, I think it will help the country get into the solar energy business, and replace existing fossil fuel heating units that are used by middle-income and wealthy individuals with solar units, and I think that is fine.

Mr. WYLIE. Well, I do not want to dwell on this, but on page 2 of the Gude bill, which you are testifying in favor of here, it says that the Secretary is authorized to make loans as provided in this section to individuals and families owning and occupying one- to four-family residential structures.

Now, we are talking about retrofitting there; are we not?

Mr. OTTINGER. Yes.

Mr. WYLIE. We are converting existing houses into solar energy homes?

Mr. OTTINGER. Right. And I say the overriding importance is those people are either going to use fossil fuel or they are going to use solar. At the present time, they are not using solar for a variety of reasons. One is the lack of availability of financing. So it is to his advantage, even though this is a particular help to people who cannot afford owner-occupied one- to four-family home. It is in the national interest that they be encouraged to use solar.

Mr. WYLIE. But if a person cannot afford a conventional loan then how could he afford a solar equipment loan because it would be more expensive? Actually, the loan would go to a builder, as I have suggested, and the builder would either have to add the cost of the solar energy loan to the person who is buying the house, or the builder would have to take a loss on it.

Mr. OTTINGER. With respect to the cost of these loans, they are going to be cheap loans to the individual. These are below the market. They are at a rate equal to the average market yield on all marketable interest bearing obligations of the United States.

Mr. WYLIE. But the cheap loan—cost would be determined how?

Mr. OTTINGER. Plus one-half of 1 percent.

Mr. WYLIE. But would the cheap loan go to a person retrofitting his house or to a person who is buying a new solar energy house?

Mr. OTTINGER. All of the loans under this program were going to be at that rate of one-half of 1 percent above the market for U.S. securities.

Mr. WYLIE. To the builder of a new solar energy house?

Mr. OTTINGER. If he is building a new solar energy house, right.

Mr. WYLIE. OK, I thank you, Mr. Chairman.

Mr. MOORHEAD. Mr. Rousselot.

Mr. ROUSSELOT. Thank you, Mr. Chairman. Again, we are appreciative of our colleague and of his interest in this area. Many of us on this subcommittee, we wish to assure you, have a continuing interest in the use of solar energy, especially in the single family dwelling category, and feel that we should move on it to see that the technology is, in fact, utilized.

Now, I have talked to many of the mortgage people in California and I do not find an unwillingness on the part of the private market to include relatively well-proven solar systems in the heating and cooling part of either new housing or existing housing, if it is an add-on loan. So, I really do not know that the case has been made that we have to have the entry of the Federal Government in a direct lending program to provide the kind of incentive that we are talking about.

I appreciate his comment on the fact that FHA only insures relatively 20 percent of the marketplace in mortgages, so that, obviously, their entry would not amount to total coverage. But, has the gentleman found any evidence that the lending institutions which lend on individual homes are unwilling to accept this kind of equipment as a normal part of the mortgage?

Mr. OTTINGER. Yes; though I think we can get some evidence in that regard, I get it primarily from the builders who have been interested in solar energy and have found that the banks are unwilling to finance that additional cost because they are not sure they are going to get it back on resale of the house.

Mr. ROUSSELOT. And the reason for that is the additional cost of the dwelling; is that correct?

Mr. OTTINGER. That is correct.

Mr. ROUSSELOT. Well, I know you support the direct loan concept and I hate to keep coming back to the same place, but is it not true that where we really have to provide the incentive is with the builder, to get him to include this kind of equipment in a home or in a multifamily dwelling?

Mr. OTTINGER. One of the incentives that, I think, would be meaningful to him would be to finance the solar equipment outside of the existing financial resources that are available to him and at an interest rate that is lower, than would ordinarily be available to him on a mortgage.

Mr. ROUSSELOT. But, a direct loan to the builder does not lower the ultimate cost to the consumer. It adds on, and so is not really the incentive going to have to primarily be in the tax area?

Mr. OTTINGER. Well, I entirely favor the tax incentive. I think it performs a different function. The tax incentive comes, sometimes, later when the guy pays his taxes, number 1.

Mr. ROUSSELOT. But he pays them every year.

Mr. OTTINGER. The loan comes up front, and I think that it meets a need which presently builders tell me—and you can get testimony on this from the builders' association and the architects' association—that they presently cannot get the financing from the banks at the going rate of interest and with the tremendous competition that I know you are very aware exists.

Mr. ROUSSELOT. They cannot get it in a construction loan?

Mr. OTTINGER. They cannot get it as part of their overall construction loan because the banks do not yet have confidence enough. We have not yet had enough experience out in the marketplace with solar heating so that they are confident they can get back that increment of price that is added by the addition of solar energy back when a house is resold, and that is what I have been told by the builders.

Mr. ROUSSELOT. Well, we both are looking for the same objective and that is to get solar energy systems in place in primarily single family dwelling units, and, of course, ERDA has a project to go over the next 5 years for 4,000 units, and, as the gentleman knows, there will be grants given to stimulate that. I realize that that has not gotten off the ground as fast as, maybe, the gentleman and I would like.

Mr. OTTINGER. I think that if it would make you more comfortable, you could do this through guaranteed loans. Somebody has suggested that. I am kind of soft on guaranteed loans these days.

Mr. ROUSSELOT. It is opening up as a new vista in New York City. [General laughter.]

Well, my experience with builders is that if they had the tax incentives to generate their interest in this, and, assuming that they could be convinced as individual builders that these were sufficient heating and cooling supplementary units to go into the home, that they would, in fact, put them in there if we gave them the right kind of incentives. At least, that is a way to get it done.

Mr. OTTINGER. We find the builders in our area are very eager to get into this. They think it is something exciting, something that will attract buyers to their homes. They are having difficulty with the financing. They are having some difficulty with building codes. In some cases, they are having labor difficulty.

Mr. ROUSSELOT. Now, you will inform them that FHA has a central approval office available for FHA guaranteed financing——

Mr. OTTINGER. I certainly will when that becomes available.

Mr. ROUSSELOT. That is available now. FHA makes the regional office get approval from the central office, but it can be done, and I intend to encourage more builders who are used to working with FHA to make use of that. The availability is limited to central FHA approval procedures of this FHA money only because they have not set their minimum standards; they have not quite resolved their final minimum standards yet.

Well, I again want to thank my colleagues for their contribution by this subcommittee, to the consideration of solar energy development. Many of us are very interested in this form of heating and cooling, and want to see it come into being, and, though you and I may disagree on the direct loan approach, we both want to see it get done and accomplished and in place, so I thank the gentleman.

Mr. MOORHEAD. Thank you very much, Mr. Ottinger, for your excellent statement. The subcommittee would now like to hear from a panel of experts in the field, Robert DeBlois, chairman, the solar energy application committee, New England Fuel Institute, accompanied by Charles H. Burkhardt, executive vice president of the New England Fuel Institute; also from Sheldon H. Butt, president, Solar Energy Industry Association, and C. A. Morrison, director of research, Solar Energy & Energy Conversion Laboratory, University of Florida.

We welcome all of you gentlemen, but my colleague from Rhode Island, Mr. St Germain, has a particular welcome.

Mr. ST GERMAIN. Thank you, Mr. Chairman. I am very pleased to welcome Mr. DeBlois, who is from the State of Rhode Island, to the panel and to testify before the subcommittee. I have worked with him and his family—it is a family-owned business, the DeBlois Oil Co.—over the 15 years I have been in Congress. We, in New England, have always had special problems. We first worked together during the period when import quotas gave us such difficulties year after year after year. And now, today, in his testimony, Mr. DeBlois, on behalf of the New England Institute, brings forth another special problem that arises under the legislation before us, that requires that we have some amendments and some consideration given to New England's situation when the retrofit would seem to be the ideal and where it is necessary to allow the small business people to participate in this conversion. I do hope and feel that the testimony of Mr. DeBlois, on behalf of the New England Fuel Institute, will have an impact on the subcommittee and on the Congress when it considers this legislation because it is so crucial to the future of New England.

Thank you, Mr. Chairman.

Mr. MOORHEAD. Gentlemen, we have a time problem here because we do have a joint session of Congress scheduled for today, so, if any of you could abbreviate or highlight your full statements, we will see that your full statements are put into the record without objection. Mr. DeBlois.

STATEMENT OF ROBERT DeBLOIS, EXECUTIVE VICE PRESIDENT OF THE DeBLOIS OIL CO., PAWTUCKET, R.I., CHAIRMAN, SOLAR ENERGY APPLICATION COMMITTEE, NEW ENGLAND FUEL INSTITUTE; ACCOMPANIED BY CHARLES H. BURKHARDT, EXECUTIVE VICE PRESIDENT OF NEW ENGLAND FUEL INSTITUTE

Mr. DEBLOIS. Thank you, Mr. Chairman, and thank you, Congressman St Germain, for the kind words. Let me say at the outset that if it were not for representation here in Washington by people such as our Congressman St Germain and other Representatives and Senators from all of the New England States, I think those of us in the heating oil and heating equipment business in the New England States would, indeed, be hard-pressed today.

The statement that we have is relatively brief and, since I know most of the members have not had a chance to read it, I would like, if I could, to just go through it quickly.

As has already been stated, my name is Robert DeBlois. I am executive vice president of the DeBlois Oil Co. in Pawtucket, R.I. Our oil company has been a family business, and it is now in its second generation. We are a sizable distributor and installer of home heating oil and oil-fired heating equipment throughout the Rhode Island and southeastern Massachusetts area. We also service this oil-fired heating and domestic hot water heating equipment.

Today I represent the New England Fuel Institute, of which I am past president and past chairman of its board. I am presently chairman of its finance committee and also chairman of its applied solar energy equipment committee. Accompanying me is Charles H. Burkhardt, executive vice president and managing director of the institute who is here to answer any questions posed by members of the subcommittee.

The New England Fuel Institute is an association of about 1,300 independent retail and wholesale heating oil and oil heating equipment distributors and installers throughout the six-State region. This association was incorporated under the laws of the Commonwealth of Massachusetts in 1943, as the Oil Heat Institute of New England. Our corporate name was changed to New England Fuel Institute in 1962.

The independent sector of the home heating oil industry in New England sells more than 85 percent of all distillate product at retail. In addition, 40 percent of the fuel oil sold at the wholesale level is marketed by independents. Further, 19.4 percent of all the oil heating equipment sold throughout the United States is installed in New England homes and buildings. Over 90 percent of this large quantity of oil heating equipment and accessories are sold, installed and serviced by these independent heating oil dealer-distributors. About 125,000 to 140,000 oil burners are sold and installed in New England every year. Most of these are replacements. We usually average somewhere between 38,000 to 40,000 oil burners as new installations. These can be conversions from other fuels or installations in newly built homes.

There are 2,430,000 oil burner units operating in New England at the present time; about 890,000 central gas heating units and about 275,000 dwelling units utilizing electricity for heating. Gas and electricity combined account for about 1,165,000 centrally heated units, while oil has slightly over 2,400,000. Unlike most gas and electric utilities, the retail oil heating dealer-distributor sells and installs heating equipment and accessories and/or newer replacement equipment, himself. With a present market of over 2,430,000 oil heating customers, it is obvious that a built-in, practical and effective merchandising, marketing, engineering, installation, and service mechanism exists on a broad scale in New England for any heating procedure and/or process to which the independent segment of the oil heating industry would apply itself. This especially applies to retrofit installations wherever solar energy equipment would be added to an existing heating installation.

Therefore, we believe that the heating oil dealer-distributor apparatus in New England is ideally endowed with all of the experience, technical skills, processes, and procedures necessary for a mass introduction to the New England market, of solar heat generating equipment as an adjunct to existing or proposed oil heating systems or for that matter, gas or electric residential heating systems.

There is a strong potential for New England to achieve some independence from foreign energy imports if solar energy was to be used on any large scale in conjunction with oil as a source of energy for home heating and for domestic hot water production. Solar heating would be a practical way to reduce New England's dependence on imported, refined products, specifically distillate and residual, and yet provide a means of sustaining the livelihood of the more than 2,000 retail small businesses, heating oil dealers and distributors of the area who provide jobs for well over 35,000 people.

Since the New England climate is such as to have many periods without sunshine with extremely cold winters, it is our considered opinion that solar energy could supply, theoretically, in an oil-heated home, up to about 35 percent of the total heat required. More practically, this will evolve to about 28 percent to 30 percent. Thus, through the application of solar energy as an adjunct to oil heat, many more people could enjoy the benefit, comfort, virtues, and service of oil heat without substantially increasing or more practically, even decreasing, New England's dependence upon imported, refined product.

Research on the part of this institute shows that it is feasible for adjunct solar heating equipment to be installed with presently operating oil heated equipment in 71 percent of the 2,430,000 oil heating installations now existing in New England. This means we have a practical potential of approximately 1,600,000 adjunct solar heating installations.

Under section 3(a)(1)(A), page 6 of H.R. 3849, that we are discussing, the requirement that such equipment be designed to meet more than 40 percent of the total heating needs, including domestic hot water, of the type of structure for which it is intended, or substantially all of the needs of such a structure for domestic hot water, where its remaining heating needs are met by other methods, rules out completely any financial assistance to homeowners as proposed by H.R. 3849, for 70 percent of all of the residential heating and domestic hot water installations throughout New England. We believe that this is a serious deficiency inherent in the act as now written; for in New England with its existing 2,430,000 oil heating installations and its 890,000 gas central heating installations, the real opportunity for solar energy in the form of an adjunct heating producing apparatus is readily available. To rule out this vast retrofit market is not rational. In the opinion of this institute, financial assistance for the retrofit market will be more productive immediately, than for the new home market.

The retrofit market, especially for domestic hot water, is the real, present, immediately available opportunity and one that can be effective in quantity much sooner. Oil and gas and electric domestic hot water use is especially adaptable to adjunct solar heat generators, can be easily installed by independent dealers. This opportunity simply must go, cannot, be missed. Under no circumstances should financial assistance be denied to this vast immediate market by restricting such assistance to the now heavily depressed new home market.

Mr. MOORHEAD. Mr. DeBlois, I am afraid I am going to have to ask you to sum up and give us the recommendations that you have at the end because it would not be fair to the other members of the panel if you had all of the time.

The time factor today is a problem that we did not anticipate. I am sorry.

Mr. DEBLOIS. I understand this.

If we can skip to the last page of the testimony. The points that we suggest are technical points basically, to the act as it has been recommended. And that is that the 40 percent requirement that is in section 3(a)(1)(A) be reduced for the inclusion of that 70 percent of the homes in New England that I mentioned to 25 percent or possibly to as low as 20 percent with qualifying dollar amounts to meet such lower requirements. I think we have already made this point.

Second, that the act include provisions for retrofit installations which provide, in our opinion, certainly the most immediate and the most readily available and the largest volume of benefits immediately.

Third, that the act include provisions to provide for qualified installations as well as qualified equipment. We believe this is—you can take the greatest piece of equipment in the world and, if you massacre it, installing it or putting it in incorrectly, of course, the benefits are immediately right out the window.

Fourth, that the act include in its purpose and thrust for decreasing the national dependence on imported petroleum products.

And, fifth, that the act include, if at all possible, some type of financial assistance for small business installers, who, unfortunately, are going to bear the brunt of the sales certainly in the northeastern section of the country.

Thank you, Mr. Chairman. I am sorry I took too much time.

Mr. MOORHEAD. Thank you, Mr. DeBlois. We particularly appreciate specific recommendations as you have in your testimony.

[The prepared statement of Mr. DeBlois follows:]

PREPARED STATEMENT OF ROBERT DEBLOIS, EXECUTIVE VICE PRESIDENT, DEBLOIS OIL CO., PAWTUCKET, R.I., ON BEHALF OF THE NEW ENGLAND FUEL INSTITUTE

My name is Robert DeBlois. I am Executive Vice President of the DeBlois Oil Company in Pawtucket, Rhode Island. Our oil company has been a family business, now in the second generation. We are a sizeable distributor and installer of home heating oil and oil fired heating equipment throughout Rhode Island and southeastern Massachusetts. We also service this oil fired heating and domestic hot water heating equipment.

Today I represent the New England Fuel Institute of which I am past president and past chairman of its board. I am presently chairman of its Finance Committee and also chairman of its Applied Solar Energy Equipment Committee. Accompanying me is Charles H. Burkhardt, Executive Vice President and Managing Director of the Institute who is here to answer any questions posed by members of the Committee.

The New England Fuel Institute is an association of about 1300 independent retail and wholesale heating oil and oil heating equipment distributors and installers throughout the six state region. This association was incorporated under the laws of the Commonwealth of Massachusetts in 1943, as the Oil Heat Institute of New England. Our corporate name was changed to New England Fuel Institute in 1962.

The independent sector of the home heating oil industry in New England sells more than 85% of all distillate product at retail. In addition, 40% of the fuel oil sold at the wholesale level is marketed by independents. Further, 19.4% of all the oil heating equipment sold throughout the United States is installed in New England homes and buildings. Over 90% of this large quantity of oil heating equipment and accessories are sold, installed and serviced by these independent heating oil dealer-distributors. About 125,000 to 140,000 oil burners are sold and installed in New England every year. Most of these are replacements. We usually average somewhere between 38,000 to 40,000 oil burners as new installations. These can be conversions from other fuels or installations in newly built homes.

There are 2,430,000 oil burner units operating in New England at the present time; about 890,000 central gas heating units and about 275,000 dwelling units utilizing electricity for heating. Gas and electricity combined account for about 1,165,000 centrally heated units, while oil has slightly over 2,400,000. Unlike most gas and electric utilities, the retail oil heating dealer-distributor sells and installs heating equipment and accessories and/or newer replacement equipment, himself. With a present market of over 2,430,000 oil heating customers, it is obvious that a built-in, practical and effective merchandising, marketing, engineering, installation and service mechanism exists on a broad scale in New England for any heating procedure and/or process to which the independent segment of the oil heating industry would apply itself. This especially applies to retrofit installations wherever solar energy equipment would be added to an existing heating installation.

Therefore, we believe that the heating oil, dealer-distributor apparatus in New England is ideally endowed with all of the experience, technical skills, processes and procedures necessary for a mass introduction to the New England market, of solar heat generating equipment as an adjunct to existing or proposed oil heating systems or for that matter, gas or electric residential heating systems.

There is a strong potential for New England to achieve some independence from foreign energy imports if solar energy was to be used on any large scale in conjunction with oil as a source of energy for home heating and for domestic hot water production. Solar heating would be a practical way to reduce New England's dependence on imported, refined products, specifically distillate and residual, and yet provide a means of sustaining the livelihood of the more than 2,000 retail small business, heating oil dealers and distributors of the area who provide jobs for well over 35,000 people.

Since the New England climate is such as to have many periods without sunshine with extremely cold winters, it is our considered opinion that solar energy could supply, theoretically, in an oil heated home, up to about 35% of the total heat required. More practically, this will evolve to about 28% to 30%. Thus, through the application of solar energy as an adjunct to oil heat, many more people could enjoy the benefit, comfort, virtues and service of oil heat without substantially increasing or more practically, even decreasing, New England's dependence upon imported, refined product.

Research on the part of this Institute shows that it is feasible for adjunct solar heating equipment to be installed with presently operating oil heated equipment in 71% of the 2,430,000 oil heating installations now existing in New England. This means we have a practical potential of 1,600,000 adjunct solar heating installations.

Under Section 3, (a), (1), (A), Page 6 of HR 3849, that we are discussing, the requirement that such equipment be designed to meet more than 40% of the total heating needs (including domestic hot water) of the type of structure for which it is intended, or substantially all of the needs of such a structure for domestic hot water (where its remaining heating needs are met by other methods) . . . rules out completely any financial assistance to homeowners as proposed by HR 3849, for 70% of all of the residential heating and domestic hot water installations throughout New England. We believe that this is a serious deficiency inherent in the act as now written; for in New England with its existing 2,430,000 oil heating installations and its 890,000 gas central heating installations, the real opportunity for solar energy in the form of an adjunct heating producing apparatus is readily available. To rule out this vast retrofit market is not rational. In the opinion of this Institute, financial assistance for the retrofit market will be more productive immediately, then for the new home market.

The retrofit market, especially for domestic hot water, is the real, present, immediately available opportunity and one that can be effective in quantity much sooner. Oil and gas and electric domestic hot water use is especially adaptable to adjunct solar heat generators, can be easily installed by independent dealers. This opportunity simply must not, cannot, be missed! Under no circumstances should financial assistance be denied to this vast immediate market by restricting such assistance to the now heavily depressed new home market.

Furthermore, it is the considered opinion of this Institute and many technical authorities working in the field including professors of engineering, that it would be very difficult to produce hot water of more than 120 degrees in New England by an economically feasible system that would not be priced out the market. For instance, an adjunct combination oil solar energy domestic hot water heater can be purchased at a price ranging from $625 to $1800. A solar home heating system would cost from $8,000 to $15,000 without any oil, gas or electric heating system backup. It is with adjunct solar energy equipment that the real opportunity lies. In New England it easily becomes financially impractical to produce heat by solar energy as the system required is so large and complex and requires so much auxiliary collecting equipment that it could approach one-half the total cost of the dwelling.

Therefore, the 40% limitation as noted in the act should be, for the New England area, and for adjunct solar systems that can be allied or attached to oil, gas or electric heating systems, reduced to 20%. The 40% figure is self-defeating if energy conservation is a prime consideration. This high figure will only result in continuing the nation's dependence on foreign oil.

NEFI will soon have three adjunct domestic hot water solar energy-oil systems installed in three homes in Rhode Island. We will study their operation and method of installation, and become appraised of such maintenance as is required. Following on this, there will be four adjunct solar energy domestic hot water generators, coupled with oil heating equipment, installed in Connecticut. Subsequently, a combination solar generator-oil home heating and domestic hot water system will be installed in a one-family home in the general area of Hanover, New Hampshire. We will, in this way, be testing eight different types and/or kinds of solar heat generators coupled with oil at the same time.

These units which range in cost, as has been noted above, for the equipment at the present time, from $625 per unit to $1800. They would reduce heating oil consumption for domestic hot water by about 28 to 30%. This type of installation should be included in the financial assistance that the proposed HR 3849 would provide.

While HR 3849 provides assistance for the home buyer and builder, it does not quite face up to another problem that is very important to small businessmen who make the great majority of residential heating and domestic hot water installations throughout the U.S. For any one of the 2400 retail heating oil and oil heating equipment distributors throughout New England or the U.S. for that matter, to inventory a single well made efficient oil burner, costs $50. To inventory an adjunct solar energy equipment domestic hot water generator runs from $600 to $1800. Quite an increased capital demand for a small oil heating equipment dealer and installer.

From this, it can be clearly seen that the capital demand for inventorying solar energy equipment will be enormous and many times that for conventional oil, gas or electric equipment. What will be done to help these small businessmen who through their sales, installation and service departments provide the ideal outlet for the residential installation of solar heating equipment? It is not just financial help to homeowners and/or builders that will provide the necessary practical impetus to make solar heating a working factor in conserving energy and reducing dependence on existing fuels. It is financial assistance to the retrofit market that will be most readily effective.

Also, while HR 3849 clearly defines that *qualified* solar heating equipment must be used, what does it say to insure the technical skill and qualifications for the installation and maintenance of that equipment? The finest and most qualified piece of solar heating equipment can result in being ineffective because of improper installation and orientation. The granting of tens of thousands of low interest, long term loans to homeowners and builders for solar heating equipment will encourage many unscrupulous, even "fly by night" operators to come into business. We will see many abuses, some financial tragedies and general disillusionment, with what can be the most massive energy opportunity for America since the discovery and development of nuclear fission. The technical qualifications of those making field installations and applications of solar heating equipment are going to have to be standardized and consistently policed so that this entire concept will be productive and not frustrated. It is here that the independent heating oil installer will be most qualified and have the most to offer.

It is not only necessary to establish a mechanism or procedure, or both, for the inspection and evaluation of each type or model of solar heating equipment, in addition there must be a substantial mechanism and procedure for the inspection, evaluation and performance of the actual installation of such qualified equipment. The finest equipment in the world can be ruined and rendered ineffective by poor installation. If this is not recognized, the noble purpose of H.R. 3849 could be completely and quickly frustrated.

The installation of adjunct solar energy domestic hot water heaters backed up by oil fired equipment has, as noted above, a potential market in New England alone, of 1,600,000 installations. If only one-fifth of these were achieved, it would result in 320,000 adjunct solar energy domestic hot water generators. That is where the opportunity lies. Further, this number of installations would reduce by 5,000,000 barrels of distillate oil, New England's annual importation of 25,-000,000 barrels of such product. A goal worth shooting for—a 25% reduction of our distillate imports.

In light of this, New England Fuel Institute recommends the following:

1. That the 40% requirement in Section 3(a), (1), (A), be reduced to 25% and possibly to 20% with qualifying dollar amounts to meet such lower requirements.

2. That the act include provisions for retrofit installations which provide the most readily available and largest volume market.

3. That the act include provisions to provide for qualified installations as well as qualified equipment. One is useless without the other.

4. That the act include in its purpose a thrust for decreasing the national dependence on imports.

5. That the act include financial assistance for the small business installers who will bear the brunt of the sales, installations and servicing of such solar equipment as well as the inventorying of its costly components and basic devices.

Thank you.

STATEMENT OF SHELDON H. BUTT, PRESIDENT, SOLAR ENERGY INDUSTRY ASSOCIATION

Mr. BUTT. Thank you.

Basically, I agree with much of what Congressman Ottinger and Congressman Gude said, so I will not go over that. It is in the written testimony.

There are a couple of points I would like to make.

First of all, I do believe that the percentage limitation on domestic hot water heating, which now calls for substantially all, should be reduced to 60 percent.

There are a couple of other points of a general nature. We are concerned, all of us, with the cost of various programs to the Treasury. The direct loan or loan guarantee, which ever way it turns out, will not necessarily have a permanent impact on the Treasury. Incentives, which I believe are a needed part of any solar package, would have great market impact but again, would not necessarily have permanent impact on the Treasury since the need for them should be regarded as temporary.

When you think about replacing oil and gas with something for home heating, the only two things that are available to you are electricity and solar.

Now, the impact on the Treasury of existing legislation, depreciation allowances and tax credits, of replacing oil and gas with electricity is greater than the impact of the incentives which the Solar Energy

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Industry Association has recommended. So from that point of view of the two alternatives available, solar is a bargain.

H.R. 3849 has the effect, basically, of channeling capital funds into solar, which, obviously, means away from something else. Again, in comparison with the electric alternative, the impact on total capital requirements of a solar approach is less than an all-electric approach. So that, again, I think, in terms of the Nation's chronic capital shortage, solar is a bargain.

I think that these are the points I want to make.

Thank you.

[The prepared statement of Mr. Butt follows:]

TESTIMONY OF THE SOLAR ENERGY INDUSTRIES ASSOCIATION
NOVEMBER 5, 1975
TO THE SUBCOMMITTEE ON HOUSING AND COMMUNITY DEVELOPMENT OF THE
COMMITTEE ON BANKING, CURRENCY AND HOUSING
U. S. HOUSE OF REPRESENTATIVES
PRESENTED BY SHELDON H. BUTT, PRESIDENT OF THE
SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. Chairman, I want to thank you for the opportunity to testify before you upon H.R. 3849 which will provide direct low interest loans to assist homeowners and builders in the purchase and installation of solar equipment. I am testifying on behalf of the Solar Energy Industries Association which is a trade association comprising approximately 400 members, including manufacturers, architects, engineers, installation contractors and others who are involved in the solar industries.

The central purpose of H.R. 3849, as well as that of other complementary pending legislation, is to accelerate widespread commercialization of solar heating and cooling so as to reduce demand for scarce fossil fuel resources. In considering this legislation, we should first address the following questions:

1. Is the legislation timely? Is technically and economically viable solar equipment available or becoming available which could be installed as the result of the passage of H.R. 3849 and other Governmental action?

2. Is such legislation needed? Is legislation such as H.R. 3849 required to accelerate commercialization of solar energy to reach national goals? For how long?

3. The effect of H.R. 3849 will be to channel capital resources into solar installations. How does investment in solar equipment compare to investment in other alternative energy sources as a means of reducing consumption of scarce energy resources?

4. What results (fuel savings) may we anticipate?

SUMMARY

1. Timeliness: Solar space heating and hot water heating equipment is being produced, sold and installed today which is technically sound. As detailed later in this testimony, cumulative savings in the cost of conventional energy resulting from a solar installation become equal to the first cost of the installation in a relatively few years. In the typical cases presented, savings pay-out time ranges from 5 to 9 years when the solar installation replaces electric energy; 7 to 12 years when fuel oil is replaced; and 12 to 15 years when still low cost natural gas is replaced. Equally cost-effective solar cooling equipment is not now available. Engineering development now in progress promises availability in about two years.

2. Need: High interest rates paid by consumers, builders and others stretch out the time required to pay back a loan used to purchase solar equipment from fuel cost savings substantially. The additional funds required to finance the purchase of a solar system may not be available to the buyer. Although the number of solar installations being made is growing rapidly, most consumers still view solar installations as "new" and therefore, somewhat risky. These factors combine to severely restrict consumer acceptance of solar energy at the present time. It is expected that the price of "conventional" energy forms will continue to escalate more rapidly than the general rate of inflation. Conversely, it is expected that, as the volume of solar equipment produced increases, its "constant dollar" cost will decrease. Increasing familiarity with solar equipment will reduce the perceived risk. This applies both to the user and to the lender. The need for legislation such as H.R. 3849, as well as other legislation, intended to accelerate commercialization of solar energy will diminish and ultimately disappear. The ten year term incorporated in H.R. 3849 is adequate.

3. Capital Cost-Effectiveness: The capital cost of solar equipment required to replace one barrel of crude oil is less than the capital cost of electric generating plant capacity with the same capability. If the energy storage capability integral to the solar equipment is managed so that supplementary electric energy is required only during "off peak" hours, the capital cost of the combination solar-off peak electric alternatives is far less than that of the all electric alternative.

4. Results: Basically, we view the task of making "low cost" money available to solar users as an essential part of a comprehensive solar program. The comprehensive program proposed by S.E.I.A. is detailed in the attached exhibit. We believe that implementation of the comprehensive program would result in annual savings of 1,000,000 barrels of crude oil per day within ten years. Rapid growth would continue thereafter.

DETAILS

1. Timeliness

a. Technical Status of Solar Heating and Cooling

The basic technology used in solar heating and cooling is quite simple. A flat plate collector is heated by sunlight. The energy collected as heat is removed by a heat transfer fluid which can be either a liquid or air. The heat is then either delivered to the load or stored for future use or, in the case of solar air-conditioning, used to power absorption air-conditioning apparatus. The only unique component of such a system is the collector itself. The piping (or duct work) used to transport heated fluid from the collector is conventional, conventional pumps, fans and controls are used. Insulated tanks containing hot water or insulated bins of hot rocks are used as energy storage. Conventional heat exchangers may be used to transfer energy into and out of storage. Simplified diagrams of typical solar systems are shown in Figures 1 and 2.

The collector consists of a flat absorber plate. Generally, this is a flat metal plate with an absorptive surface which may be flat black paint or, in some devices, a "selective" surface. Characteristically, the back of the absorber plate is insulated to reduce heat losses. One or two layers of glass or transparent plastic are mounted in front of the absorbing surface to reduce convection, conduction and radiation losses and to provide a "greenhouse effect." The basic engineering principles are very simple.

As in the case of other simple engineering concepts, considerable detailed engineering effort goes into balancing and optimizing the various components of the system. Continuing engineering development can and will lead to improvements in efficiency and reduction in the cost of solar systems. As the industry grows, we are confident that the magnitude and scope of these efforts will grow. Government assistance to accelerate the pace of these developments is a part of S.E.I.A.'s comprehensive solar program.

Solar cooling is also technically practical today. It is not economically viable. Heat driven absorption air-conditioning apparatus now available is designed for relatively high input temperatures consistent with the use of steam "firing." At these temperatures, presently available flat plate collectors lose efficiency while, if the existing absorption air-conditioning equipment is operated at lower temperatures, capacity and efficiency are lost. Engineering development is needed and is now underway to design absorption cooling equipment adapted for lower energy input temperatures as well as to produce collectors which will operate efficiently at higher temperatures. Progress is encouraging.

The standards required to implement H.R. 3849 are currently being prepared by the National Bureau of Standards and interim standards should be available early next spring. Longer term, industry is engaged in the development of permanent standards through the Nation's voluntary standards organizations. We expect that much of the solar equipment now being manufactured, marketed and installed will meet these standards when they are issued.

b. Economic Status of Solar Heating

We have prepared a series of life cycle cost analyses of "typical" residential solar installations. These are based upon currently available "state of the art" solar equipment and do not take credit for expected improvements in efficiency or future cost reduction. Analyses are presented for installations in Boston and in Los Angeles. Boston was selected as representative of areas in which climatic conditions are relatively unfavorable to solar energy while Los Angeles represents areas in which relatively favorable conditions exist.

Boston area studies were based on $.035 per KWH electric cost and $.45 per gallon fuel oil costs. Los Angeles studies were based upon $.03 per KWH electric cost, $.40 per gallon fuel oil cost and $1.50 per MCF for natural gas. We assumed 7-1/2% per year escalation in electricity costs (5% general inflation + 2-1/2%) and 10% per year escalation in oil and natural gas. We estimated overall conversion efficiency from oil to useful heat at 55% and from gas at 60% (percent of total heating value of the fuel delivered to the load). Calculations made on this basis are summarized in Table I and presented graphically in Figures 3, 4 and 5.

It will be seen that, in the Boston area, the pay-out time when solar energy replaces electricity ranges from 6.4 to 9.8 years depending upon the type of installation and the proportion of the load carried by the solar installation. In Los Angeles, expected results are somewhat more favorable; the range being from 5.2 to 6.8 years. Since fuel oil as a source of heat is less costly than electricity, results are less favorable when fuel oil is replaced by solar, the pay-out time in the Boston area ranging from 9.1 to 11.6 years and in the Los Angeles area from 7.4 to 11.3 years. To the extent that relatively low cost natural gas is available, the time required to pay-out the solar investment increases substantially, the range in the Los Angeles area being 12.0 to 14.5 years.

c. Nationwide Applications for Solar

Although pay-out time for a solar installation in Los Angeles is somewhat less than in Boston, the differences are relatively small, particularly so considering the climatic differences. One reason for this result is that "conventional" energy costs tend to be higher in the Northeast than elsewhere in the U. S. Another reason is that, popular belief to the contrary, the differences in available sunshine, particularly as related to seasonal load profile, are not overwhelmingly great. Finally, and most importantly, since solar system efficiency varies with the percentage of load carried, a system in Boston can carry a smaller percentage of load as efficiently as a system in Los Angeles can carry a larger percentage of load. This is illustrated in Figure 6 which plots useful heat production per square foot of standard collector against percent of load carried for Los Angeles and Boston in water heater applications. For example, productivity in Boston is the same at the 50% load level as in Los Angeles at 85% of load.

c. Required Size of the Solar Installation

As now written, H.R. 3849 requires that eligible systems must be designed to meet at least 40% of total heating needs and "substantially all" of the needs for domestic hot water. The 40% minimum related to heating needs is practical. The requirement that hot water systems meet "substantially all" of the domestic hot water needs is not. If this provision were rigorously interpreted, no economically viable hot water heating system would be able to qualify. It is recommended that solar hot water heating systems be required to meet 60% of the requirement for hot water.

2. Need

The pay-out times quoted in the preceding section were derived by comparing cumulative savings with first cost. If it is assumed that the system is purchased with borrowed funds, interest payments stretch out the time required to amortize the investment in solar facilities.

As an example, let us consider the relatively favorable case of a homeowner in Los Angeles who purchases a solar heating and hot water system to replace an all electric system and designed to carry 60% of the total load. Based on Table I, the pay-out time is 6.8 years. If he makes this purchase with a 25% down payment and an 8 year loan at 12% interest, his cash flow position is as follows:

			Cash Out Flow	
	Payment	Savings	Year	Cumulative
Down Payment	$1687.50			$1687.50
Year 1	1017.56	$ 492.00	$ 525.56	2213.06
2	1017.56	528.90	488.66	2701.72
3	1017.56	568.56	449.00	3150.72
4	1017.56	611.21	406.35	3557.07
5	1017.56	657.07	360.49	3917.56
6	1017.56	706.32	311.24	4228.80
7	1017.56	759.30	258.26	4487.06
8	1017.56	816.23	201.33	4688.39
9	0	877.48	- 877.48	3810.91
10	0	921.37	- 921.37	2889.54
11	0	990.45	- 990.45	1899.09
12	0	1064.74	-1064.74	834.35
13	0	1144.59	-1144.59	- 310.24

Thus, the consumer does not "break even" on a cash basis until the thirteenth year. The availability of a loan at 7% materially changes the picture as follows:

	Payment	Savings	Cash Out Flow Year	Cumulative
Down Payment	$1687.50			$1687.50
Year 1	845.44	$ 492.00	$ 353.44	2040.94
2	845.44	528.90	316.54	2357.48
3	845.44	568.56	276.88	2634.36
4	845.44	611.21	234.23	2868.59
5	845.44	657.07	188.37	3056.96
6	845.44	706.32	139.12	3196.08
7	845.44	759.30	86.14	3282.22
8	845.44	816.23	29.21	3311.43
9	0	877.48	- 877.48	2433.95
10	0	921.37	- 921.37	1512.58
11	0	990.45	- 990.45	522.13
12	0	1064.74	-1064.74	- 542.61

"Break even" comes a year earlier. More importantly, the maximum cumulative net outlay is 30% less than in the case of the 12% loan.

Consumer reponse will still tend to be somewhat sluggish since cash out-flows (after the down payment) are still substantial, particularly in the earlier years. In effect, the consumer's loan payments, even with a 7% loan, are greater than his electricity cost savings. Although help with interest costs is important and the loan program has other advantages, the tax credits called for in S.E.I.A.'s program are required in order to present a really attractive prospect to the consumer. We have recommended a 40% credit on the first $2,000 and 25% on the next $6,000. In our example, the total tax credit would be $1,987.50. If we assume a 7%, 8 year loan on the balance ($4,762.50), with the tax credit applying to the down payment, the cash flow picture is as follows:

	Payment	Savings	Cash Out Flow Year	Cumulative
Year 1	$ 795.34	$ 492.00	$ 303.34	$ 303.34
2	795.34	528.90	266.44	569.78
3	795.34	568.56	226.78	796.56
4	795.34	611.21	184.13	986.69
5	795.34	657.07	138.27	1118.96
6	795.34	706.32	89.02	1207.98
7	795.34	759.30	36.04	1244.02
8	795.34	816.23	- 20.89	1223.13
9	795.34	877.48	- 877.48	345.65

"Break even" comes shortly after the ninth year. Maximum cumulative cash out-flow is 63% less than without the tax incentive. Furthermore, the consumer will have no difficulty in recognizing that the extent to which his investment has increased the value of his property is greater than his cumulative cash outlay at all times. In effect, the solar investment is a "good" investment. The picture is as follows:

7%, 8 Year Loan and Tax Credits

	Loan Balance	Cumulative Cash Flow	Total	Value = Original Cost Less 5%/Year	Net
Year 1	$4300.54	$ 303.34	$4603.88	$6412.50	$1808.62
2	3806.24	569.78	4376.02	6075.00	1698.98
3	3277.31	796.56	4073.87	5737.50	1663.63
4	2711.39	980.69	3692.08	5400.00	1707.92
5	2105.83	1118.96	3224.79	5062.50	1837.71
6	1457.90	1207.98	2665.88	4725.00	2059.12
7	764.62	1244.02	2008.64	4387.50	2378.86
8	0	1223.13	1223.13	4050.00	2826.87

Obviously, without the tax credit but with the 7% loan, there would be a period during which the total of the balance due on the loan plus net cash outlays would exceed the depreciated value of the solar system.

We anticipate that within ten years, the "constant" dollar costs of solar systems will be reduced by 50%. Based on a 5% per year rate of general inflation, this means that the "current dollar" cost in ten years will be 77.6% of present "current dollar" cost. In the meantime, because of inflation, annual savings will have substantially increased. The "1985" picture with an eight year loan at 12% and a 25% down payment and without tax credits would be as follows:

	Payment	Savings	Cash Out Flow Year	Cash Out Flow Cumulative
Down Payment	$1309.50			$1309.50
Year 1	789.63	$ 990.45	$-200.82	1106.68
2	789.63	1064.74	-275.11	833.57
3	789.63	1144.59	-354.96	478.61
4	789.63	1230.44	-440.81	37.80
5	789.63	1322.69	-533.06	- 495.26
6	789.63	1421.93	-632.30	-1127.56
7	789.63	1528.55	-738.92	-1866.48
8	789.63	1643.18	-853.55	-2720.03

There is a net cash saving every year of operation. "Break even" is rapid. Obviously, there is no need for Government assistance.

3. Capital Cost-Effectiveness

In our summary, we have stated that the capital cost of solar equipment required to save one barrel of crude oil is less than the capital investment in electric generating facilities needed to accomplish the same purpose. Data on this point was prepared and submitted to the Energy Subcommittee of the Committee on Science and Technology of the U. S. House of Representative in response to questions raised at their October Hearings. A copy of the study is attached to this testimony.

In a "typical" situation, the investment cost required to replace one barrel of oil with a solar installation supplying 60% of the thermal requirements and the balance supplied by "off peak" electric power (utilizing the storage capability of the solar system to store heat from "off peak" electric power) is $130.50 (current situation). The capital cost of the "all electric" alternative is $228.38. Even without the use of "off peak" electric power with solar, the capital cost of solar alone is $217.50 per barrel of oil saved.

We may ask, why is Government assistance required? Why do we need low interest loans? Why do we need tax credits? In part, the need relates to the first cost sensitivity of the consumer, the apartment owner or the builder. In larger part, it relates to the fact that the extent to which the Government "assists" the investment in utility facilities with tax credits and with before tax depreciation allowances is greater than the extent to which we are asking for help for the purchaser of solar equipment. As is detailed in the study attached, the cost to the U. S. Treasury of replacing one barrel of oil with electric generating capacity is $121.50, while the cost to the Treasury of the solar-off peak electric alternative is only $40.46.

TABLE I

LIFE CYCLE COST ANALYSIS, TYPICAL SOLAR SYSTEMS

	Total Load (10^6 Btu/yr.)	Solar Contribution (10^6 Btu/yr.)	Conventional Energy Form	Conventional Energy Savings Units	1st Year	Cumulative 10 Yrs.	Cumulative 20 Yrs.	Solar System Cost	Pay Out Time, Yrs.
Boston Area									
Multi-Family Low Rise									
Hot Water Only									
50% Solar	1000	500	Electricity	146,400 KWH	$ 5124	$ 72,261	$218,190	$ 40,320	6.4
60% Solar	1000	600	Electricity	175,680 KWH	6149	86,716	261,837	53,550	6.9
70% Solar	1000	700	Electricity	204,960 KWH	7174	101,171	305,483	71,430	7.7
50% Solar	1000	500	Oil	6,500 Gal.	2925	46,617	167,529	40,320	9.1
60% Solar	1000	600	Oil	7,800 Gal.	3510	55,940	201,035	53,550	9.7
70% Solar	1000	700	Oil	9,100 Gal.	4095	65,264	234,541	71,430	10.6
Los Angeles Area									
Multi-Family Low Rise									
Hot Water Only									
50% Solar	1000	500	Electricity	146,400 KWH	$ 4392	$ 61,931	$187,020	$ 26,685	5.2
60% Solar	1000	600	Electricity	175,680 KWH	5270	74,320	224,407	34,620	5.5
70% Solar	1000	700	Electricity	204,960 KWH	6149	86,716	261,837	44,685	6.0
50% Solar	1000	500	Oil	6,500 Gal.	2600	41,437	148,915	26,685	7.4
60% Solar	1000	600	Oil	7,800 Gal.	3120	49,725	178,698	34,620	7.8
70% Solar	1000	700	Oil	9,100 Gal.	3640	58,012	208,481	44,685	8.4
50% Solar	1000	500	Gas	833 MCF	1250	19,922	71,594	26,685	12.0
60% Solar	1000	600	Gas	1,000 MCF	1500	23,906	85,912	34,620	12.5
70% Solar	1000	700	Gas	1,167 MCF	1,750	27,890	100,231	44,685	13.3
Boston Area									
Multi-Family Low Rise									
Heating + Hot Water									
40% Solar	1847	739	Electricity	216,320 KWH	$ 7571	$106,773	$322,397	$ 62,260	6.6
50% Solar	1847	924	Electricity	270,400 KWH	9464	134,466	402,996	86,580	7.2
60% Solar	1847	1108	Electricity	324,480 KWH	11357	160,159	483,595	125,000	8.3
40% Solar	1847	739	Oil	9,600 Gal.	4320	68,850	247,428	62,260	9.4
50% Solar	1847	924	Oil	12,000 Gal.	5400	86,062	309,284	86,580	10.0
60% Solar	1847	1108	Oil	14,400 Gal.	6480	103,274	371,141	125,000	11.3

Table I (cont'd.)

	Total Load (10^6 Btu/yr.)	Solar Contribution (10^6 Btu/yr.)	Conventional Energy Form	Conventional Energy Savings Units	1st Year	Cumulative 10 Yrs.	Cumulative 20 Yrs.	Solar System Cost	Pay Out Time, Yrs.
Boston Area									
Single-Family Residence									
Heating + Hot Water									
40% Solar	96	38.4	Electricity	11,244 KWH	$ 394	$ 5,556	$ 16,777	$ 4,875	9.1
50% Solar	96	48.0	Electricity	14,054 KWH	492	6,937	20,946	6,750	9.8
40% Solar	96	38.4	Oil Heat	333 Gal.	150	2,391	8,591)	4,875	11.0
			Elec. H.W.	3,742 KWH	131	1,847	5,578)		
			Total		281	4,238	14,169		
50% Solar	96	48.0	Oil Heat	462 Gal.	208	3,315	11,913)	6,750	11.6
			Elec. H.W.	4,216 KWH	148	2,087	6,302)		
			Total		356	5,402	18,215		
Los Angeles Area									
Single-Family Residence									
Heating + Hot Water									
40% Solar	50	20.0	Electricity	5,856 KWH	$ 176	$ 2,478	$ 7,481	$ 1,125	5.4
50% Solar	50	25.0	Electricity	7,320 KWH	220	3,103	9,368	1,605	6.0
60% Solar	50	30.0	Electricity	8,784 KWH	264	3,723	11,242	2,250	6.8
40% Solar	50	20.0	Gas	33.3 MCF	50	797	2,863	1,125	12.8
50% Solar	50	25.0	Gas	41.67 MCF	63	1,004	3,608	1,605	13.3
60% Solar	50	30.0	Gas	50.0 MCF	75	1,195	4,296	2,250	14.5

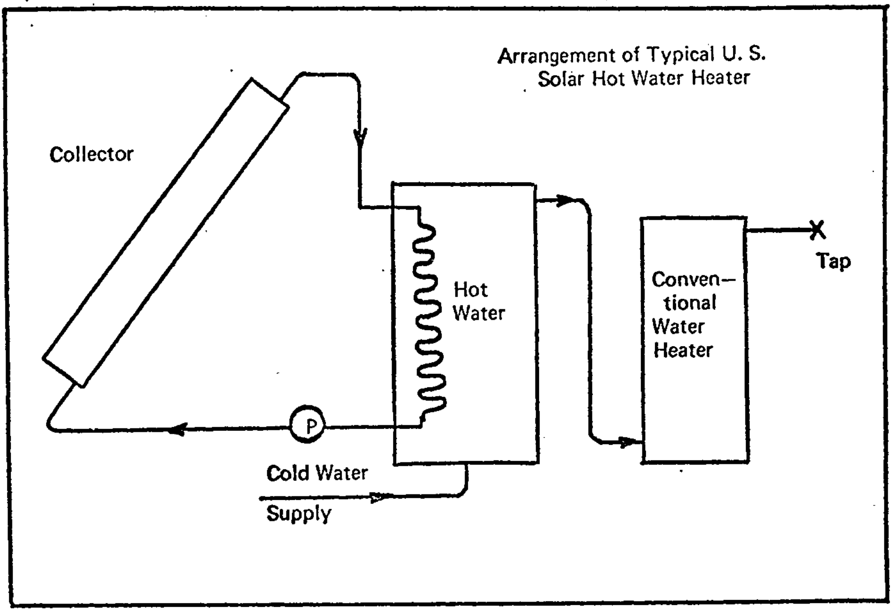

Figure 1.

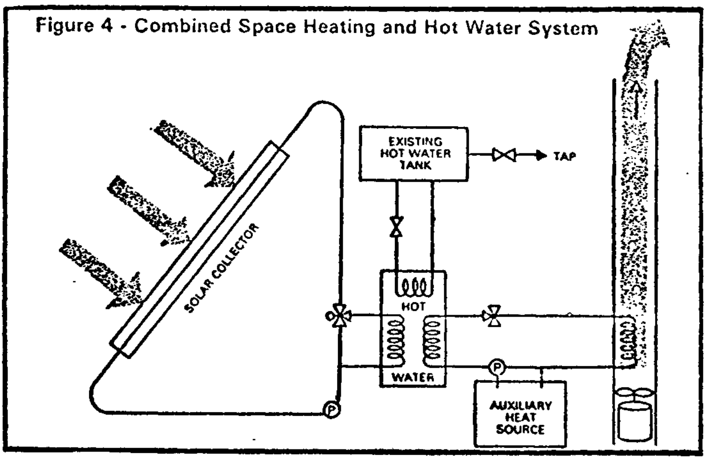

Figure 2.

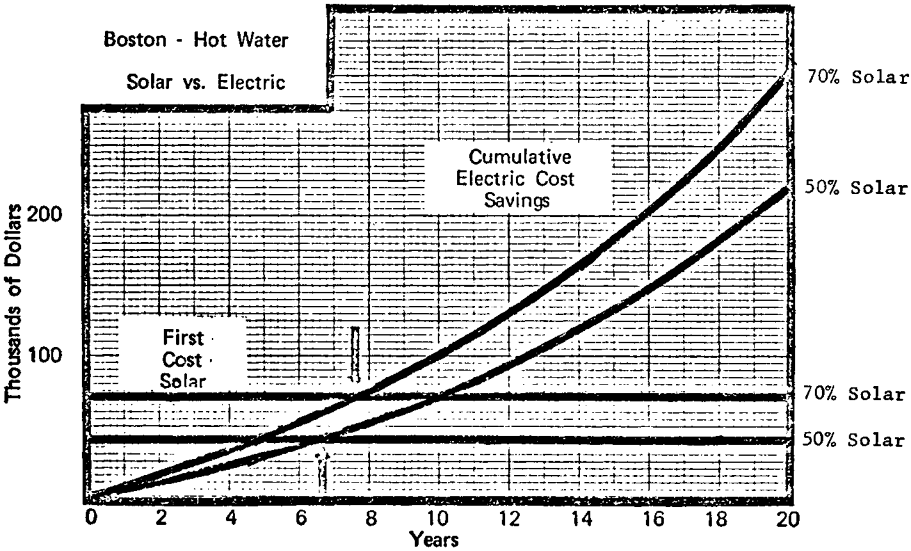

Figure 3.

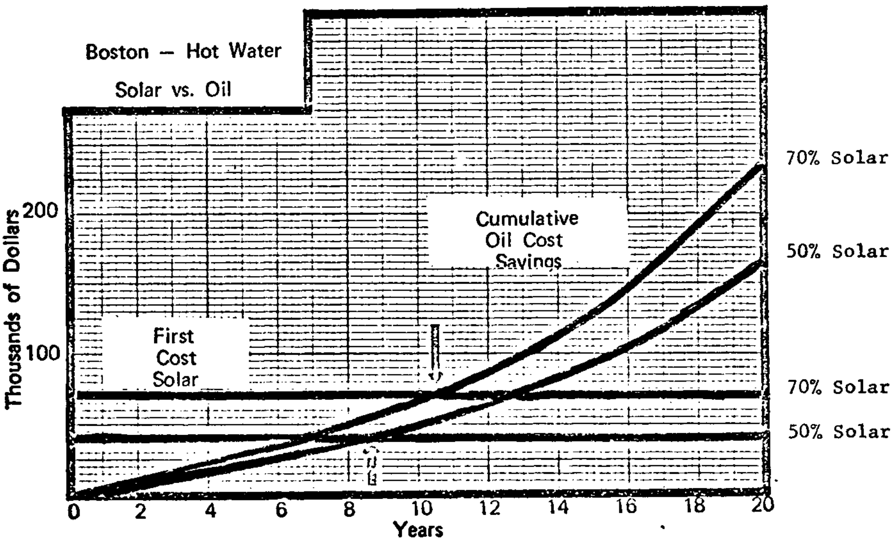

Figure 4.

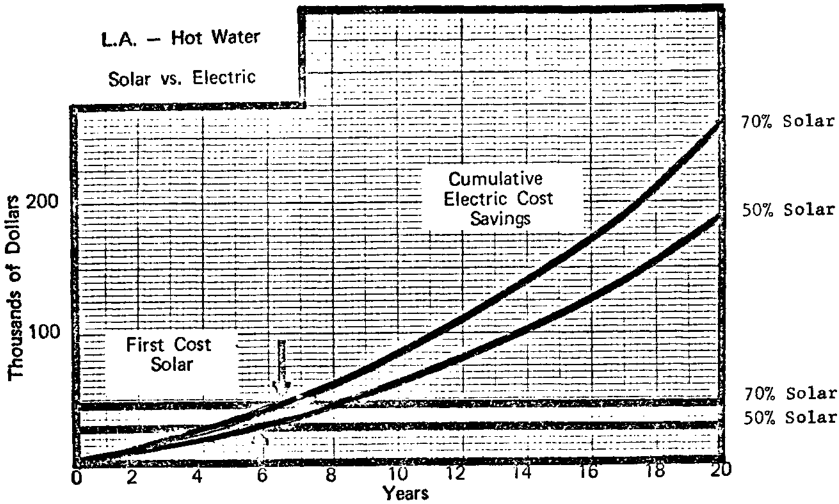

Figure 5.

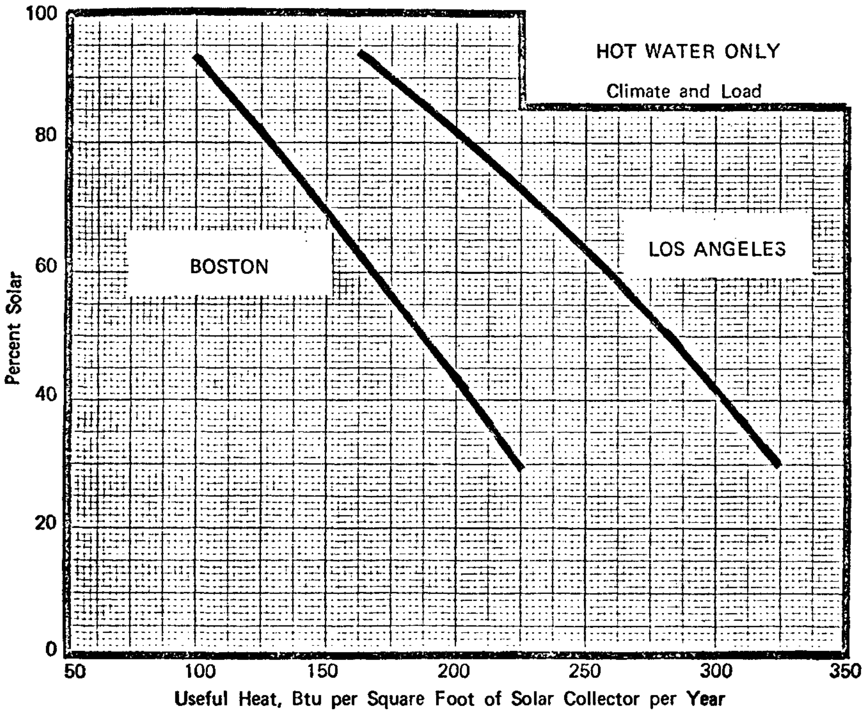

Figure 6.

SOLAR ENERGY INDUSTRIES ASSOCIATION PROPOSALS FOR TEMPORARY SOLAR ENERGY INCENTIVES AND FOR OTHER GOVERNMENT ACTIONS TO ACCELERATE SOLAR ENERGY APPLICATION

The following summarizes present thinking of SEIA . . .

Homeowner Incentives. A tax credit to homeowners equal to 40% of the first $2,000 and 25% of the next $6,000 invested in equipment to "produce" solar energy. To be eligible for incentive tax credits, the installation must meet "Temporary Standards" now being developed by NBS and/or future ANSI National Consensus Standards.

Incentives for Multi-Family Residential, Commercial and Industrial Applications. A tax credit equal to 20% of the investment or provision for five year rapid amortization at the option of the investor. Eligibility as above.

Incentives for Non-Profit Entities. A grant equal to 40% of the investment. Applies to state and local governments, schools, hospitals, non-profit corporations, etc. Eligibility as above.

Incentives for Producers of Solar Equipment. Five year rapid amortization of capital investments made to produce solar energy equipment. A development loan program to assist capital formation by small business firms planning to produce solar energy equipment. A program to permit the Federal Government to purchase specialized eqipment required to produce solar energy equipment and lease such equipment to industry for such use.

Loan Guarantee Programs -- Homeowners. Government loan guarantees applying to installed cost of solar equipment such that the additional investment required will not add to the down payment required for new residencies. Government loan guarantees, and if necessary, interest subsidies for retrofit applications to equalize interest costs with new installations. Program is similar to educational loan program. Eligibility as above.

Loan Guarantee Programs - Other. Government loan guarantees applying to installed cost of equipment such that the additional investment in solar energy equipment does not require additional equity financing by owner. Interest subsidies to equalize owner's money cost with that of other energy producers (oil companies, etc.), who normally borrow at or near the "prime rate."

FEA Solar Energy Commercialization Activities. FEA should be provided with adequate funding to support its solar activities. These activities include: overcoming institutional, economic and legal barriers; developing state and local programs; educating the public, etc.

Government Buildings Program. Implementation of a program based on S-2095 with certain modification to assure adequate solar energy equipment utilization.

Demonstration Programs. Adequate implementation of PL 93-409, the "Solar Heating and Cooling Demonstration Act of 1974," is needed. At present it appears that too great emphasis is being placed on "development in support of demonstration" and too little upon an adequate number of demonstrations. There is also concern that ERDA spending plans may involve diversion of effort from support of direct solar thermal applications (heating, hot water and cooling) which have mid-term as well as long term potential to applications requiring extensive research efforts and having only long term potential for energy savings--if R&D is successful. (Solar thermal electric, ocean thermal gradients, etc.)

Specific Programs to Accelerate
Development of Photovoltaics

All of the above programs relate to photovoltaic applications as well as to solar-thermal applications. In addition, the following programs are proposed as a means of accelerating development of photovoltaic applications.

Air Conditioning Programs. Applications in which solar electric energy gathered by photovotaic cells is used to power compressor air-conditioning apparatus become cost-effective at higher photovoltaic cell costs than the generality of applications. Basically, this is because energy storage in the form of chilled water is low cost. Immediate proof of concept and early demonstration installations are propsed.

Remote Government Installation Programs. Programs similar to the general Government Buildings Program aimed at installation of photovoltaic devices in remote areas should be initiated at this time.

Results To Be Expected

The combined effect of these programs will substantially accelerate development of solar energy applications. We estimate total solar energy production predicted upon these and those programs already in place equivalent to 1 million barrels per day of crude petroleum within ten years. Without the package proposed and with only those programs now in place, savings would not exceed 100,000 barrels per day in ten years.

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COMPARATIVE CAPITAL AND TAX REVENUE COSTS OF REPLACING IMPORTED CRUDE OIL WITH ELECTRIC POWER AND WITH SOLAR THERMAL ENERGY

The Basic Concept

Scarce energy forms, such as oil and gas, used in heating and cooling may be replaced with alternative energy sources, such as solar energy or electric energy (when generated using coal, nuclear fuel, and later in time, solar electric energy, geothermal energy or fusion, which energy resources are in relatively plentiful supply).

Basic Findings

The capital cost of exploiting solar energy for this purpose is lower than the capital cost of electric generating facilities required to accomplish the same purpose, particularly so when the solar installation derives its auxiliary energy requirements from "off peak" electric power. The cost to the Treasury, per barrel of crude oil saved, of the incentives proposed by the Solar Energy Industries Association is less than those incorporated in existing tax legislation applying to electric utility companies. The results are as follows:

Capital Requirements, Tax Revenue Effects And Primary Energy Implications of Various Alternatives To Replace One Barrel of Crude Oil

Primary Energy Content
5.8 to 6.0 Million Btu

	Capital Cost	Cost To The Treasury	Primary Energy Required
100% Electric Generation	$228.38	$121.50*	9.5 Million Btu
60% Solar	$130.50	$ 40.46	
+40% Off Peak Electric Power	0	0	3.8 Million Btu
	$130.50	$ 40.46	

*If that portion of the cost to the Treasury representing the effect of depreciation allowances for tax purposes and which is a deferred cost is discounted to its "present worth" at a discount rate of 6% per year, the $121.50 becomes $95.66.

Electric Energy Capital Costs

One barrel of crude oil has a heat value of 5.8 to 6.0 million Btu. Crude oil is a "primary" energy source. As primary energy, the heat content of crude oil is 5.8 to 6.0 million Btu per barrel. In relating crude oil as a primary energy source to the heat required to heat building space or to heat domestic hot water, we must first account for the various losses involved in converting crude oil into heating oil, a refinery product, distributing this product to the users and the losses encountered in converting the energy content of the heating oil into useful heat applied to the load. These are primarily combustion losses. It is estimated that 12% of the primary energy contained in the barrel of crude oil is lost in refining and distribution. This means that one barrel of crude oil with a heat content of 6.0 million Btu is equivalent to 5,280,000 Btu in heating oil delivered to the user. In the process of burning the heating oil, further losses are encountered--the heat in the relatively hot flue gas exhausted into the atmosphere, losses associated with thermal cycling of the furnace, etc. These losses are estimated to equal 45% of the heat value of the heating oil burnt. Deducting this 45%, we find that one barrel of crude oil delivers 2.9 million Btu to the space heating or hot water heating load.

Electric energy applied to such loads can be utilized with virtually 100% efficiency. (There are no combustion losses.) Upon this basis, 2.9 million Btu (equivalent to one barrel of crude oil) requires delivery of 850 kilowatt hours to the load. The costs of electric generating plants and distribution systems are usually related to the generating capacity of the plant. There are energy losses involved in the transformers and transmission lines required to ultimately deliver electric energy to a residence. These are estimated to be 15% of the power generated. Therefore, 850 kilowatt hours delivered to the load requires that 1,000 kilowatt hours be generated at the electric generating system.

If electric generating plants operated at a 100% utilization factor, each kilowatt of capacity in the generating plant would produce 8,760 kilowatt hours per year. Because the demand for electricity is not uniform and also because generating capacity must be shut down periodically for maintenance, the utility industry typically averages less than 50% utilization of installed capacity. If we estimate 50% equipment utilization, one kilowatt of capacity will produce 4,380 kilowatt hours per year.

Under today's conditions, we estimate that the installed cost of new generating capacity, together with the installed cost of new distribution and support facilities totals $1,000 per kilowatt of capacity. If this kilowatt of capacity will generate 4,380 kilowatt hours per year and recognizing that 1,000 kilowatt hours must be generated to replace one barrel of imported crude oil, we find that, at $1,000 per kilowatt of capacity, the capital cost of replacing a barrel of crude oil with electric energy is $228.38.

Solar Capital Costs

The useful heat produced by a solar installation will vary with insolation conditions, with the load profile and also with the extent to which solar energy is used to carry the load. Studies indicate that solar installations made with presently available "state of the art" equipment should produce 200,000 Btu of usable heat energy per square foot of collector area. (The "capacity" of the equipment is substantially higher, the 200,000 Btu net figure discounts capacity for the fact that load profiles are such that the full capacity of the solar system is not always needed and therefore, is not always useful.) Experience, as well as the prices of presently commercially available solar equipment, indicate that the cost of the solar equipment installed should be $15 per square foot. Therefore, 14.5 square feet of solar collector, together with other required equipment at a total cost of $217.50, is required to replace one barrel of crude oil.

The capital investment required in solar equipment to save a barrel of crude oil of $217.50 is modestly lower than the $228.38 investment required in electric generating facilities to accomplish the same purpose.

Solar Installations and Electric Utility Load Management

On the average, cost-effective solar installations will carry 50% or 60% of the heating or domestic hot water load, leaving the balance to be carried by "conventional" energy sources. Since somewhat over 50% of new residential units now utilize electric heat and well over 50% use electric domestic hot water heaters, and recognizing that we are considering electricity and solar as alternative means of reducing crude oil consumption, we may consider the case in which the auxiliary energy requirements are provided by electric energy. As is discussed in more detail in the analysis being presented in response to Congressman McCormack's request, the thermal energy storage capability, which is an integral part of the solar installation, provides an opportunity for utility load management such that the auxiliary energy requirements of the solar installation may be furnished on a strictly "off peak" basis. Since off peak power requires no additional investment in generating or distribution facilities but simply increases the level of utilization of existing facilities, no investment is necessary to supply auxiliary electric energy requirements.

Therefore, if the solar system supplies 60% of the energy required to replace a barrel of crude oil, the solar investment is $130.50. No investment is required in electric facilities and the total new investment is, therefore, $130.50.

Cost to the Treasury Of
Various Alternatives

The Solar Energy Industries Association has proposed a program of temporary incentives to accelerate use of solar energy. In the case of individual homeowners, we have proposed a tax credit equal to 40% of the first $2,000 invested by the homeowner and 25% of the next $6,000. If we assume that the average cost of the solar installations made by the individual homeowners is $5,000, the average incentive tax credit becomes 31%. (This is a somewhat low estimate of total equipment cost; a higher estimate of equipment cost would generate a somewhat lower average tax credit.)

Based on an average tax credit of 31% to the homeowner, the cost to the Treasury per barrel of crude oil saved would be:

Crude Oil Savings Derived From Solar Alone	$67.43
Crude Oil Savings Derived From Solar (60%) Integrated With Off Peak Electric Power (40%)	40.46

Under the terms of existing legislation, an electric utility company building new capacity is allowed a 10% investment tax credit. On the basis of an investment of $228.38 per barrel of oil saved, the cost of this investment tax credit to the Treasury is $22.84.

In addition, the electric utility is permitted to depreciate the remainder of their investment for tax purposes by deducting the remaining investment from taxable income over a period of time. Assuming a corporate tax rate of 48%, the cost to the Treasury of these deductions from income for depreciation upon the remaining $205.54 is $98.66. Thus, the total cost to the Treasury of the "all electric" alternative is $121.50.

It is true that the depreciation allowances and their impact upon Treasury revenue occurs over a period of years. If the future costs to the Treasury are discounted to the present at a discount rate of 6% (representative of the Treasury's cost for money), and we assume that, for tax purposes, the facilities are depreciated over a twenty year period and that the utility uses the "sum of the digits" method of depreciation; the present value of the $98.66 becomes $72.82. Adding back the immediate effect of the investment tax credit of $22.84, the discounted cost to the Treasury of the "all electric" option is $95.66.

In either event, the cost to the Treasury of supporting solar development with the tax incentives proposed by S.E.I.A. is less than the cost to the Treasury of supporting further development of electric energy resources already established by existing tax legislation applicable to electric utilities.

Questions were also raised as to the relationship between the investment required for a solar installation and that required to develop shale oil resources, to develop production of synthetic natural gas from coal or to develop production of liquid fuels from coal. Our answer to these questions was and is that we do not have any reliable estimates for these alternatives. Development of such estimates would be highly complex. For example, in the case of shale oil development, we must consider not only the cost of the plant facility required to extract oil from shale itself but we must also consider the capital cost of refinery capacity to refine the crude product, and most particularly, we must consider the capital cost inherent in development of water resources required by the shale oil plants. It is unfortunately true that shale oil reserves are located in areas which are semi-arid and in which existing water resources are limited, with very limited present availability of surplus water resources. What would be the capital cost to the Government to increase water availability in these areas?

Mr. MOORHEAD. Well, thank you very much, Mr. Butt.

The subcommittee would now like to hear from Mr. C. A. Morrison, director of research, solar energy and energy conversion laboratory.

Mr. ROUSSELOT. May I ask a question?

How many members do you have in your association?

Mr. BUTT. Approximately 400.

Mr. ROUSSELOT. Thank you, Mr. Chairman.

Mr. MOORHEAD. Mr. Morrison.

STATEMENT OF C. A. MORRISON, DIRECTOR OF RESEARCH, SOLAR ENERGY AND ENERGY CONVERSION LABORATORY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLA.

Mr. MORRISON. Thank you, Mr. Chairman.

Briefly, I have noted in my comments there appears to be some inconsistency in section 2, paragraph B, "Authorization of Loans." It is covered in my comments.

Also in that section under "Cooling equipment," there is a section there that appears to be creating the Energy Research and Development Administration as an agency to establish performance criteria for the solar heating and cooling equipment and issue certification and do other police work in this area. I find this somewhat alarming, because I feel that industry, in as far as possible, should not be under the direct jurisdiction of governmental bureaus. I think they are more capable of policing themselves.

I have prepared a packet of material for you that has given much information concerning various types of research work that have been accomplished in the field of solar energy at the University of Florida. It will show you operational prototypes that you can study.

Mr. MOORHEAD. Without objection, the material, which is very interesting, will be made a part of the record.

[The material referred to concerning various types of research work that have been accomplished in the field of solar energy at the University of Florida follow Mr. Moorhead's prepared statement:]

Mr. MOORHEAD. Thank you.

Many of these materials and prototypes have been in operation for over 15 years. Insofar as flat plate collectors are concerned, I personally know that they were in use in south Florida in 1930. So these are not new technologies. I think a better thing is to say that solar energy has been a neglected technology.

The flat plate collector has been operational for many years. We have been able to establish the fact that it is rather efficient. Currently, a well-designed collector is roughly 50 percent efficient in the range of about 150° F.

There are some corrections on my statement that should be so noted. Your secretary has these corrections.

Mr. MOORHEAD. They will be noted.

Mr. MORRISON. The best possible efficiency would be 100 percent Fahrenheit—correction, 100 percent efficiency. So we cannot look for any dramatic breakthrough in the design of flat plate collectors that will triple or quadruple the efficiency. It is just not going to do it.

I believe, though, that through the proper manufacturing incentives and equipment selection, material selection, mass production techniques, that cost reductions of considerable magnitude can be effected. This will bring the product into the purchasing capability of the homeowner.

The same flat plate collector which has proved very efficient in our experimental work can also be used to power refrigeration devices. We have made ice with it. We have absorption systems that are producing air-conditioning. We have developed 11 such systems over the past 20 years. Currently we have in operation in our test house an air-conditioning system that successfully operated under manual control. Solar-powered air-conditioning is here. It is a matter of automation and perfecting the systems. It is not a question of whether or not it can be done.

Our residential unit is currently being heated by solar energy. It is under thermostatic control. It operates just exactly like any other residential heating plant operates, and you cannot tell the difference whether it is being heated by solar or some other, more conventional method.

We have two separate systems in the house; both of them work. We have various other projects that are being pursued, which I will not be able to go into.

On the basis of our data, which has been gathered over a number of years, we have determined that our hot water heating cost in our residential unit has been reduced 85 percent through the use of solar energy. We estimate that at least 80 percent of our heating requirements for the solar-powered residence will be able to be met. So on the basis of these experiments, I believe that the overall heating, water heating and house heating bill for the residential homeowner or small business owner could be reduced as much as 75 percent on a national basis, if we were to go to a strong program that would accelerate the use of this energy.

Now, I do not really think that solar energy is the cureall. It is not going to meet all of the demands, but it certainly is a source of energy that should be used wherever it is possible. When it is not possible to use solar energy or some other renewable type of energy source, then and only then should the more conventional energy of the non-renewable type be used.

Thank you.

[The prepared statement of Mr. Morrison follows:]

PREPARED STATEMENT OF MR. C. A. MORRISON, DIRECTFR OF RESERCH, SOLAR ENERGY AND ENERGY CONVERSION LABORATORY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLA.

COMMENTS ON H.R. 3849 AND SOLAR ENERGY TECHNOLOGY

Since it was November 3, 1975, when I received my copy of House Bill No. H.R. 3849, I have not been able to examine the bill in depth. A preliminary review of the bill indicates that the overall effect of this enactment should be quite beneficial to those who are interested in the practical application of solar energy technology at the earliest possible time.

I noted that under Section 2, "Authorization of Loans", paragraph B, line 6, a figure of $6,000 is to be made available for a one to four family structure. In reviewing the remainder of the paragraph, I assume that the intent of this subsection "A" was to make available $6,000 per dwelling unit in the case of a one to four family structure. If this was not the intent, then it would seem as if the subsequent items would not be consistent.

While my general reaction to the bill was quite favorable, I am somewhat concerned about the content of the "Cooling Equipment" section, paragraph B, which is on page 7 and starts at line 6. It appears as if the Energy Research and Development Administration is being commissioned to establish performance criteria for solar heating and cooling equipment, issue certification regarding the performance of this equipment, and police the manufacturing and marketing of the equipment. This I find alarming, because I feel that industry, insofar as possible, should not be under the direct jurisdiction of governmental bureaus. It has been my experience that bureaucratic regulations more often deter, rather than promote, progress in the field of industrial research and development.

In order to assist the members of this committee in evaluating the present state of solar water heating, house heating, and cooling technology I have prepared a packet of material which will be distributed to each of you for your perusal. While examining these materials, you will see that solar energy has been widely and successfully applied at the prototype level of development for many years. Many of the solar powered devices, which are discussed in these pamphlets, were operational in our laboratories at the University of Florida more than 15 years ago. In the case of flat plate solar collectors, I personally know that they were successfully operated in south Florida as early as 1930. With these thoughts in mind, I think it would be more accurate for us to think of solar energy not as a new technology but rather as a neglected technology, for its use declined, not because it was inoperable, but because it was more convenient and often more profitable to use some alternative which invariably employed the consumption of our non-renewable resources.

Since the flat plate collector has been in use for many years, it is not realistic to think that there will be any great "breakthrough" in technology that will vastly improve the efficiency of these collectors. The obvious truth of this statement becomes evident when it is realized that, under normal circumstances and with a flat plate solar collector of good quality, it is possible to achieve overall thermal efficiencies in the range of 50% when the equipment is operating so as to produce hot water of approximately 150° F. Since the best possible efficiency would be 100%, it is evident that there will be no design breakthrough which will double or triple the output of these devices. The cost of producing these flat plate collectors at the present time is rather expensive, and the average cost per square foot of solar collector surface ranges from 10 to 20 dollars. I believe that, through the proper encouragement, the manufacturing community will be able to employ mass production techniques, proper material selection and efficient marketing procedures to significantly reduce the cost per square foot of collector surface so that a breakthrough in this area in my opinion is not only feasible, it is to be expected. The incentive required to stimulate the industrialist is the profit that will be visualized as he views the potential of a rapidly expanding market for his product.

The same flat plate collectors that are used for furnishing potable hot water to residences or small commercial operations may be used to operate absorption type refrigeration systems or other types of refrigeration devices which may be used for refrigeration or air conditioning purposes. Eleven such devices have been produced and operated in the laboratories at the University of Florida over a period of the last twenty years. While most of these systems were on the prototype scale, some have had sufficient capacity to power conventional air conditioning systems. Currently we have in the solar test house at the University of Florida a three-ton, intermittent, ammonia/water air conditioning system which was successfully operated during this past summer. We are currently in the process of automating this system so that it will not require manual control. We expect to have this automation complete so that the system will work effectively during the next cooling season.

Currently in use in the solar test house are two heating systems which employ the hot water produced by flat plate collectors to furnish the heat required for the residents who occupy this house. Either of the heating systems are designed so that they operate from thermostatic controls, and one cannot tell whether the house is being heated with solar energy or some other more conventional method. The two heating systems that are currently in use in the house are:

(*a*) Baseboard hot water convectors.

(*b*) Forced air circulation system which utilizes a hot water coil heat exchanger.

Each of these systems has been tested and found to be capable of supplying the needs of the residence.

Other projects, which are currently being investigated at the University of Florida, include the solar purification of waste water, power generation for residential requirements, cooking devices which employ hot fluids produced by solar concentrators, solar tracking devices which are totally powered by solar energy, and various other equipment directly or indirectly related to these projects.

Our records of energy consumed by the hot water system, which has been in operation at the solar test house for a number of years, indicates that we save approximately 85% of the energy required to heat potable water for the residence. While we did not have sufficient data on the energy savings related to the heating of the residence, it is estimated that we will be able to furnish at least 80% of the heating requirements of our residence through solar energy. The system is designed so that it can operate effectively for several days even when there is minimal sunshine. Subsequent to such a period of time we need several days of good sunshine in order to recharge the storage tank. If we consider only the savings on space heating and hot water heating for the normal American residence, I feel that it would be safe to say that we could reduce these utility bills by 75% through the use of solar energy. Such a savings is certainly significant to the small businessman or home owner who is currently becoming painfully aware of the rapidly increasing cost of energy.

While I do not think that solar energy is a "cure-all" for the energy problem, I do believe that it is one source of energy which should certainly be utilized, since it is constantly being renewed. It should be used wherever it is possible to employ its use successfully, and the non-renewable fuels should be utilized only for those purposes that cannot adequately be met through the use of some type of renewable energy.

[The material referred to by Mr. Morrison in his prepared statement may be found at the end of the hearing on page 165.]

Mr. MOORHEAD. Thank you all very much.

I have some questions in writing that I would like to submit to you, but I would not ask them orally because of the time constraints.

Mr. MOORHEAD. Just one question—and this would be to you, Mr. Butt, and any other comments from the others.

In your statement, on page 3, you spoke of solar cooling as technically practical today but not economically feasible.

Do you mean it is not economically feasible when used by itself, or as part of a larger system for cooling?

Mr. BUTT. Well, basically, I would say that economically feasible means that the cumulative savings will equal the first costs in no more than 10 years. You cannot achieve that with solar cooling today. That is, it would take more than 10 years for the savings to equal the first costs.

Mr. MOORHEAD. Is there any dissent from the panel?

[No response.]

Mr. MOORHEAD. Mr. St Germain.

Mr. ST GERMAIN. I have no questions.

Mr. MOORHEAD. Mr. Rousselot?

Mr. ROUSSELOT. I will try to be brief.

Mr. DeBlois, I was interested, since you serve as chairman of the solar energy application committee for your fuel institute, in knowing whether you have any test units now going in the area that your people serve?

Mr. DEBLOIS. We are in the process, Mr. Rousselot, of installing and developing seven water heating units, which will be installed. None has been installed and is in actual operation at this time.

Mr. Rousselot. You have none in operation now?
Mr. DeBlois. We have none now.
Mr. Rousselot. But you plan to have seven in operation when?
Mr. DeBlois. They will start about in December, and I assume all of them will be in. Mr. Burkhardt is giving me a more updated figure than I am giving you, but from a practical standpoint, I think they will all be installed by, let us say, next April or May.
Mr. Rousselot. Next spring?
Mr. DeBlois. Yes, sir. They will be operating.
Mr. Rousselot. And will they be able to provide cooling effects as well as heating, or just heating?
Mr. DeBlois. We are not involving ourselves at this time with cooling, sir. There is a reason for this, and Mr. Burkhardt will answer that.
Mr. Burkhardt. In New England, we do not have a supercooling problem. There are only an average of 16 days a summer throughout the region that require cooling.
Mr. Rousselot. I appreciate that. I was just asking the question. Then you would be prepared to give us some kind of a report by, say, next July, as to what the effect of this has been?
Mr. DeBlois. We should be able to give you an initial report.
Mr. Rousselot. Will they be in different States?
Mr. DeBlois. There are two States for the water heating. Three units are going to be installed in the State of Rhode Island; four units are going to be installed in the State of Connecticut. At some point after that, we hope to install a whole house heating system.
Mr. Rousselot. Are these privately financed, or did you get a Government grant?
Mr. DeBlois. At this time, the units, the water heating units, in Rhode Island and Connecticut, are being privately financed through the institute.
Mr. Rousselot. So the seven units are all being basically privately financed?
Mr. DeBlois. That is correct.
Mr. Rousselot. Did you have difficulty in getting the financing?
Mr. DeBlois. Mr. Burkhardt, do you want to tell him about the financing?
Mr. Burkhardt. The institute appropriated $50,000, or asked the finance committee to appropriate $50,000.
Mr. Rousselot. Which came from membership dues?
Mr. Burkhardt. Yes. And it might interest you, in the space of three phone calls to three dealers, they each contributed $10,000 in a single day. Mr. DeBlois' company was one of the companies that put out $10,000. And the remaining $20,000 is coming from the six affiliate associations that make up NEFI, which is a federation. We raised it in 1 week.
Mr. Rousselot. We ought to put you in charge of New York City. [Laughter.]
In other words, because it is a test, your own membership really contributed?
Mr. DeBlois. Yes. We felt it was to the benefit of the consumers in our area. We certainly have gotten a lot out of the industry, our home heating oil industry. And the members in the institute felt that this

was an opportunity that just could not be missed to add solar heating, hopefully.

Mr. ROUSSELOT. Are these in new or existing homes?

Mr. DEBLOIS. These will all be retrofits.

Mr. ROUSSELOT. And do you have a single builder doing all of them?

Mr. DEBLOIS. No, sir. It will be individual homeowners that will be contacted, or have been contacted already, in some instances, that will add solar panels, either in conjunction with an existing water heater, or with a new water heater, or an existing tankless heater.

Mr. ROUSSELOT. Do they come from your association?

Mr. BUTT. Well, there is one quite substantial manufacturer of solar water heaters in the Boston area.

Mr. ROUSSELOT. Is that the one you are using?

What I am asking is, did you have trouble finding viable manufacturers to produce this equipment?

Mr. DEBLOIS. No. I think we had just exactly the opposite.

Mr. ROUSSELOT. Thank you. I appreciate that.

Mr. MOORHEAD. Mrs. Spellman.

Mrs. SPELLMAN. I would just ask one question.

On those buildings that are being retrofitted, was there a cost-effectiveness factor involved in that?

Mr. DEBLOIS. It was estimated by the institute at this time that the equipment itself, because it is going to be seven different types of equipment, basically, it will be slightly different, it will run somewhere between $600 and $1,800 for the equipment itself. You could generally double that, let us say, by the time you get it installed. Then, of course, it has to be monitored. We have already spoken with two institutes of higher learning to monitor the equipment for results. It is a costly project.

Mrs. SPELLMAN. Thank you. Thank you, Mr. Chairman.

Mr. MOORHEAD. Thank you very much, gentlemen. We appreciate it.

I am sorry that we had to cut the time short, because we could have gone on at length. But I know you did not want to come back tomorrow, and we could not find a way of arranging it for this afternoon.

The subcommittee would now like to hear from Mr. Claude E. Barfield, Deputy Assistant Secretary for Research and Demonstration of the Department of Housing and Urban Development.

STATEMENT OF CLAUDE E. BARFIELD, DEPUTY ASSISTANT SECRETARY OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, OFFICE OF RESEARCH AND DEMONSTRATION

Mr. BARFIELD. Mr. Chairman, I will submit a statement for the record, and I would make two points about the thrust of it.

One is that, basically, our report is not in disagreement with much that was said here today. The major problem area is the question of timing with respect to incentives. We feel that one of the mandates to HUD and to ERDA under the demonstration program is to take a look at any incentives which should or could be utilized and make recommendations. Within the time-frame of the demonstration the HUD Secretary and the ERDA Administrator will make those recommendations.

Mr. MOORHEAD. Then I would like to ask you just one question. And that is when?

When will this demonstration period be?

Mr. BARFIELD. Well, the demonstration period for heating and cooling is for 5 years. And we think during the last 2 years of the demonstration we will have enough experience behind us, both in regard to the cost of the systems as well as the performance by region, to give some indication to the Congress—indeed, definite indication to the Congress as we are mandated to do under the Demonstration Act—as to what, if any, incentives are needed. That is a part of our charge already.

Mr. MOORHEAD. When did you say?

Mr. BARFIELD. I could not give you an exact date, but I would say some time within the last 2 years of the demonstration.

Mr. MOORHEAD. And that is a 5-year demonstration period?

Mr. BARFIELD. Well, we are 1 year into the demonstration. It would be some time, I assume, in 1978 or 1979.

Mr. MOORHEAD. Well, I think it could be expedited.

[The prepared statement of Mr. Barfield follows:]

PREPARED STATEMENT OF CLAUDE E. BARFIELD, DEPUTY ASSISTANT SECRETARY FOR RESEARCH AND DEMONSTRATION, DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Mr. Chairman and members of the subcommittee, I appreciate the opportunity to discuss with you the role of the Department of Housing and Urban Development in the Federal solar heating and cooling program, and in particular our comments on the various proposals before the Congress which would provide financial incentives for the use of solar energy.

The potential value of solar energy in reducing our Nation's need for fossil fuels and in reducing the cost of energy to individuals and commercial establishments has been discussed in many forums. Congress clearly stated the case for using solar energy to heat and cool buildings and heat domestic water in the Section on Findings and Policy in the Solar Heating and Cooling Demonstration Act of 1974, P.L. 93-409. I need not, therefore cite statistics on fuel use and the potential fuel savings through the use of solar energy.

I think it is useful, however, to begin with an abbreviated overview of the Federal program in solar heating and cooling which has been developed to carry out the requirements of P.L. 93-409. P.L. 93-409, as enacted, called upon the Secretary of Housing and Urban Development and the Administrator of the National Aeronautical and Space Administration to develop and conduct the solar heating and cooling demonstration program. The legislation creating the Energy Research and Development Administration, however, transferred overall responsibility for energy research to ERDA. In addition, the NASA and National Science Foundation responsibilities stated in P.L. 93-409 were transferred to ERDA. HUD's role was not changed.

In response to this legislation, ERDA, HUD and a number of other agencies developed a comprehensive plan for the solar heating and cooling program. This plan, initially published in March as the Interim Report, National Plan for Solar Heating and Cooling, ERDA-23, has just been revised and reissued as the National Program for Solar Heating and Cooling, ERDA-23A.

The National Program calls for a four-part approach to meeting the goal of widespread utilization of solar energy for heating and cooling, and assigns responsibility to various agencies for different parts of the program.

The first part involves research into the use of solar energy, identification and testing of new materials and material applications, and development of new techniques to use solar energy for cooling. These activities will be undertaken by ERDA, the National Science Foundation, and other agencies at ERDA's request.

The second part is concerned with the development of solar energy systems, including improvement to existing systems and the development of new system concepts. This activity has been assigned to NASA's Marshall Space Flight Center, which has issued a series of Requests for Proposals for solar energy system development, for component development, and for instrumentation systems to be used in the demonstration program.

The third part of the program has received the greatest public interest and will involve the largest expenditures; this is the demonstration of solar heating and cooling systems in actual residential and commercial installations. Responsibility for the demonstration activities has been split, with ERDA managing demonstrations in commercial installations and HUD supporting similar installations in single-family, townhouse and apartment residential units. These demonstration projects will be selected through competitive proposals submitted in response to formal solicitations. This competitive procedure will permit ERDA and HUD to select the projects which best meet the program objectives.

The demonstration portion of the program has two objectives. First, it will provide an opportunity to test solar energy installations in a wide variety of situations involving different climates, geographic locations, housing types and designs, and technical approaches. Data from these projects will provide invaluable information in the development of technical standards, financing alternatives, and marketing procedures.

Second, the demonstration program will offer a chance for the public to see what solar energy is all about, or, as the automobile salesman puts it, to "slam the doors and kick the tires."

Three project solicitations were issued this fall in the demonstration program. The first, Program Opportunity Announcement (or POA) DSE 75-1, was issued jointly by ERDA and HUD. The POA solicits proposals for solar energy systems which can be used in the demonstration program in either residential or commercial installations, or in both. A solar energy *system*, to qualify for this solicitation, will usually consist of a collector which receives the solar energy radiation and converts it to heat energy, a method of transporting this energy to storage or to its point of use—the usual transport mechanisms are liquids such as water or certain oils, or air—a storage subsystem which can hold the energy for use at night or when the sun is not shining, a heat exchanger or other device to distribute the heat into the regular heating syystem, and a control system which will turn on and off the various valves, dampers, pumps, fans or other components of the system.

The POA closed on Monday, November 3. All proposals will be carefully reviewed by qualified technical panels from various Federal agencies, supported by a technical consulting team provided by the American Society of Heating, Refrigerating and Airconditioning Engineers. The panel will determine whether the proposed system has been developed to the point that it can be used in demonstration units at an acceptable level of risk.

Systems which are determined to be ready and appropriate for the residential demonstration program will be matched with selected project locations in various areas of the Nation to assure that good research data can be secured on system performance and on the nature of local development problems which may exist. These projects will be selected through solicitations issued on a local basis to builders and developers who are interested in the program and wish to participate in it.

The second project solicitation is Request for Grant Application (or RFGA) No. H-2353, issued by HUD on September 26, with a due date of November 10. This solicitation calls for project proposals which involve a complete, integrated, project package—building, land, financing, and solar energy system. Projects under this solicitation will differ from those using systems selected through the Program Opportunity Announcements since we will also accept "passive" systems where the building design itself is part of the solar package, as well as more "conventional" approaches where a separate system is installed in the building much in the same way that a regular heating system is used. We don't know how many proposals will be received, of course, but over 4,000 copies of the Request were mailed out in response to requests from individuals, manufacturers, builder/developers architects, public agencies, and others. We expect to make at least 20 awards after the proposal evaluation process is completed, probably late in December.

The third project solicitation issued this fall is ERDA's Program Opportunity Notice (or PON) DSE 75-2. It calls for integrated project package proposals for commercial projects, similar to the integrated residential project which HUD is seeking under RFGA H–2353. Proposals in response to PON DSE 75–2 are due at ERDA on November 26.

The demonstration projects selected under either HUD RFGA H–2353 or ERDA PON DSE 75–2 will receive grants or contracts providing for funding for part or all of the solar energy portion of the project. For example, funding could cover the purchase and installation costs of the solar system, the costs of building modifications to adapt the building structure for the solar system, and the cost of designing these modifications. In general, the solar demonstration project funds will not be used to cover the basic building costs. Projects involving "passive" approaches where the building is an integral part of the solar package will be treated on an individual basis.

I should note here that the Government will not take title to either the building or the solar energy installation under this funding approach. Rather, we are providing a mechanism to get solar energy demonstrated, and contracting for the right to obtain data from the installation for a period of five years, as authorized in P.L. 93–409.

The fourth part of the overall program is the development of a market for solar energy. This activity involves the creation of appropriate standards and system qualification procedures, the identification of potential barriers to widespread acceptance and development of ways to overcome these barriers, and the dissemination of information on solar energy to all interested parties.

The information dissemination programs is a joint ERDA–HUD responsibility, and will involve the use of ERDA's Technical Information Center at Oak Ridge as a primary depository of solar information. In the residential demonstration program, HUD will collect data from the demonstration projects and from other sources, will assemble these data into the proper format for storage and processing at Oak Ridge, and will develop and implement a program to disseminate this information to all potential users. This dissemination aspect of the program is very important. We must get accurate and timely demonstration data out to the builders, the bankers, the manufacturing industry, and—most importantly—the housing customer.

The other market development activities—identifying and overcoming barriers and developing appropriate standards—are also HUD functions under the demonstration program. Many potential barriers to the use of solar energy have been discussed in the literature relating to the solar energy field. Among these are the impact of building codes and zoning regulations upon the practical use of solar energy; attitudes of labor organizations, builders, and other elements of the housing industry; the pricing practices of utility companies; the generally higher first cost of solar energy installations; and concern regarding the reliability of the systems.

In the demonstration program we will be collecting data on all of these factors and evaluating their real impact on the development of a solar energy market. Many of these factors are interrelated with our function of developing appropriate performance standards and with the question of whether incentives are necessary to encourage the more widespread utilization of solar systems. The concern for reliability, for example, can best be answered by warranty protection based upon accurate performance data, which we will be obtaining from the demonstration projects. As a second example, high first costs may call for the provision of some type of financial or other incentive.

I would like to discuss the related issues of standards and the possible need for incentives in somewhat greater detail within the general context of some of the legislative proposals now pending before the Congress.

H.R. 3849, which has been referred to the House Committee on Banking, Currency, and Urban Affairs, would authorize this Department to make direct loans to homeowners and builders for the purchase and installation of qualified solar heating and solar heating and cooling equipment. Another legislative proposal (H.R. 6860) would provide tax credits to homeowners for installation of solar energy equipment in their dwellings.

One specific responsibility assignment to the Secretary in P.L. 93–409 is that of studying "the necessity of a program of incentives to accelerate the commercial application of solar heating and cooling technology. This study is being incorporated into our demonstration program, but we do not at this time have sufficient information to determine whether incentives are necessary, or what the best approach to providing any needed incentive may be. For this reason, it appears that the proposed legislation on incentives is premature.

The purpose of these proposed incentives, of course, is to assist the homeowner in absorbing some of the additional cost of a solar installation so that the buyer can afford to install the system, and thereby reduce his demand for conventional fuels. The need for such incentives, however, depends upon the economics of the particular situation and upon the current practices in the local financial community. The assumption underlying these proposals is that a solar energy system will reduce the demand for conventional fuels, and thereby reduce the average monthly operating costs for fuel to the property owner. Based on his fuel costs, on the cost of money, and on some estimated period of amortization, it is possible to determine whether the additional first cost of the solar energy system will pay for itself by reducing the expenditures for conventional fuels. In areas where the only available conventional energy source is electricity and where the costs of electricity are approaching 5¢/kilowatt hour, it is quite likely that no additional economic incentive would be required. On the other hand, in areas where natural gas is available at controlled prices, solar energy systems are not currently competitive.

In addition, each of the proposed Bills includes system cost limits and system performance level requirements. Whether either the costs or the performance levels are realistic and rational cannot yet be determined based on our current data.

Although solar energy installations have been around for over thirty years, most of them have been individual experimental projects. The most recent edition of a continuing private survey of solar heated buildings, updated to September 9 of this year, lists 163 buildings. There are probably another 100 to 200 units which have been built or are being designed. Almost all have been one-of-a-kind units with costs that reflect only their special nature. Good, long term performance and cost data are not generally available.

Information on systems is also limited. System costs are being quoted, or estimated, at everywhere from a few hundred dollars to tens of thousands of dollars for various types of installations, depending on local climatic and geographic conditions. Performance claims are being made based on evaluation procedures developed by the system producer, without any clear correlation to procedures used by other producers; thus, it is almost impossible to make any useful comparisons.

The demonstration program will provide "real-time" performance and cost data, collected and evaluated on a consistent, common basis. This will provide the information needed by the Secretary to carry out her responsibility to recommend incentives, and needed by the Congress in determining what forms incentives should take.

In their present form, these proposed incentive programs could result in windfalls to those homeowners and others who could economically justify the use of solar energy based on current energy costs, while at the same time they may not provide nearly enough incentive tc attract new solar energy installations which are in competition with lower price conventional fuels such as natural gas at controlled prices.

For example, a loan under H.R. 3849 can provide 75 percent of a maximum system cost of $8,000, to be repaid over 8 years at a rate equal to the average cost of Federal borrowing plus ½ percent for administration. For a loan interest rate of 6½ percent, the annual principal and interest payment is approximately $964. If, as is likely, such a system would provide approximately 75 percent of the total hot water and space heating loads, this is equivalent to a total yearly heating bill of $1,285. In other words, if the homeowner is currently paying more than $1,285 for heating and hot water annually, the solar energy system would save him money under this formula. Note, though, that this does not include the $2,000 out-of-pocket portion of the cost.

At this time, only electric heat in some areas of the country will approach this cost for energy, and therefore, the value of the loan program under H.R. 3849, as an economic incentive is probably limited. Incidentally, the 25 percent tax credit provisions included in Section 232 of H.R. 6860 will result in a similar situation if the balance of $6,000 is borrowed on an FHA/insured Title I property improvement loan.

In evaluating various incentive approaches, consideration must be given to their impact on the Federal budget. We have not yet made such an analysis, since, as I noted earlier, we do not have good data on the cost factors and size of the demand which are essential elements in this analysis. We recommend, therefore, that any action on incentives be deferred until the need for and method and costs of appropriate incentive programs can be determined during the latter part of the demonstration program.

Another aspect of the incentive problem interacts with the demonstration program. All of the proposed Bills would limit incentives to solar energy systems which are "qualified" under standards and procedures established under the authority of P.L. 93–409. This is an appropriate way to protect the public, the Federal government and the lending institutions.

P.L. 93–409 calls for Interim Performance Criteria to be developed within 120 days after enactment, and Definitive Performance Criteria to be developed as soon as possible, "utilizing data available from the demonstration programs." The Interim Performance Criteria were developed by HUD and the National Bureau of Standards within the specified time, but these Criteria are not sufficient for a program of system qualification, since many of the test methods and evaluation procedures must be developed and proved in the demonstration program.

At the same time, appropriate solar standards are needed now by this Department as a basis against which to evaluate existing solar energy systems for HUD mortgage insurance purposes, as well as to provide a basis for any forthcoming incentive programs. We have, therefore, instituted with NBS the development of an intermediate set of Minimum Property Standards for solar installations which can be used until the Definitive Performance Criteria are ready. These intermediate Minimum Property Standards will be ready in May of 1976.

It is our recommendation, then, that any consideration of financial incentives for solar energy systems for heating and cooling buildings be delayed until the need for, effective form of, and cost of such incentives can be analyzed based on data from the demonstration program.

Thank you.

Do you have any questions, Mrs. Spellman?

Mrs. Spellman. No.

Mr. Moorhead. Thank you very much, Mr. Barfield.

[The following are written questions submitted by Congressman Moorhead to the witnesses, along with their answers:]

Questions Submitted by Congressman Moorhead to Mr. Burkhardt and Mr. Butt

Question 1. Mr. Burkhardt or Mr. Butt, do you think the low-interest direct loan program as proposed in this legislation is the best way to encourage greater use of solar heating and cooling equipment, or would other incentives be more effective, such as tax write-offs or direct loans to manufacturers; Federal Home Loan Bank Board home mortgage purchase commitments to lenders making mortgage loans on homes with solar energy systems?

Reply by Mr. Burkhardt

Answer. It is our belief that tax write-offs or tax incentives would be a greater stimulus to the installation and use of solar heating equipment; especially for people with homes valued at $40,000 or more, involving a retrofit program. A long term, low interest, direct loan could be of greater value for solar energy installation for people with incomes under $25,000 and whose homes are valued at less than $40,000.

Reply by Mr. Butt

Answer. We believe that there are a number of constraints which must be resolved in order to rapidly accelerate commercialization of solar energy applications. At the consumer level, one of the constraints is the ability to obtain financing for a solar installation. H.R. 3849 and H.R. 8524 would resolve this problem. There is also a problem of "first cost." The fact that the interest rates implicit in the proposed legislation are lower than normal mortgage or home improvement loan interest rates has only moderate effect upon the consumer's monthly payments and therefore, only moderate effect upon the consumer's "cash flow." Incentives, income tax credits or the like, exercise more leverage on "first cost" as is spelled out in the examples incorporated in the written

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statement submitted November 5. Another constraint might be called "credibility." The consumer needs to be assured that solar systems will perform. The demonstration program implementing the Solar Heating and Cooling Demonstration Act of 1974 bears upon this constraint, provided that implementation does result in an adequate number of individual demonstrations adequately distributed across the Nation.

The comprehensive program developed by the Solar Energy Industries Association, a copy of which is attached, covers these and other required actions in outline form is as follows:

SOLAR ENERGY INDUSTRIES ASSOCIATION, PROPOSALS FOR TEMPORARY SOLAR ENERGY INCENTIVES AND FOR OTHER GOVERNMENT ACTIONS TO ACCELERATE SOLAR ENERGY APPLICATION

SUMMARY

The following summarizes present thinking of SEIA—

Homeowner incentives.—A tax credit to homeowners equal to 40 percent of the first $2,000 and 25 percent of the next $6,000 invested in equipment to "produce" solar energy. To be eligible for incentive tax credits, the installation must meet "Temporary Standards" now being developed by NBS and/or future ANSI National Consensus Standards.

Incentives for multifamily residential, commercial, and industrial applications.—A tax credit equal to 20 percent of the investment or provision for five year rapid amortization at the option of the investor. Eligibility as above.

Incentives for non-profit entities.—A grant equal to 40 percent of the investment. Applies to state and local governments, schools, hospitals, non-profit corporations, etc. Eligibility as above.

Incentives for producers of solar equipment.—Five year rapid amortization of capital investments made to produce solar energy equipment. A development loan program to assist capital formation by small business firms planning to produce solar energy equipment. A program to permit the Federal Government to purchase specialized equipment required to produce solar energy equipment and lease such equipment to industry for such use.

Loan guarantee programs—homeowners.—Government loan guarantees applying to installed cost of solar equipment such that the additional investment required will not add to the down payment required for new residencies. Government loan guarantees, and if necessary, interest subsidies for retrofit applications to equalize interest costs with new installations. Program is similar to educational loan program. Eligibility as above.

Loan guarantee programs—other.—Government loan guarantees applying to installed cost of equipment such that the additional investment in solar energy equipment does not require additional equity financing by owner. Interest subsidies to equalize owner's money cost with that of other energy producers (oil companies, etc.), who normally borrow at or near the "prime rate."

FEA solar energy commercialization activities.—FEA should be provided with adequate funding to support its solar activities. These activities include: overcoming institutional, economic and legal barriers; developing state and local programs; educating the public, etc.

Government buildings program.—Implementation of a program based on S-2095 with certain modification to assure adequate solar energy equipment utilization.

Demonstration programs.—Adequate implementation of PL 93-409, the "Solar Heating and Cooling Demonstration Act of 1974," is needed. At present it appears that too great emphasis is being placed on "development in support of demonstration" and too little upon an adequate number of demonstrations. There is also concern that ERDA spending plans may involve diversion of effort from support of direct solar thermal applications (heating, hot water and cooling) which have mid-term as well as long term potential to applications requiring extensive research efforts and having only long term potential for energy savings—if R&D is successful. (Solar thermal electric, ocean thermal gradients, etc.)

SPECIFIC PROGRAMS TO ACCELERATE DEVELOPMENT OF PHOTOVOLTAICS

All of the above programs relate to photovoltaic applications as well as to solar-thermal applications. In addition, the following programs are proposed as a means of accelerating development of photovoltaic applications.

Air conditioning programs.—Applications in which solar electric energy gathered by photovoltaic cells is used to power compressor air-conditioning apparatus become cost-effective at higher photovoltaic cell costs than the generality of applications. Basically, this is because energy storage in the form of chilled water is low cost. Immediate proof of concept and early demonstration installations are proposed.

Remote Government installation programs.—Programs similar to the general Government Buildings Program aimed at installation of photovoltaic devices in remote areas should be initiated at this time.

RESULTS TO BE EXPECTED

The combined effect of these programs will substantially accelerate development of solar energy applications. We estimate total solar energy production predicted upon these and those programs already in place equivalent to 1 million barrels per day of crude petroleum within ten years. Without the package proposed and with only those programs now in place, savings would not exceed 100,000 barrels per day in ten years.

SOLAR SYSTEM ECONOMICS

[About the tables attached (IA, IB, IIA, IIB, IIC)]

1. They are intended to illustrate the economics of Solar systems under "typical" conditions in various parts of the U.S.A.
2. Water heater calculations are based on "typical" hot water use by an "average" family of four.
3. Space heating calculations are based on a 1,500 square foot single family residence which is of "typical" construction for the area (varies from one area to another).
4. Electricity, oil and gas prices used cover the ranges encountered in each area. They are current prices. In calculating future savings, it was forecast that electricity prices would escalate at 7.5 percent per year (5 percent inflation+2½ percent). Gas and oil prices were forecast to escalate at 10 percent per year.
5. Pay-out time is the time required for cumulative savings to equal first cost.

I. WHAT ARE THE ECONOMICS OF STANDARD SIZE SOLAR HOT WATER HEATERS?

A. VERSUS ELECTRIC HOT WATER

	Solar, percent of hot water	Solar system cost	Pay-out time—years (electricity)		
			3¢/kWh	3½¢/kWh	4¢/kWh
East coast (New York, Boston, Washington):					
50 ft² system	47	$900	8.9	8.0	7.2
75 ft² system	60	1,200	9.2	8.2	7.4
100 ft² system	72	1,500	9.5	8.5	7.7
South Florida (Miami): 50 ft² system	69	900	6.7	5.8	5.3
Upper Midwest (Chicago-Omaha):					
50 ft² system	54	900	8.1	7.1	6.4
75 ft² system	69	1,200	8.3	7.4	6.7
100 ft² system	84	1,500	8.5	7.5	6.8
Lower Midwest (St. Louis-Nashville):					
50 ft² system	51	900	8.4	7.5	6.7
75 ft² system	65	1,200	8.7	7.7	7.0
100 ft² system	79	1,500	8.9	7.9	7.1
Southwest (Dallas):					
50 ft² system	62	900	7.4	6.4	5.7
75 ft² system	84	1,200	7.1	6.3	5.7
Desert Southwest: 50 ft² system	80	900	7.1	6.3	5.7
Southern California (Los Angeles):					
50 ft² system	62	900	7.4	6.4	5.7
75 ft² system	84	1,200	7.1	6.3	5.7

B. VERSUS GAS HOT WATER

	Solar, percent of hot water	Solar system cost	Pay-out time—years (gas)			
			12.5¢/thm	15¢/thm	17.5¢/thm	20¢/thm
East coast (New York, Boston, Washington):						
50 ft² system	47	$900	19.0	17.4	16.1	15.0
75 ft² system	60	1,200	19.4	17.8	16.5	15.4
100 ft² system	72	1,500	19.7	18.1	16.8	15.7
South Florida (Miami): 50 ft² system	69	900	15.7	14.3	13.1	12.1
Upper Midwest (Chicago-Omaha):						
50 ft² system	54	900	17.8	16.2	15.0	13.9
75 ft² system	69	1,200	18.1	16.6	15.3	14.3
100 ft² system	84	1,500	18.4	16.8	15.5	14.5
Lower Midwest (St. Louis-Nashville):						
50 ft² system	51	900	18.3	16.7	15.4	14.4
75 ft² system	65	1,200	18.7	17.1	15.8	14.7
100 ft² system	79	1,500	18.9	17.3	16.0	15.0
Southwest (Dallas):						
50 ft² system	62	900	16.6	15.1	13.9	12.9
75 ft² system	84	1,200	16.5	15.0	13.8	12.8
Desert Southwest: 50 ft² system	80	900	14.5	13.1	12.0	11.1
Southern California (Los Angeles):						
50 ft² system	62	900	16.6	15.1	13.9	12.9
75 ft² system	84	1,200	16.5	15.0	13.8	12.8

II. WHAT ARE THE ECONOMICS OF SOLAR SPACE HEATING PLUS SOLAR HOT WATER HEATING?

A. VERSUS OIL HEAT PLUS ELECTRIC HOT WATER

	Solar system cost	Pay-out time—years (electricity: oil)			
		3¢/kWh: 40¢/gal.	3½¢/kWh: 43¢/gal.	4¢/kWh: 45¢/gal.	5¢/kWh: 45¢/gal.
East coast:					
Boston:					
40 percent solar	$4,875	12.1	11.4	10.7	
50 percent solar	6,750	12.6	11.8	11.2	
New York:					
40 percent solar	4,700	13.0	12.1	11.4	10.5
50 percent solar	6,800	14.4	13.5	12.8	11.9
Washington:					
40 percent solar	3,475	10.4	9.6	9.0	
50 percent solar	5,300	12.0	11.2	10.5	
Upper Midwest (Omaha-Chicago):					
40 percent solar	3,200	9.2	8.5	8.0	
50 percent solar	4,825	10.6	9.8	9.3	
Lower Midwest (St. Louis-Nashville):					
40 percent solar	3,275	10.8	10.0	9.3	
50 percent solar	4,825	12.3	11.4	11.0	
Southwest (Dallas):					
40 percent solar	2,200	9.2	8.3	7.7	
50 percent solar	3,000	10.0	9.1	8.5	
60 percent solar	4,875	12.4	11.5	10.8	
Southern California (Los Angeles):					
50 percent solar	1,500	6.7	6.1	5.6	
60 percent solar	2,175	7.8	7.2	6.7	
70 percent solar	3,000	9.0	8.3	7.7	

B. VERSUS ELECTRIC HEAT AND HOT WATER

	Solar system cost	Pay-out time—years (electricity)			
		3¢/kWh	3½¢/kWh	4¢/kWh	5¢/kWh
East coast:					
Boston:					
40 percent solar	$4,875	10.2	9.1	8.2	
50 percent solar	6,750	10.9	9.8	8.9	
New York:					
40 percent solar	4,700	11.5	10.3	9.3	7.8
50 percent solar	6,800	12.7	11.4	10.4	8.9
Washington:					
40 percent solar	3,475	8.8	7.9	7.1	
50 percent solar	5,300	10.2	9.1	8.3	
Upper Midwest (Omaha-Chicago):					
40 percent solar	3,200	7.6	6.7	6.1	
50 percent solar	4,825	8.8	7.8	7.0	
Lower Midwest (Nashville-St. Louis):					
40 percent solar	3,275	9.5	8.5	7.6	
50 percent solar	4,825	10.7	9.6	8.6	
Southwest (Dallas):					
40 percent solar	2,200	8.2	7.3	6.6	
50 percent solar	3,000	8.7	7.8	7.0	
60 percent solar	4,875	10.9	9.8	7.8	
Southern California (Los Angeles):					
50 percent solar	1,500	5.7	5.0	4.5	
60 percent solar	2,175	6.7	5.9	5.3	
70 percent solar	3,000	7.6	6.7	6.0	

C. VERSUS NATURAL GAS HEAT PLUS HOT WATER

	Solar system cost	Pay-out time—years (gas)			
		12.5¢/thm	15¢/thm	17.5¢/thm	20¢/thm
East coast:					
Boston:					
40 percent solar	$4,875	20.5	18.9	17.6	16.5
50 percent solar	6,750	21.5	19.8	18.5	17.3
New York:					
40 percent solar	4,700	22.1	20.5	19.1	17.9
50 percent solar	6,800	23.5	21.8	20.4	19.2
Washington:					
40 percent solar	3,475	18.8	17.3	16.0	14.9
50-percent solar	5,300	20.6	19.0	17.6	16.5
Upper Midwest (Omaha-Chicago):					
40-percent solar	3,200	17.1	15.6	14.4	13.4
50-percent solar	4,825	18.8	17.2	15.9	14.8
Lower Midwest (Nashville-St. Louis):					
40-percent solar	3,275	19.7	18.1	16.8	15.7
50-percent solar	4,825	21.2	19.5	18.2	17.0
Southwest (Dallas):					
40-percent solar	2,200	18.0	16.4	15.2	14.1
50-percent solar	3,000	18.7	17.2	15.9	14.8
60-percent solar	4,875	21.4	19.8	18.4	17.3
Southern California (Los Angeles):					
50-percent solar	1,500	14.2	12.8	11.7	10.8
60-percent solar	2,175	15.7	14.3	13.1	12.1
70-percent solar	3,000	17.1	15.6	14.4	13.3

The loan guarantee provisions which were added by the Senate in S. 598 to H.R. 3474 would provide a source of financing for larger solar installations; and if further amended as we have recommended, would become applicable to manufacturers of solar equipment. This is particularly important since many of the present manufacturers are small businesses who characteristically have difficulty in obtaining adequate financing. I refer you to my statement made to the Subcommittee on Energy Research, Development and Demonstration of the Committee on Science and Technology of the U.S. House of Representatives of October 7. A copy of this statement is as follows:

Testimony of Sheldon H. Butt, President, Solar Energy Industries Association, Before the Committee on Science and Technology

Mr. Chairman and Members of the Committee: The Solar Energy Industries Association is pleased at the opportunity to testify on the subject of the Loan Guarantee Provision added by the Senate in S. 598 to H.R. 3474, the E.R.D.A. Authorization Bill, FY–1976.

Fundamentally, S.E.I.A. supports the National Goal of achieving energy independence at an early date and maintaining independence thereafter. We believe that energy independence is necessary to our economic well being and essential to a truly independent foreign policy. We believe that, in order to achieve this goal, it is necessary that we develop and use a variety of domestically available energy resources, including fossil fuel resources as well as solar energy and other renewable energy sources. E.R.D.A.'s investigations of the near term, mid-term and long term potential for each of the alternatives, as spelled out in E.R.D.A. 48, amply demonstrate that no single solution by itself offers sufficient potential to provide for independence. Our own estimates of the potential for solar energy, although somewhat higher than those provided by E.R.D.A., also indicate a need for multiple solutions. We include among the energy sources required in the future to achieve independence the following:

1. Direct use of solar thermal energy for heating and cooling of buildings, for agriculture and for industrial process heat.
2. Generation of electric power from solar energy including; photovoltaics, solar thermal, ocean thermal gradients, biomass conversion and wind energy.
3. The direct use of solar thermal energy to "drive" catalytic and other chemical processes intended to produce hydrogen, hydrocarbons and other chemical raw materials now normally produced from natural gas and petroleum.
4. The use of geothermal energy, both as a direct source of heat and in the generation of electric power.
5. The conversion of abundant domestic energy resources including oil shale and coal into synthetic fuels.
6. The expanded use of nuclear energy, both from nuclear fission and fusion to produce electric energy.

Thus, we support both the provisions of the legislation proposed by the Senate which relate to the production of synthetic fuels from oil shale and coal, and those provisions relating to the utilization of solar energy and other renewable energy resources. We favor retention of those provisions of Section 103 which relate to solar energy and other renewable energy resources with amendment as discussed following:

Paragraph (b)(1)(B) of proposed Section 103 of S. 598 refers only to the construction and operation of "facilities to generate power or heat." In the case of solar energy, this means that the loan guarantees would apply only to the owner and user of the solar energy equipment since it is he who is the producer of power or heat. As written, this paragraph does not provide loan guarantees for the construction and operation of the facilities essential to the production of the solar equipment itself.

At present, many of the producers of solar equipment may be categorized as small and moderate sized businesses. In addition to the "normal" problems which small and moderate sized businesses encounter in raising capital funds for new enterprises, these businesses also are faced by the problem that the financial community still considers the business of producing solar equipment as being highly speculative. As a result, these solar equipment producers encounter extreme difficulty in raising capital funds.

In addition, in some cases, such as the case of facilities required to mass produce photovoltaic cells, specialized equipment and production lines are involved. Often, these are not of use in the production of other commercial products. Thus, their installation by private enterprise in advance of the development of a mass market for the specialized solar products which they will produce entails an extremely high degree of risk. At the same time, development of a mass market for the specialized solar products is substantially dependent upon the prior availability of products produced in large volume at cost levels reflecting the economies of large volume production. This is a classic "which comes first, the chicken or the egg" dilemma.

Accordingly, we recommend that paragraph (b)(1)(B) of Section 103 be amended to add the following, after the word "resources" in line 14:

"and facilities to produce systems or unique components and materials required for generation of power or heat from the energy sources enumerated:"

We recommend further that Paragraph (a)(1)(2) be amended to add the following after the word "sources" in line 15:

"and for the construction and operation of facilities required to produce systems and unique components and materials required by facilities deriving energy from renewable sources; and"

Mr. Chairman, it is pertinent to note that, on Thursday, October 2, in my capacity as President of S.E.I.A., I received a call from an officer of a major bank, now actively involved in arranging financing for geothermal energy projects under the terms of the Geothermal Energy Research and Development Act of 1974. He indicated that his bank was interested in arranging similar financing for solar energy projects provided that the Congress passed suitable loan guarantee legislation.

We have received an explanation of proposed changes in Section 103, including a proposal to delete loan guarantee authority for facilities utilizing "renewable energy sources," which includes solar energy. The explanation identifies the mechanism provided by the Solar Heating and Cooling Demonstration Act of 1974 as the preferred approach for introducing solar technology. We recognize demonstration as one of the major key elements required to accelerate development of solar energy as a major energy resource. Incentives, loan guarantees and assistance in the development of standards are others included in a comprehensive program. S.E.I.A. thoughts regarding a comprehensive program are outlined in a statement appended to this testimony.

The explanation further states that, "many of the technologies for utilizing other renewable energy sources have not yet reached the stage of development where commercial quantities of power and heat could be economically generated by facilities suitable for loan guarantee support." While this is true in some cases, e.g., ocean thermal gradients, it is certainly not true in the case of the use of direct solar thermal energy. We receive frequent inquiries from commercial and industrial energy users interested in the use of solar energy to provide substantial process heat requirements. Most of these potential applications are feasible. In most cases, the necessary solar equipment cou'd be installed and begin its job of producing energy much more rapidly than could be projected shale oil or coal gasification plants.

We want to thank you for the opportunity to appear before you. We will be pleased to answer any questions you may care to put to us.

As H.R. 3849 and H.R. 8524 are written, they appear to be particularly applicable to the following classes of potential users:

1. Solar installations retrofitted to residential property. The difference between the interest rates implicit in the legislation and the "going" rate of interest upon home improvement loans is particularly great and thus, the impact upon monthly loan payments is particularly large.

2. "Merchant" builders constructing single-family or multi-family residential structures for resale. Again, the interest rate difference as compared to the interest rate which this class normally pays for construction loans is particularly large and the potential savings, therefore, particularly attractive.

The provisions of the proposed legislation would have impact, but to a less extent, upon individuals who had contracted for a custom-built home or upon investors who had contracted for construction of a multi-family residential development.

Congressman Moorhead's question speaks of Federal Home Loan Bank Board home mortgages purchase commitments to lenders making mortgage loans on homes with solar energy systems. Certainly, the Federal Home Loan Bank Board should be willing to undertake such commitments. If they were not, the results would be negative. Whether or not loans on solar energy systems could be given any form of preferential treatment within the existing charter of the Board is not known to me.

Similarly, F.H.A. should be in a position to commit to loan guarantees for solar equipped homes. I understand that they are administratively in a position to do this today, although the current procedure is somewhat clumsy, requiring that such commitments be made only at the Washington level and not in the Field Offices. Additionally, as has been proposed elsewhere, the dollar limitations upon F.H.A. commitments should be increased sufficiently so as to cover the added cost of a solar system as compared to a conventional system.

Question 2. Mr. Burkhardt and Mr. Butt, at present cost of solar equipment, is it cost-effective to use such equipment just to provide hot water?

REPLY BY MR. BURKHARDT

Answer. At present costs, solar heating equipment for providing total heating energy to a home is not cost effective; however, as an adjunct for the production of domestic hot water and/or heating, we do believe it could be cost effective, especially if there were a large number of installations.

We have been informed by a manufacturer that he estimates if we could buy 500 units, the price of a piece of solar energy equipment would drop from $625 to about $325 for the solar-adjunct unit. Further, we envisage this unit not only producing domestic hot water, but providing heated water to the boiler for a steam or hot water system. While this latter is not large in quantity, it still is an item that could bear some consideration. Whether or not it will become cost effective to use such equipment to produce domestic hot water will be directly proportionate to the number of these units that are installed.

Fifty years ago there were just a few hundred thousand oil burners installed in the U.S. To convert from coal to oil at that time cost $2,000. Today, fifty years later, with 15 million oil heating installations and with inflation plus the general rise in the cost of living over a fifty year period, and with highly sophisticated controls and a much more sophisticated oil burner, the same installation costs $300. We believe that with proper handling and with effective stimuli to the small business heating equipment installer, we could make the same financial progress with solar energy in 10 years—one-fifth of the time!

Further, of the 2,400,000 oil heating installations in New England, 1,600,000 are good to fair prospects for solar energy adjunct installations coupled with oil fired heating or domestic hot water generating equipment.

REPLY BY MR. BUTT

Answer. A solar installation substitutes a capital investment with very low subsequent operating costs for a continuing relatively high operating cost representing the continuing cost of conventional energy resources; electricity, oil, gas. Utilization of the equipment thus becomes an important factor in determining cost-effectiveness. Heating hot water is intrinsically quite cost-effective since the demand for hot water is uniform and year-round. This point is illustrated in the economic analyses referred to earlier which are appended.

Question 3. Mr. Burkhardt and Mr. Butt, what impact could this limited loan program have on increasing market demand for the product?

REPLY BY MR. BURKHARDT

It is difficult to judge just what this limited loan program would provide as an effective force toward increasing market demand for the product.

Its effect would possibly be indirect, since it is only through increased production of the amount of equipment and increased number of installations of the equipment that we would achieve lower prices for solar heat generators.

To NEFI, direct financial stimulus would provide an opportunity to get thousands of small businessmen such as oil heating dealers throughout New England who install 140,000 pieces of oil heating equipment each year, as well as sell and service them, to apply themselves with the same vigor and experience to the sale and installation of solar energy equipment as they exhibit with oil heating equipment. A program geared to providing financial or tax incentive to these small businessmen might be just as valuable or more valuable as loans to the homeowners.

REPLY BY MR. BUTT

Answer. The loan programs incorporated in the proposed legislation have limited application and address only one of the constraints perceived by the "typical" consumer. This was discussed at some length in response to an earlier question. As part of a comprehensive program structured as S.E.I.A. has recommended, they would be important and effective. We believe that the comprehensive program proposed, if enacted and vigorously implemented, would generate solar induced savings in crude oil (or its equivalent) of one million barrels per day within ten years after the program was in place and in operation.

I don't believe that we are in a position to accurately estimate the effect of a single facet of the program—such as the proposed loan program—by itself. The interrelationship between the various parts of a comprehensive program is very greatly synergistic.

Natural market forces aided by the demonstration program already in place are estimated by E.R.D.A. to potentially produce savings of 100,000 barrels per day in ten years. We agree with this estimate. The loan program envisioned by the presently proposed legislation might add 25% to 50% to this total.

QUESTIONS SUBMITTED BY CONGRESSMAN MOORHEAD TO MR. MORRISON AND MR. BUTT

Question 1. Mr. Morrison and Mr. Butt, if the installation of solar energy equipment will result in great fuel cost savings over the life of the home, why should the government get involved in subsidies at all?

REPLY FROM MR. MORRISON

Answer. There can be no doubt that the installation of solar powered equipment to furnish the basic heating and cooling requirements of the home will drastically reduce the operational cost of the home from the standpoint of energy consumption, however the American public has been educated to accept the monthly payment plan with relatively high payments rather than to accept a high initial first cost and relatively low monthly payments thereafter. In general, the average home owner or prospective home owner does not have the funds available which are required for the installation of a solar powered system. Even though the home owner may feel that the solar energy route is the desirable way to go, many times he simply cannot generate the funds necessary to take advantage of the benefits offered by this alternate energy source.

The benefits which the government will derive through incentives such as tax credits and subsidies are at least twofold.

1. There is no doubt that this nation must conserve its reservoir of fossil fuel energy insofar as it is humanly possible. Every unit of energy that is furnished through the use of solar energy conserves the fossil fuel supply which would otherwise be called upon to furnish this heat unit. In my opinion, this irreplaceable reservoir of fossil fuels should be used to furnish only those needs which cannot be adequately met through the use of some alternate energy source.

2. The government should get involved in encouraging the public to accept alternate energy sources through the use of tax credits, subsidies and other similar incentives since it will ultimately benefit the individual citizen. It is the function of government to lead the way in energy conservation, and the use of incentives is one manner in which this may be accomplished. It is my opinion that the government should be interested in anything that will ultimately benefit the individual citizen from whom the government ultimately derives its authority and power.

REPLY FROM MR. BUTT

Answer. It is true that, on a life cycle cost basis, solar heating and solar domestic hot water are cost-effective in most areas as compared to electricity. This is true even based upon the current relatively high cost of the solar equipment, which cost reflects the fact that solar equipment is not now being mass-produced. A less favorable but still viable picture is presented when a solar installation is compared to a conventional system using fuel oil. Solar, as compared to low cost natural gas where it is still available, pays off only in a rather extended period of time. Some economic analyses of "typical" solar installations were incorporated in my written statement of November 5. Additional such analyses of single-family residential applications are appended.

Typically, consumers are quite "first cost" sensitive. Incentives are an important and effective means of addressing this problem. More potential users will elect to make solar installations and make this election at an earlier date if the economic picture which they perceive is improved through the application of incentives.

There is no doubt in my mind that, given the realities of the future potential supply of natural gas and fuel oil and the implications which these supply constraints have upon future prices, ultimately solar energy will be very widely applied to the thermal energy requirements of all types of residential structures. The effect of incentives and the other elements of the comprehensive plan which S.E.I.A. has proposed is to accelerate this process. We perceive that acceleration of the commercialization of solar energy applications is very greatly in the National Interest. Accelerated commercialization provides the opportunity to develop an industry, with all that this implies, in advance of a potential crisis.

The preceding discussion has been concerned with "need" for incentives. There is also a question of equity. The homeowner who installs solar equipment becomes an energy "producer." The economics of his investment, the return which he will realize upon this investment, depend upon the market prices of the conventional energy forms with which his solar installation competes. His savings are smaller and therefore, his return less if the price of electricity, oil or gas, as the case may be, is low. Conversely, his savings increase with increase in the cost of the competing energy form. In a market economy, the price of commodities—including energy—tends to reflect the cost of production, including the cost of borrowed funds plus some return upon investment. The key element tends to be net cash flow as compared to invested capital. Because of depreciation allowances, investment tax credits and, where applicable, depletion allowances, business and industry are provided with "tax free" cash flows which are of important magnitude. A consumer who has purchased a solar installation and is thereby an energy producer does not obtain equal treatment under the tax laws and is in the position of having to pay for his solar installation entirely with "after tax" dollars. This is not equitable.

Stated differently, economics would dictate that the market prices for the competing conventional energy forms would be higher than they are now were it not for the "incentives" in the form of tax free cash flow available to the producers, distributors and sellers of conventional energy forms. In a very real sense, proposals for solar incentives may be in large part justified as being required to provide equitable treatment to the solar energy "producer" and particularly so when this "producer" is a homeowner. Congressman Gude touched upon this point in his written statement.

Question 2. Mr. Morrison and Mr. Butt, in what areas of the country would rapid installation of presently available solar equipment be most beneficial economically?

Are there areas of the country where it would not be useful to encourage installation?

REPLY FROM MR. MORRISON

Answer. The installation of solar equipment would have widespread application throughout the continental United States. The availability of solar energy is very much dependent upon the existing environmental conditions. In areas where cloud cover exists for extended periods of time, the use of such devices is less effective than when used in those areas which receive large exposure to solar radiation such as the majority of the southern region of the United States. It should be borne in mind that these devices can be used effectively in the northern sections of the United States even as far north as Alaska, when adequate periods of sunshine are available. In most areas it would be necessary to provide a backup capability for the system, in order to furnish the energy required when inclement weather prohibited the collection of sufficient solar energy. It should be remembered that all of the solar energy collected represents a net reduction in the conventional energy requirements. In my opinion the area of the country which would economically benefit most through the use of solar energy is the southwestern United States even to a point as far north as Colorado.

In order to determine the areas of the country where the installation of solar energy equipment would not be beneficial, it would be necessary to have long term weather data records available for study. The most significant portion of this study would be the percentage of cloud cover which is not a very accurate figure even when taken by persons familiar with the measurement and recording of meteorological data. In general, the more predominant and persistent the cloud cover, the less effective solar energy devices become. If I were arbitrarily selecting those areas of the country where solar energy would be least effective, I would think it would be the coastal regions of the northwestern portion of the United States and the coastal regions of the northeastern portion of the United States.

REPLY FROM MR. BUTT

Answer. Certainly, solar equipment is more cost-effective in areas of high insolation. However, it is economically beneficial in most areas in the United States. Again, this is illustrated by the economic analyses appended. This is particularly true in the case of solar water heating.

Question 3. Mr. Morrison and Mr. Butt, are there any major technical hurdles to using presently designed solar heating equipment?

Is the equipment reliable? Is expensive maintenance necessary?

What is life expectancy?

REPLY FROM MR. MORRISON

Answer. So far as I know there are no major technical hurdles that are standing in the way of the use of solar energy for heating either potable hot water or water for space heating of residential and commercial buildings. Many such installations have been proven reliable through past experience; properly designed systems will operate effectively.

Since the equipment used for water heating and space heating is basically the same type equipment which has been used in hydronic systems for years, it must be considered that this equipment is highly reliable. From the standpoint of maintenance, there is little to go wrong with either the solar collector or the hydronic convectors. In general, pumps are used to transfer the fluid from one point in the system to another. These pumps are operated by conventional thermostatic controls, solenoid valves, and such other sensors as are required. All of these devices are currently available on the open market. The design of a proper system depends upon selecting the right components to do the job which is being considered.

The life expectancy of a hydronic system, when properly maintained, should be in the range of 15–20 years, since there is virtually nothing to go wrong with the system other than the pump and controls which are used in the operation of the system. Naturally, both the pump and controls would be subject to periodic repairs and/or replacement. The cost of such repairs or replacement would probably be no more than that which is currently being experienced by conventional hydronic heating systems. The electric energy required to operate such a system is miniscule when compared to the energy required to heat the building or furnish the building with potable hot water.

REPLY FROM MR. BUTT

Answer. Although this question is addressed primarily to Dr. Morrison, I would like to comment upon it.

There are certainly no major technical hurdles to overcome. Many hundreds or thousands of solar heating or hot water heating installations are in service today to prove this point. This is not to say that there is not a need for engineering development to improve efficiency and for cost engineering to reduce cost. There is. The "Development in Support of Demonstration" programs underway as a part of the implementation of the Solar Heating and Cooling Demonstration Act of 1974 are addressed to these ends. More importantly, there is increasing privately funded effort in these areas. There is no question in my mind that the rate of the privately funded efforts in these areas will be substantially accelerated as and when industry perceives serious commitment by Government to the commercialization of solar energy. The various incentive programs which we have discussed will energize such an accelerated commercial and privately funded effort.

There is no inherent reason why properly designed, built and installed solar equipment should not be reliable or should not have a life expectancy as long as the structure to which it is attached. Equally, there is no inherent reason why maintenance cost should be high. Certainly, much of the equipment presently available on the market is quite adequate from these points of view. Standards, which are now being developed both by the National Bureau of Standards and by industry through the voluntary standards system, will be forthcoming and are needed to assure the user on these points.

QUESTIONS SUBMITTED BY CONGRESSMAN MOORHEAD TO MR. MORRISON

Question 1. Mr. Morrison, what is the molten-salt storage method? Is it sufficiently developed to be mass produced?

How does the life-cycle cost of this method compare to water storage methods?

REPLY FROM MR. MORRISON

Answer. The molten-salt storage method is designed to operate with its heat of fusion temperature at that temperature which the solar system as a whole would operate most effectively. The theory of the system is based upon the fact that much energy is released by the molten-salt as it transforms from a liquid to a solid at the point of fusion. As an example, the energy released by hot water as it drops from 212° F to 32° F is approximately 180 Btu's. As the water is transformed to ice, an additional 144 Btu removal is required in order to produce ice at 32° F. It may be seen that, in theory, this is a very logical manner in which to approach the heat storage problem.

Dr. Maria Telkes of the University of Delaware is perhaps the world's leading authority on the storage of energy through the use of phase change media. Many of the salts with which she has experimented over the years have been rather thoroughly investigated, and certainly there are applications where the use of this method of heat storage would be applicable. As to which of these salts are best suited for mass production techniques and utilization in the solar energy field, I suggest that you contact Dr. Telkes who is much more qualified than myself to answer this question.

The life cycle cost of molten-salt storage versus water storage has been a matter of some debate for many years. Naturally the proponents of each system are able to point to the advantages of the system which they favor. Those favoring the use of water storage point to the fact that water is readily available, cheap, easily handled, relatively noncorrosive, stable, nontoxic, has a good thermal heat capacity, etc. The proponents of the use of the molten-salt method of heat storage point to the fact that a much smaller space is required for the storage of a given quantity of heat, the cost of the container to house this storage is less than that required of water, the insulation problems are minimized due to the systems operating at a relatively constant temperature, and other advantages may be pointed out that do not readily come to my mind. The life cycle cost of one method versus the other largely depends upon the relative first cost of the installation and the frequency with which the heat transfer media must be replaced or replenished. Since I am a proponent of the use of water for heat storage, I am of the opinion that the life cycle cost of such a system is less than that which would usually be the case if molten-salt storage were employed.

Question 2. Mr. Morrison, has an effective and economical solar cooling equipment been designed, and is it ready for mass production?

REPLY FROM MR. MORRISON

Answer. Various absorption type refrigeration systems have been successfully used with solar energy as the primary source of power. Most of the systems that utilize absorption type equipment which is currently being manufactured accomplish the cooling by "derating" the refrigeration components. As an example; in order to produce 3 tons of refrigeration, a considerably larger unit, designed to operate at temperature associated with gas flames, is used with the lower temperature heat source in order to produce the desired cooling effect. In general, these systems are usually backed up with some type of conventional energy source. It is my opinion that such systems cannot operate at the efficiencies which are ordinarily obtainable when these units are operating at their design point.

Various experimental models of solar powered absorption type refrigeration systems have been produced by University of Florida personnel and other research organizations. All of this equipment is custom designed to suit the particular research need. In my opinion these prototypes have proved to be operationally effective, however additional redesign and development would be required, if these units were to be mass produced. It is not probable that any of these refrigeration devices will become economical from the standpoint of first cost, until mass production procedures have been employed in their manufacture. In all probability, a custom designed refrigeration system would prove economically acceptable, if the life-cycle cost were considered and if this equipment operated on a year round basis.

QUESTIONS SUBMITTED BY CONGRESSMAN MOORHEAD TO MR. BUTT

Question 1. Mr. Butt, what are the 20-year life-cycle costs, including initial cost of equipment, life-time fuel, environmental impact and maintenance costs for solar heating systems over conventional oil, gas or electric systems?

Is this premised on expectation that the cost of oil and electricity will increase? What happens if fuel costs decrease?

REPLY BY MR. BUTT

Answer. As is indicated, these economic analyses are based upon the expectation that eletricity prices will escalate in the future at a rate of 7.5 percent per year. This represents a 5 percent rate of general inflation plus 2½ percent, recognizing that conventional energy costs can be expected to increase at rates greater than the average or overall rate of inflation. Similarly, the analyses are based upon a forecast of a 10 percent per year year rate of escalation in fuel oil and natural gas prices. I believe that few, if any, economists will dispute that future general inflation rates will be 5 percent or more per year. There are considerable differences of opinion regarding the extent to which the rate of escalation in conventional energy costs may or may not exceed the general rate of inflation. More to this point later.

Let us select three of the specific examples analyzed in the economic analyses to illustrate "life cycle costs."

The first of these is a 75 square foot "standard" solar water heater installed in a single-family residence on the East Coast. This example appears at the top of Table I–A on the attachment. You will note that, at a present electricity rate of 3½¢ per kilowatt hour, the pay-out time—meaning the time within which the cumulative savings equal the first cost—is 8.2 years. Reflecting continuing escalation beyond this point of equivalency, cumulative savings in twenty years would equal 3.93 times first cost. If electricity cost escalated at only 5 percent per year, which would mean that the "constant dollar" cost of electricity would not change and the increase in cost would simply reflect general inflation, the length of time required to "pay-out" would increase from 8.2 years to 8.9 years. Over a twenty year period, the cumulative savings would equal 3.05 times first cost.

The term "life cycle cost analysis" is somewhat ambiguous. It may simply mean a comparison of cumulative savings to first cost, in which case the answers presented above would apply.

However, some consider that a life cycle cost analysis should discount future cash flows to their "present value," using an appropriate discount rate. The choice of an appropriate discount rate, in a case such as this, is a matter of judgment. If we elect to use as a discount rate the maximum interest which the consumer might expect to realize from his savings in electric energy cost, were he to invest them in long term savings with a Savings and Loan Association, we might well select 7.5 percent as an appropriate discount rate to apply in determining the present value of future savings. Upon this basis, the present value of the savings over a twenty year life are 1.84 times the cost of the installation. The pay-out time on this basis is 10.8 years.

As our second example, let us consider the same solar water heating system installed in the Southwest. The basic economic analysis for the case also appears on Table I–A. Since electric rates tend generally to be somewhat lower in this area than in the Northeast, let us base our analysis upon a present cost of 3¢ per kilowatt hour for electric energy. We note that the pay-out time in this instance is 7.1 years as compared to the 8.2 years in the preceding example. As would be anticipated, the solar system operates somewhat more efficiently in this area. Therefore, over a twenty year period with electricity cost escalating at 7.5 percent per year, cumulative savings are 4.74 times the initial cost of the solar equipment. If electricity escalates at only 5 percent per year, cumulative savings are 3.66 times the initial cost. If we discount future cash flows by 7.5 percent, their present value is 2.21 times the cost of the installation. Pay-out time is 9.0 years.

As a third example, let us consider the case in which a 50 square foot solar system is installed as an alternative to natural gas in Southern California. This case is shown on Table I–B. Let us assume further that the present market price of natural gas is 12.5¢ per therm and that it escalates in price at a rate of 10 percent per year. Upon this basis, pay-out is in 16.6 years. Cumulative savings over a twenty year period are only 1.48 times the cost of the original equipment. Were we to assume that natural gas prices escalated at only 5 percent per year, which would imply that their "constant dollar" magnitude did not change, cumulative savings in twenty years would only be 0.85 times the initial cost. Pay-out would be materially greater than twenty years—22.1 years. If we assumed the 10-percent rate of escalation in gas prices but discounted future savings by 7.5 percent per year to derive their "present value," we would find that the "present value" of the savings in twenty years would be .67 times the cost of the initial installation. Obviously, on this basis, the results of a "life cycle cost analysis" would be negative.

These three examples are representative of a substantial portion of the range of life cycle results which could be anticipated. They illustrate the point that life cycle results are dependent upon the identity and cost of the conventional energy form being replaced, the rate of future cost escalation and also upon climatic factors.

The final portion of the question asks, "What if fuel costs decrease?" Although it is certainly possible to temporarily roll back domestic crude oil and natural gas prices by legislative action, I scarcely believe that, in the context of twenty years, this can be accomplished without, at the same time, assuring that shortages of domestic resources will become so great as to lead to serious questions of reasonably broad availability. Roll backs in the price of electricity would inevitably lead to the inability of the utility industry to obtain financing and would inevitably lead to severe shortages of electric power. I recognize that there are some fuel economists who feel that the control exercised by O.P.E.C. will relax and that, therefore, there will be a temporary reduction in the price of foreign petroleum. Again, this could only be temporary in nature since lower prices will encourage more rapid acceleration in consumption. Although the reserves available to many of the O.P.E.C. nations are very large, they, too, would become inadequate to meet worldwide demand as it would develop at substantially reduced price over an extended period of time. We should bear in mind that, in the face of a 5-percent per year rate of inflation, a contsant dollar price for fuel in twenty years represents a 60-percent decrease in "real" or "constant dollar" prices.

It is, of course, mathematically possible to calculate life cycle cost analvses upon any given hypothetical scenario envisioning reductions in fuel prices. We believe that such analyses would be most unrealistic.

Question 2. Mr. Butt, if production of solar heating units increases, how soon could we expect the cost of equipment to decrease and by how much?

REPLY BY MR. BUTT

Answer. Present solar equipment volume is still quite modest. I would not expect any significant price decreases related to "economies of scale" to emerge until volume has reached ten times its present level. However, the best information available to us indicates that 1975 volume is roughly three times that of 1974. With vigorous action in support of continuing growth, market volume could grow to levels in which cost reductions related to economies of scale would be realized in three years. We must also consider cost reductions which relate to engineering development. Again, these are indirectly related to increase in market volume since market volume—both current and forecast—influences the "investment" of funds in engineering development activity. As a matter of fact, there are cost reductions of modest dimensions occurring currently as a result of continuing engineering development.

Based upon my own general knowledge of the situation, as well as upon discussion with others in the industry, I would anticipate that cost reductions in the range of 25 percent to 50 percent will develop in the next five to ten years, assuming that volume develops rapidly as the result of aggressive action to accelerate commercialization. Please note that these percentages relate to "constant dollar" costs and do not include the effect of inflation.

A meaningful analogy is provided by the price experience of the household appliance industry. Over the last 25 years, the price (in current dollars) of equivalent household appliances has increased very little despite the very considerable intervening inflation. "Constant dollar" prices of most appliances are on the order of 50 percent of 1950 prices.

QUESTIONS SUBMITTED BY CONGRESSMAN MOORHEAD TO MR. BARFIELD

Question 1. Mr. Barfield, since the rapid increase in utility costs has recently plagued the financial stability of subsidized low-income housing projects, has HUD considered giving preference to projects using solar heating and cooling equipment in order to minimize future increases in costs?

REPLY BY MR. BARFIELD

Answer. Mr. Chairman, HUD does not at this time give preference to projects using solar heating and cooling equipment, although we recognize that there are potential savings in costs. As I stated in my prepared testimony, the Department will approve, on an individual review basis, projects which use solar energy equipment. But, as I also stated in my testimony, we do not yet have objective standards by which solar energy systems may be tested, evaluated, and approved for general use on a widespread basis. Nor do we know the real economies of solar energy systems and the trade-off between first costs and operating costs. Adding solar heating and cooling equipment to low-income subsidized housing projects, of course, will increase the project first cost. Whether the savings in fuel costs will justify the increased cost of subsidized projects, are policy questions which cannot be answered without accurate cost and benefit data.

The demonstration program is designed to obtain this information, and we expect to include low-income subsidized projects in the demonstrations to obtain data which will permit us to make specific recommendations in the future.

Question 2. Mr. Barfield, if, as many experts feel, solar technology is ready for practical commercial application and if a direct consumer loan program could encourage mass production of solar equipment and would cause a decrease in consumer costs, why must we wait for the research and demonstration programs to be concluded before helping consumers finance the installation of energy-conserving solar equipment?

Answer. Mr. Chairman, the phrase, "solar technology is ready for practical commercial application" has been widely used in solar energy literature, various hearings, and other forums. Yet the most comprehensive survey of solar heated buildings, that by Mr. William Shurcliff, lists only 187 buildings in the most recent, November 11, 1975, edition, beginning with the 1939 MIT house. Only a very few of these installations has been operated for as long as ten years, and even fewer have been instrumented to provide a continuing operating history. This is a narrow data base on which to build commercial applications

For example, while many of the components in a solar energy system are standard products, others are not, and the total systems have not generally been subjected to detailed evaluation. Successful commercial applications involve assurances to the buyer that the system he installs will deliver the promised energy output over the promised life of the system within operating and maintenance costs he is willing to pay. We do not believe that these assurances can be given for a number of systems now being proposed, since adequate test data are not available. As one example, operating an aluminum collector assembly with a liquid coolant utilizing an anti-freeze solution may require an annual or biennial drain-down and replacement of the anti-freeze to avoid corrosion, but the cost of this anti-freeze replacement has not been generally touched on in discussions of system economics.

I am not saying that we have to develop a new technology. I am saying that we have to learn to use the existing technology effectively and economically. The research, development, and demonstration program set forth in ERDA-23A is, I believe, the best approach yet available for moving this technology from one involving one-of-a-kind, hand-tooled products to a technology involving the reliable, marketable, trustworthy products necessary for consumer acceptance.

The subcommittee will stand adjourned, subject to the call of the Chair.

[Whereupon, at 12 noon, the subcommittee was adjourned, subject to the call of the Chair.]

[The following material was received by the subcommittee for inclusion in the printed record:]

STATEMENT OF HON. LINDY BOGGS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF LOUISIANA

Mr. Chairman, in 1973, I had the privilege to co-sponsor the first "Solar Heating and Cooling Demonstration Act", and have since been a supporter of its subsequent laws and similar ones which sought to provide financial assistance to the foresighted users of solar energy, and which collectively encouraged the utilization of solar energy in homes, businesses, industry and government.

I believed then, and still do, that the demonstration of the feasibility of using solar energy for the heating and cooling of our buildings could help to relieve the demand upon our energy and fuel supplies, and that the technologies for solar heating and cooling have reached the point of efficient mass commercial application in the United States.

My State of Louisiana has affirmed a similar faith in a solar energy system, and is actively working to construct a viable program for its citizens.

On October 16, Louisiana State University hosted a conference attended by more than 250 people, which reported on the status and potential of solar energy research in Louisiana, on national plans for solar energy, and on demonstration projects now underway.

The conference addressed the problem of cooling, the all-important process to Louisiana along with dehumidification, which while now technologically feasible, is also the most technologically demanding process for researchers. It was estimated by the attendees that the development of an efficient and economical energy storage system, even with a back-up system, could reduce energy consumption by as much as 80 percent. Thus, each demonstration project is now approached with the view toward making a system economically competitive and realistic.

As evidence of the extent to which Louisianans are committed to energy alternatives, our Attorney General in his remarks outlined the legal problems of mass application of solar energy, such as access to sunlight, building codes, and zoning laws, and prescribed legal research to insure that performance standards become a high priority. Many potential applications of solar energy were catalogued, ranging from food dehydration and meat packaging to heated swimming pools, hydrogen production, electric power towers, and ocean-thermal power plants.

Next week, Mr. Chairman, the Louisiana Department of Conservation will sponsor a program aimed at dissemination of the energy conservation information contained in its recent publication *Energy Conservation Program Guide* *for Industry*, and at obtaining feedback from industry on the ways in which the State may be of greatest assistance to them. In addition, from April 19–23, 1976, Louisiana State University will be the site of the Second Southeasern Conference on the Application of Solar Energy.

Solar energy is no panacea to our critical energy needs. Yet, while Louisiana may not be blessed with as conducive a climate as other States, and, on the other hand, abounds in precious resources such as oil and natural gas, the citizens and government of Louisiana are letting it rapidly occupy a significant place in total energy design.

Unfortunately, Mr. Chairman, that concern is not being shared nationally. Review, if you will, the hundreds of publications which have been sponsored by private and industrial research units and made available to the Congress yearly since 1972, such as "Outlook for Energy in the United States to 1985", and "A Call for Action!—U.S. Energy Independence by 1985". Read also the October 1975 Monthly Energy Report of the Federal Energy Administration and an accompanying report from FEA Administrator Frank Zarb on the status of the United States' energy efforts compared to international programs.

None of these, and few of the others, make mention of energy alternatives, i.e., solar energy. The Congress had a glimpse of a promise from industry and government back in 1972 in testimony presented to the then Committee on Science and Astronautics. Reports from the subunit Executive Committee of the Solar Energy Panel of the Executive Branch's Committee on Energy R & D Goals further comprised of personnel from the National Aeronautics and Space Administration and the National Science Foundation, said that each of the executive agencies contacted was ready and willing to step up its efforts in solar energy research, that each considered it had the capability to conduct successful programs of this type, and that there were areas of research which appeared promising and/or not then being pursued which each agency would be willing to undertake were it given the charter to do so.

Mr. Chairman, this Subcommittee must underwrite that charter, must legislatively encourage a committed national program of solar energy research, and development, and utilization. Our energy deficiencies, our standard of living, and the already dedicated and zealous enterprise of our State and Local constituencies, deserve that endorsement.

Statement by Sheet Metal Workers' International Association

The energy crisis of the last three years, and the spiraling fuel costs which continue to characterize it, have demonstrated the need to accelerate the utilization of renewable energies such as solar radiation. The current imbalance between the domestic supply and the demand for fuels and energy is likely to continue unless a federal effort is made to test, utilize, and promote new forms of energy.

Solar energy is nonpolluting, inexhaustible and can become inexpensive. And Solar technology has developed to the point where commercial application is not only practical but economically desirable. However, the full potential of solar energy will not be realized until the cost of solar hardware is reduced through mass manufacturing. To increase public demand for solar hardware a program of Federal assistance is necessary. This assistance should include but not be limited to income tax credits for homebuyers and builders who purchase and install solar equipment, loans to homeowners and builders who purchase and install solar equipment, the use of solar equipment in buildings financed with Federal funds, Federal insurance of solar equipped buildings, direct subsidies to assist in the purchase of solar equipment, and Federal grants and contracts to the research community and manufacturers for the development of solar technologies.

The Sheet Metal Workers' International Association has become active in energy conservation and solar energy not only because it makes sense for America's energy needs but because jobs created in this area will put unemployed sheet metal workers back to work.

At the present time, one sheet metal worker in five is unemployed. Many more are working less than full time.

Energy conservation and the use of solar energy can have a large impact on unemployment. It has been estimated by the Stanford Research Institute that one-fourth of the dollars invested in solar heating and cooling will go to the

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labor costs of installation. In addition, there will be many jobs created fabricating the collectors, storage tanks, ducting and allied equipment necessary for a solar installation.

A Federal program to promote the use of solar energy will not only aid in achieving energy independence, but it will help to put Americans back to work. Dollars now being spent on expensive fossil fuels from abroad would be better spent reducing joblessness by harnessing less expensive, inexhaustive energies at home.

As a result of our interest in the use of solar energy, our union has taken several steps:

We are educating our membership to the possible impact of energy conservation and solar energy. At an August Conference of our union's business agents we devoted nearly two days to energy developments and the part our union can play.

Our National Training Fund, recognized as one of the best of apprenticeship programs, is now conducting a survey to determine if additional courses are needed for the construction of solar hardware.

We commissioned the Stanford Research Institute and the Mitre Corporation to make studies of the impact on the sheet metal industry of solar development and energy conservation. Copies of these reports have been sent to every member of Congress.

The Sheet Metal Workers' International Association strongly supports a direct low-interest loan program to assist homeowners and builders in purchasing and installing solar equipment. The passage of H 3849 will help achieve the goals of fossil fuel conservation, solar energy development and new job opportunities for Americans.

NATIONAL ASSOCIATION OF HOME BUILDERS,
Washington, D.C., December 5, 1975.

Hon. WILLIAM A. BARRETT,
Chairman, Subcommittee on Housing and Community Development, Committee on Banking, Currency, and Housing, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I should like to request that this letter be included in the record of the hearings the Subcomittee held on November 5, 1975, in regard to H.R. 3849. This bill would establish within the Department of Housing and Urban Development a direct low-interest loan program to assist homeowners and builders in purchasing and installing solar heating equipment.

NAHB, as the trade association of the home building industry with a membership consisting of more than 74,000 member firms in 603 local associations throughout the United States, is vitally interested in the subject of energy conservation, particularly as it relates to residential dwellings. Consequently, we have carefully reviewed H.R. 3849 along with its companion bill H.R. 8524, and endorse their purpose.

Sincerely,

J. S. NORMAN, *President.*

[The following statement of Robert Fawcett, chairman of the Fuel Oil Supply Study Committee of the New England Fuel Institute before the Senate Select Committee on Small Business on October 8, 1975, was received by the subcommittee for inclusion in the record:]

STATEMENT OF NEW ENGLAND FUEL INSTITUTE

My name is Robert Fawcett, I am President of Robert Fawcett & Son Co., Inc., a moderate sized retail heating oil and oil heating equipment business in Cambridge, Massachusetts. Today, I represent the New England Fuel Institute of which I am a past president, and presently chairman of its Fuel Oil Supply Study Committee. Accompanying me is Charles H. Burkhardt, Executive Vice President and Managing Director of the Institute, who will answer any questions posed by members of the Committee.

As you are well aware Senator McIntyre, the New England Fuel Institute is an association of about 1300 independent retail and wholesale heating oil distributors throughout the six state region. This association was incorporated under the laws of the Commonwealth of Massachusetts in 1946, as the Oil Heat Institute of New England. Our corporate name was changed to New England Fuel Institute in 1962.

The independent sector of the heating oil industry in New England sells more than 85 percent of all distillate product at retail. In addition 40 percent of the fuel oil sold at the wholesale level is marketed by independents. Further, 19.4 percent of all the oil heating equipment sold throughout the United States is installed in New England homes and buildings. Over 90 percent of this large quantity of oil heating equipment and accessories are sold, installed and serviced by independent heating oil dealer-distributors. About 125,000 to 140,000 oil burners are sold and installed in New England every year. Most of these are replacements. We usually average somewhere between 38,000 to 50,000 oil burners as new installations. These can be conversions from other fuels or installations in newly built homes.

There are 2,400,000 oil burner units operating in New England at the present time; about 890,000 gas burning units and about 275,000 units utilizing electricity. Gas and electricity combined account for about 1,165,000 centrally heated units, while oil has slightly over 2,400,000. Unlike most utilities, the retail oil heating dealer-distributor sells and installs heating equipment and accessories and/or newer replacement equipment himself. With a present market of over 2,400,000 oil heating customers, it is obvious that a built-in, practical and effective merchandising, marketing, engineering, installation and service mechanism exists on a broad scale in New England for any product and/or process to which the independent segment of the oil heating industry would apply itself.

Therefore, we believe that the heating oil dealer-distributor apparatus in New England is ideally endowed with all of the experience, technical skills, processes and procedures necessary for a mass introduction to the New England market, of solar heat generating equipment as an adjunct to existing or proposed oil heating systems.

We would like to take this opportunity Senator to review for a moment or two how we came to this type of thinking. In a true sense, it was due to stimulus presented to us by you and Mr. Cross, the Professional Staff Member of this Senate Select Subcommittee on Small Business. When you first approached us through Mr. Cross last May, we had mixed feelings about entertaining any effort toward popularizing or selling and installing solar heating equipment. At that time we viewed competitively rather than complementary. During the course of a series of meetings requested by you and attended by Mr. Cross, we began to see that there was a strong potential for New England to achieve some independence from foreign energy imports if solar energy was to be used on any large scale in conjunction with oil as a source of energy for home and domestic hot water heating. By the term "domestic hot water heating," we mean hot water produced at the faucet for bathing, cleaning, washing, etc. Solar heating would be a practical way to reduce New England's dependence on imported refined product, specifically distillate and residual, and yet provide a means of sustaining the livelihood of the more than 2000 retail, small business, heating oil dealers and distributors throughout New England, who provide jobs for well over 35,000 people.

Since the New England climate is such as to have many periods without sunshine and extremely cold winters, it is our considered opinion that solar energy could supply, theoretically, in an oil heated home, up to about 35 percent of the total heat required. More practically, this will evolve to about 28% to 30%. Thus, through the application of solar energy as an adjunct to oil heat, many more people could enjoy the benefit, comfort, virtues and service of oil heat without substantially increasing or, more practically, even decreasing New England's dependence upon imported, refined product.

Continued meetings with your representative and sustained investigation by the NEFI staff of the solar energy field and its potential, resulted in a change in philosophy on the part of New England Fuel Institute. This became sharply apparent about two months ago, and was accepted by the officers of the corporation and the chairmen of the standing committees, as well as the Fuel Oil Supply Study Committee. With this change and acceptance of the fact that solar energy could be a valuable adjunct to the whole New England consumer heating economy by reducing the region's dependence on imported, refined product, came the realization that it could be coupled successfully with oil heating. The decks were then cleared for action.

For such a program to be successful, some applied research for the actual coupling of solar energy heat producing equipment with existing and/or newly installed oil-fired heating units was required before a practical program for selling, installing and servicing solar energy units could be put into effect.

As NEFI is a small organization with a limited budget, it was necessary that we raise $30,000 immediately, in order to put into operation seven or eight units upon whose performance future production, sales and development would be based. We are happy to report that our efforts to raise this amount of money were immediately successful. Robert DeBlois, Executive Vice President of the DeBlois Oil Company and Chairman of NEFI's Finance Committee informed us that the DeBlois Oil Company would contribute $10,000 toward the project. On the very same day, Northeast Petroleum Corp. of New Hampshire offered to contribute $6000, and shortly thereafter, Mr. Lewis Sheketoff, President of Automatic Comfort of Hartford, Connecticut informed us that his company would contribute another $10,000. So, within a very short time, we had $26,000 of our $30,000 projected research monetary requirement committed.

We believe this points up the forward looking thinking of the heating oil distributors of New England, and points the finger of repudiation at Federal bureaucracies who claim that some businesses, including heating oil distributors could or would not be any help in the furtherance of solar heating. It demonstrates, further, that the Energy Research Development Administration should reorient its thinking concerning funds being available for the implementation and application of solar heating to homes and commercial buildings being handled by small businesses, such as the 2400 heating oil distributors throughout New England.

We will soon have three adjunct domestic hot water solar energy-oil heating systems installed in three homes in Rhode Island. We will study their operation and method of installation, and become appraised of such maintenance as is required. Following on this, there will be four adjunct solar energy domestic hot water generators, coupled with oil heating equipment, installed in Connecticut. Subsequently, a combination solar generator-oil heating and domestic hot water system will be installed in a one-family home in the general area of Hanover, New Hampshire. We will, in this way, be testing eight different types and/or kinds of solar heat generators coupled with oil at the same time.

Upon completion of these projects, we expect to have sufficient knowledge to institute training courses at NEFI's Technical Training Center in Cambridge, Massachusetts, which is fully licensed as a private vocational-technical school by the Commonwealth of Massachusetts' Department of Education. These courses will be devoted entirely to the practical application of solar heat generators to be used adjunctively with oil heating equipment. The proposed courses will be on the "nuts and bolts" level. It is our belief that we will be the first small business group providing state department-of-education-approved solar heat installation and servicing courses. In addition, we expect to train the sales forces of the retail and wholesale heating oil distributors in New England on the technology, sizing, heat loss calculations, and basic installation and servicing of solar heating equipment. Thereby, our dealers can intelligently sell the equipment where its application will be of benefit to the heating oil consumer and home owner. Our program entails (1) applied research, using actual operation of the equipment in existing homes; (2) cooperation with manufacturers in developing the most effective types of solar energy adjunct equipment; (3) the training of sales forces to promote and sell this equipment to the oil heating consumer; and (4) the training of installation and service technicians for applying this specific type of equipment. NEFI firmly believes it will demonstrate that small business is the true key to the mass sale, application, installation and servicing of solar heat generators.

It is this Institute's considered opinion that after the completion of the eight month period of applied research, we will install 500 adjunct solar-oil hot water generators in the first year, and an average of 2500 for the next two years. From that time on our potential will be unlimited in the New England area. It is not over optimistic nor "pie in the sky," thinking to project 75,000 of these installations within five years of completion of the applied research projects if the Federal and local governments cooperate in a practical manner.

However, it will be necessary for the Federal government to realize that in many cases solar heat is not economically attractive to the consumer. Also, present real estate tax practices, Federal tax laws, federal, state and local building and appliance codes and regulations all strongly, actively and consistently militate against the installation of solar heating equipment. There has been some considered thinking on the part of the Federal government that will provide the following and/or solutions to the following.

This means that Federal, state and local governments will have to help considerably in achieving tax reforms and incentives, and building and appliance code reforms, or solar energy goals will not be reached. Among reforms and changes most needed are:

1. On the local level, and possibly with some assist legislatively from the Federal government, local tax departments and assessors must realize that if they increase the assessed valuation of a residence because a solar heat generator is added to a house already heated by oil, gas or electricity (to decrease the use of energy), such increase will effectively deter and even kill the acceptance and use of much needed solar equipment. While increased assessed valuation may be accorded homes installing swimming pools, that concept is not going to help solar heat, nor is it going to do anything to decrease the national dependence on imported, refined product, crude oil, liquefied natural gas or high cost residential electric heating. The latter consumes three and a half times as much oil to produce a BTU of heat as does burning oil directly in a boiler or furnace within the residence. There has to be some understanding that the installation of high cost solar energy heating equipment will never really catch on if it is going to result in increased assessed valuations, and thereby, higher real estate taxes.

2. On state, municipal, county and local levels, codes and regulations may actually prevent, inhibit or make costly, beyond return, the installation of solar heating equipment.

3. Solar energy equipment at the present time, to provide domestic hot water in conjunction with an oil fired, gas fired or electrically powered water heater, costs from $600 to $2,000 per unit, while 100% oil, gas or electric water heaters sell for just a fraction of that cost. It will be several years before competitive forces in the marketplace plus advanced technology will be producing solar energized domestic hot water heaters at a cost remotely competitive with oil, gas or electric equipment. Therefore, the home owner who will expend money for this higher cost generating equipment must of necessity have a tax incentive or tax credit that will rationally enable him to go ahead with the installation.

Otherwise, solar energy will continue to be a novelty that will be the province of the rich or affluent, like high cost automobiles and/or luxurious swimming pools. Any incentive on the part of the home owner to use solar energy must be repaid by adequate income tax credits and/or some other reciprocal economic benefit that will make it economically justifiable for the average home owner to buy and install solar heat devices.

4. Further, the more than 11,000 independent heating oil and oil heating equipment distributors at the retail level throughout the country will have to have some practical inducement to expend the money for inventorying such equipment; for training personnel to install and service it; as well as to promote and sell it. This is doubly important at the retail level because every time a heating oil dealer installs a piece of solar heat generating equipment, he is reducing his retail oil gallonage. It is not our purpose in working to install solar energy to take the bread and butter out of the mouths of our heating oil dealers, nor to reduce the thickness of the slice of bread that he and his family is consuming. We believe that some assistance from the Federal government will be necessary for small businesses such as oil heat distributors, who have all of the mechanisms, organization and skill to make these energy saving devices practical and effective. Such assistance from the Federal government can come in the form of long term low interest loans to small and medium sized retail dealers and distributors. These will help provide the capital necessary to develop solar energy as a saleable product. Also, tax incentives and special depreciation allowances will be required so that the dealer can successfully divert and/or augment his energies to solar heating.

The Energy Research and Development Administration should make available funds to groups or small business groups such as this Institute, to encourage a rapid development and expansion of applied solar energy research at the very grass roots level that is represented by the heating oil distributors of the New England region.

With New England more heavily dependent on imported, refined petroleum products than any region in the country, it is the ideal area in which to forward the cause of solar energy. While New Mexico, Arizona and southern California have a great deal of sunshine, they do not have winters ranging from 5000 to 9000 degree days that you find every year throughout the various sections of New England. These winters require vast amounts of heat energy that burn 130,000,000 barrels of fuel oil for heating alone.

We very much appreciate, Senator McIntyre, your request that NEFI participate in these hearings. We know that the Senate Select Committee on Small Business realizes how important small business is to providing the massive retail penetration of the market necessary for any successful application of solar energy as a means of reducing our dependence upon imported, foreign energy.

We thank you.

LENDING INSTITUTION ATTITUDES TOWARD SOLAR HEATING AND COOLING OF RESIDENCES*

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*This is Part II of a broader study entitled Demand Analysis: Solar Heating and Cooling of Buildings (Phase I Report), December 1974, prepared by: Jerome E. Scott, Associate Professor of Business Administration, University of Delaware; Ronald W. Melicher, Associate Professor of Finance, University of Colorado; and Donald Sciglimpaglia, Research Associate, University of Colorado. Part I of the report is entitled "Solar Water Heating in South Florida: 1923-1974."

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INTRODUCTION

Solar energy may represent a significant source for meeting future energy needs in the United States. Energy from the sun has been used to provide hot water since the early 1920s, and more recently, experimental solar heating and cooling systems have been built. The rate of diffusion in the future use of solar energy to heat and cool buildings will depend, however, on a number of technological, economic, social, environmental, and institutional factors.

Recent studies funded by the Ford Foundation[1] and by the National Science Foundation[2] focused primarily on an examination of the technological feasibility and economic characteristics of solar heating and cooling of buildings. Institutional factors received considerably less attention. The ability and willingness to finance solar energy installations in single family residences apparently will have a significant impact on the rate of growth of the solar energy industry. This study examines the attitudes of financiers toward the solar heating and cooling of buildings.

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[1]Richard Schoen and Jerome Weingart, Institutional Problems of the Commercial Application of New Community Energy System Technologies, With Emphasis on Solar Conversion Systems, Ford Foundation Energy Policy Project, November, 1973 (draft).

[2]General Electric Corporation, Solar Heating and Cooling of Buildings (Phase 0), National Science Foundation RA-N-74-021A, May 1974; TRW Corporation, Solar Heating and Cooling of Buildings (Phase 0), National Science Foundation RA-N-74-022A, May 1974; and Westinghouse Electric Corporation, Solar Heating and Cooling of Buildings (Phase 0), National Science Foundation RA-N-74-023A, May 1974.

More specifically, the financial institutions study encompasses the following objectives:

1. Identify factors that may enhance or impede the financing of buildings (particularly single family residences) equipped with solar heating and cooling systems.

2. Examine and compare the attitudes of savings and loan officers with the attitudes of officers from other financial institutions (i.e., mortgage banking firms, commercial banks, and mutual savings banks) on financing solar homes.

3. Identify attitudes toward possible subsidy and incentive programs that might be used to stimulate the diffusion of solar energy systems.

4. Provide suggestions for public and private sector policies to encourage solar home development.

The research program included a review of available secondary information, including the "Phase 0" reports by General Electric, TRW, and Westinghouse Electric, and personal interviews and mail questionnaire responses. Personal interviews were conducted with representatives of the United States League of Savings Associations, the Mortgage Bankers Association of America, the National Association of Home Builders, and the Federal Home Loan Bank Board. Both the United States League of Savings Associations and the Mortgage Bankers Association of America provided valuable assistance in administering mail questionnaire materials to selected members of their respective organizations.

The report is comprised of, in addition to this introduction, four sections plus appendices. The following section identifies broad factors that might affect the financing of solar heated and cooled buildings. Next, the attitudes of savings and loan and other financial institution officers toward solar homes is examined. A section then focuses on lender attitudes toward possible solar energy subsidy and incentive programs. The final section contains conclusions of this study plus suggestions for possibly increasing the rate of diffusion of solar energy systems in single family residences.

FACTORS THAT MIGHT AFFECT THE DIFFUSION OF SOLAR ENERGY

Background Information

The experience with conventional heating and cooling systems provides useful insight into the likely future use of solar energy systems. Conventional heating systems in single family residences long have been financed as part of the original mortgage in newly constructed single family residences. Replacement heating units often are financed through installment loan arrangements. Central air-conditioning systems for homes are financed in a similar fashion depending upon whether they represent original equipment or retrofit installations.

Although available during the 1930's, high costs prevented wide diffusion of central air-conditioning systems until the 1960s. This experience has important ramifications for solar energy. Phase "0" findings by General Electric, TRW, and Westinghouse Electric all suggest large initial outlay requirements for solar energy installations in single family residences. In other words, there will be a period of time before solar energy systems are economically justifiable. Consequently, without subsidies or incentives, one might expect solar energy diffusion to parallel the central air-conditioning experience.

Additional insight can be gleaned from the companion study which traces the solar water heating experience in Florida since the early 1920s. Solar water heaters generally have been retrofit installations and have qualified for financing as FHA Title I installment loans. The solar water heater industry peaked in Florida during the 1936-1941 period. In 1938 there existed a clear-cut economic justification for installing a solar energy water heating system over a conventional electric water heating system. However, rising component and installation costs and continuously declining electricity rates soon led to a cost advantage shift in favor of conventional electric water heaters. First cost differentials continued to widen in favor of electric water heater installations, while the electricity cost savings per KWH declined until the 1970s. Even now, very few new solar water heater installations are being made in Florida.

Previous experience with conventional heating and air-conditioning systems and solar water heating systems indicates that first costs and life-cycle cost economics will significantly influence the diffusion of solar energy in single family residences. Lenders involved in making loans on homes equipped with solar systems must be cognizant of the economic relationships.

Implications of Phase "0" Studies

The Phase "0" findings were further examined for possible factors, in addition to solar system economics, that may enhance or impede the financing of buildings. The General Electric report did not directly examine lender implications. TRW, in what is believed to have been a cursory survey, stated:

> Our discussions with lenders have not identified any long-range major obstacles to overcome, pending the requirement for an established solar industry which is producing reliable products.[3]

However, the TRW study does acknowledge the possibility of near-term financing problems such as mortgage approval resistance, and resistance to life-cycle cost concepts or first costs versus operating cost trade-offs.[4]

The Westinghouse Electric effort involved the mailing of 24 questionnaires to mortgage, real estate, and insurance brokers. Sixteen responses provided the basis for the following conclusions:

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[3]TRW Corporation, _op. cit._, Executive Summary, p. 4-6.

[4]_Ibid._

> Financiers believe that a solar supplement would have no direct adverse effect on financing and could possibly improve it. It is felt that solar heating and cooling systems will enhance the salability of a building...Salability of buildings with solar units would be affected by cost considerations, just as conventional systems are, but the novelty of the concept is not considered likely to impair the market and, in fact, would probably enhance it.[5]

Although limited, these findings provided the basis for further investigation into the importance of certain factors to financiers.

Institution Interviews

A personal interview approach was initiated in order to supplement the solar economics and limited lender information provided in the Phase "0" reports. Local Denver, Colorado contact was initiated with Mr. William Johnson, President of Colorado Federal Savings and Loan Association and Mr. Stan Hendrixon, Chairman of the Board of Kassler and Company Mortgage Bankers in an attempt to identify other factors that might impede or enhance the financing of homes equipped with solar energy systems.

Additional personal interviews were conducted with representatives from three national organizations and the Federal Home Loan Bank Board. More specifically, the institutions and interviewed representatives were:

1. United States League of Savings Associations (Chicago, Illinois)
    a. Mr. James A. Hollensteiner
       Staff Vice President
    b. Mr. Harold Olin
       Director of Architecture and Construction Research

2. Mortgage Bankers Association of America (Washington, D. C.)
    a. Dr. Oliver H. Jones
       Executive Vice President
    b. Additional Staff Members

[5]Westinghouse Electric, op. cit., Executive Summary, p. 50.

3. National Association of Home Builders (Washington, D. C.)
   a. Mr. Ralph Johnson
      Director, NAHB Research Foundation
   b. Mr. Carl Coan, Jr.
      Legislative Counsel

4. Federal Home Loan Bank Board (Washington, D. C.)
   a. Dr. Harris Friedman
      Director of Economic Research
   b. Additional Staff Members

Several observations were formulated as a result of these interviews. First, financiers were not likely to be very knowledgeable about solar heating and cooling systems which could be installed in single family residences. Second, the economics of solar energy will significantly affect the rate of diffusion (i.e., solar systems must be made economically competitive with conventional heating and cooling systems). Third, lenders will need to become cognizant of life-cycle costing concepts and be willing to recognize trade-offs between first costs and operating costs. Fourth, some form of subsidy or incentive program probably will be necessary in order to achieve near-term wide-spread diffusion of solar energy systems in homes.

The results of the personal discussions with representatives of the USL (Savings Associations), MBA, NAHB, and the FHLBB provided valuable insight into identifying factors that may affect the financing of solar heated and cooled buildings. However, the discussions also acknowledged the need to extend our investigation to the operating institution level (i.e., to representatives of financial institutions directly involved in the mortgage loan process). Both the United States League of Savings Associations and the Mortgage Bankers Association of America provided the opportunity for gathering responses from some of their members.

FINANCIAL INSTITUTION SURVEY RESULTS

Study Design

Financiers were not expected to be very knowledgeable about current state-of-the-art solar energy concepts. Building design innovations in single family residences traditionally have been characterized by slow adoption rates. And, only recently have major attempts been made to comprehensively study the technological and economic feasibility of solar energy systems.[6] A minimum understanding on the part of financiers concerning applications of solar energy to heat and cool buildings seemed necessary in order to examine lender attitudes. Consequently, a brief write-up describing solar energy systems and economics was prepared and is presented as Appendix 1.

A financial institutions questionnaire was designed after reviewing the research and personal interview results discussed in the prior section. The comprehensive set of questions elicits attitudes concerning the degree of importance of specific factors that are likely to be involved in making mortgage loan decisions on solar homes. Attitudes concerning the degree of importance associated with various possible incentive or subsidy proposals also were stressed. The final questionnaire is presented in Appendix 2.

A mail questionnaire package--comprised of a cover letter, a brief write-up on solar energy (Appendix 1), a six-page questionnaire (Appendix 2), and a postage paid return envelope--was developed. The United States League of Savings Associations agreed to support our efforts through the mailing of the questionnaire package to the 110 members of the Investments

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[6]See Schoen and Weingart, op. cit., and the Phase "0" studies by General Electric, TRW, and Westinghouse Electric.

and Mortgage Lending Committee and to the 65 members of the Committee on Land Use and Environment.[7] Questionnaire materials were mailed to the 175 members of the two committees during late August 1974.

In addition to examining the attitudes of savings and loan association members, we were also interested in the attitudes of financiers from other institutions involved in the mortgage lending process. Members of the Mortgage Bankers Association of America include savings and loan institutions, mortgage banking firms, commercial banks, and mutual savings banks. The Mortgage Bankers Association provided 200 mailings--80 to mortgage bankers, 60 to commercial banks, and 60 to mutual savings banks--during late September 1974.[8]

Responses to Questionnaire

One hundred thirty-one questionnaires were returned. Seventy-nine responses were received from savings and loan association officers. Based on 175 mailings, this represents a 45 percent response rate. Fifty-two responses (a 26 percent rate) were received from the MBA members--19 from mortgage bankers, 18 from commercial banks, and 15 from mutual savings banks. In a few instances, letters were received which indicated that questionnaires were not completed because the recipients felt they lacked

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[7]Mr. James Hollensteiner, Staff Vice President, United States League of Savings Associations, indicated that responses from these committee members would be particularly valuable because the members held important decision making positions in their respective organizations.

[8]Mr. John M. Wetmore, Director of Economics and Research, Mortgage Bankers Association of America, indicated that a simple random sampling procedure was used to select the 60 commercial banks and 60 mutual savings banks. The 80 mortgage banking firms were selected on the basis of a stratified random sample using classifications based on the volume of loans each firm originated.

minimal knowledge about solar energy. The higher response rate by savings and loan association members seems due to the fact that mailings were made to specific committee members and were accompanied by cover letters from the committee chairmen.

Tabulated responses to the questionnaire are presented in Appendix 3. Careful review of the tabulated results is recommended. Since respondent profiles and institutional characteristics may be relevant to this study, they are presented prior to our summarizing the important findings.

Respondent Characteristics

Table 1 provides a profile of the respondents in terms of three characteristics--job title or position, experience in the lending industry, and degree of knowledge about the solar heating and cooling of buildings. Responses are from financiers at important decision making levels in their respective institutions and who, on the average, have 20 years of experience in the lending industry. Sixty-four percent of the respondents are at the senior vice president or higher level. Approximately one-half of the savings and loan association respondents were presidents of their respective firms. Operating officer respondents, primarily from mortgage banking firms, commercial banks and mutual savings banks, included assistant vice presidents, loan officers and staff appraisers.

Only 9 percent of the savings and loan respondents had less than 11 years of experience compared with 25 percent of the other financier respondents. Both groups were, however, very similar in terms of how they perceived their knowledge about solar energy. Nineteen percent of all respondents lacked prior knowledge. That is, these respondents read only the brief write-up describing solar energy systems and economics that was attached to the financial

TABLE 1. RESPONDENT CHARACTERISTICS

Characteristic	Percentage of Responses		
	Savings and Loan Associations	Other Financiers	Total Responses
Job Title or Position			
President	49.4%	21.2%	38.2%
Executive or Senior Vice President	31.6	17.3	26.0
Vice-President	8.9	25.0	15.3
Operating Officer	10.1	34.6	19.8
No Response	0.0	1.9	.8
Total	100.0%	100.0%	100.0%
Experience in Lending Industry			
1 - 5 years	6.3%	11.5%	8.4%
6 - 10 years	2.5	13.5	6.9
11 - 20 years	44.3	36.5	41.2
21 - 30 years	35.5	30.8	33.6
31 and over	10.1	5.8	8.4
No Response	1.3	1.9	1.5
Total	100.0%	100.0%	100.0%
Average Years Experience	21.3	17.7	19.9
Knowledge About Solar Heating and Cooling of Buildings			
Read Numerous Materials	3.8%	1.9%	3.1%
Read Some Materials	77.2	78.9	77.9
Read Only Questionnaire Materials	19.0	19.2	19.1
Total	100.0%	100.0%	100.0%

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institutions questionnaire. And, as was previously mentioned, a few individuals responded with letters indicating a failure to complete the questionnaire due to inadequate knowledge about solar energy. Very few respondents felt that they were very knowledgeable about the solar heating and cooling of buildings.

Seventy-one percent of the respondents believed that solar energy would provide a feasible alternative energy source for the heating and cooling of single family residences within the next 10 years. However, only 19 percent of all respondents felt that solar energy would be a technically and economically feasible alternative within five years. Savings and loan respondents were considerably more optimistic in their opinions—24 percent envisioned solar energy feasibility within five years and 80 percent within 10 years. Thus, even though both groups of financiers held similar perceived reading knowledge about solar energy, the savings and loan respondents were more optimistic in their views when solar energy would represent a feasible alternative for the heating and cooling of single family residences.

Institution Location and Size Characteristics

Two institutional characteristics--geographic location and asset size--were examined. The United States can be divided into several climatological regions. All three Phase "0" reports indicate that solar energy system costs will differ substantially depending upon the heating and cooling requirements in a given area.[9] As a consequence, the diffusion of solar

[9]Westinghouse Electric, op cit., Volume 1, Chapter 5, provides a detailed estimate of investment, operating and maintenance, and life cycle cost differences by region.

energy installations may not be consistent throughout the United States. Possible differences in financier attitudes toward solar energy also may exist by geographic area.

Figure 1, prepared by TRW, divides the continental United States into nine climatic regions for the heating season (General Electric identifies 12 climatic regions). Initial consideration was given to possible examination of financier attitudes on the basis of these regions. However, such an approach was judged unacceptable when it was shown that regional climatic classifications for the cooling season differed markedly from those for the heating season. As an alternative, we chose to divide the United States into four regions--Northeast, South, Midwest or North Central, and West (including the Southwest).[10] Responses categorized by geographic area and asset size of institution are presented in Table 2.

Savings and loan association and other financier responses were reasonably well distributed across the four geographic regions. This enables the examination of financier attitudes for possible differences by region. Results will be presented later. In terms of asset size, 35 percent of the savings and loan association responses were from association members with less than $51 million in assets. On the other hand, approximately 27 percent of the S&L responses came from firms with assets in excess of $200 million. The result was a well balanced asset size distribution. Responses from the other financiers group, and by sub-sets within the group, also were reasonably distributed by asset size.

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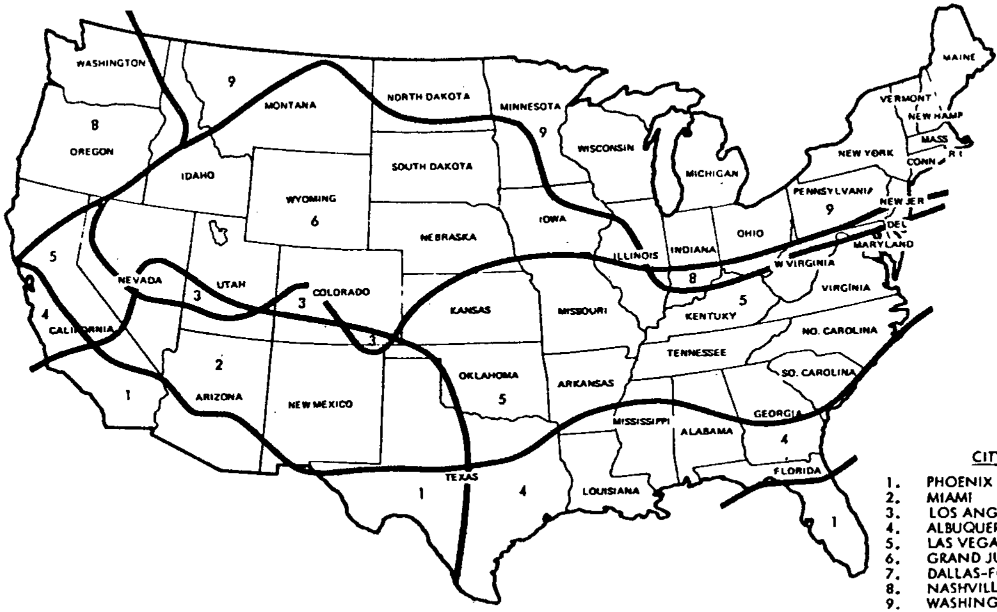
[10] This is consistent with the U. S. Bureau of the Census regional groupings with the exception of the states of Oklahoma and Texas which we placed in the West-Southwest region instead of the South region. The grouping of states by region is presented in Appendix 4.



	CITY	REGION
1.	PHOENIX	1
2.	MIAMI	1
3.	LOS ANGELES	1
4.	ALBUQUERQUE	2
5.	LAS VEGAS	2
6.	GRAND JUNCTION	3
7.	DALLAS-FORT WORTH	4
8.	NASHVILLE	5
9.	WASHINGTON, D. C.	5
10.	SALT LAKE CITY	6
11.	SEATTLE-TACOMA	8
12.	CHICAGO	9
13.	BOSTON	9
14.	NEW YORK	9

Figure 1 Regional Climatic Classification for the Heating Season (November-April)

Source: TRW, Solar Heating and Cooling of Buildings (Phase 0), Executive Summary, May 1974, page 2-2.

TABLE 2. INSTITUTIONAL CHARACTERISTICS

Characteristic	Percentage of Responses		
	Savings and Loan Associations	Other Financiers	Total Responses
Geographic Location			
Northeast	20.2%	34.6%	26.0%
South	32.9	21.2	28.2
Midwest (North Central)	32.9	19.2	27.5
West (including Southwest)	12.7	21.2	16.0
No Response	1.3	3.8	2.3
Total	100.0%	100.0%	100.0%
Asset Size of Institution			
$ 1 - $ 50 million	35.4%	23.1%	30.5%
$ 51 - $200 million	38.0	28.8	34.4
$201 million and over	26.6	34.6	29.8
No Response	0.0	13.5	5.3
Total	100.0%	100.0%	100.0%

Factors Important to the Financing of Solar Homes

Solar heating and cooling systems may be introduced in new construction of various types of structures. Respondents were asked to rank several structures--small office or professional building, single family residence ($50,000-$60,000), condominium apartment, small apartment building, and small industrial building--on the basis of the lending industry's willingness to make loans on the solar energy systems. Single family residences were ranked first by 60 percent of the respondents. Next in preference were small office or professional buildings and small industrial buildings. Low preference was given to condominium apartments and small apartment buildings.

Financiers overwhelmingly preferred to have solar systems on new homes financed as part of the total mortgage loan (conventional, VA or FHA) on the home. Little preference was given to other potential alternatives such as under separate second mortgage loans, FHA mortgage loans on the solar equipment, or installment loans (similar to the financing of large appliances).

Table 3 indicates the degree of respondent concern associated with a number of solar energy system characteristics or factors. Responses were recorded in the following fashion: 1 for little concern; 2 for some concern; 3 for much concern; and 4 for great concern (see Appendices 2 and 3 for further elaboration). This would result in a mid-point value of 2.5, with average values below 2.0 and above 3.0 being of particular interest. Respondents felt that all of the factors listed in Table 3 were important. They were, however, particularly concerned about the reliability of solar systems and the effect on salability of single family residences with solar heating and cooling systems. Respondents also expressed much concern, on

TABLE 3. DEGREE OF CONCERN FOR SOLAR SYSTEM FACTORS

Factor	Average of Responses* Total Responses	Savings and Loan Associations	Other Financiers	T-Values
Expected Life of Solar Equipment	3.02	2.94	3.16	-1.52
Fuel Cost Savings	2.88	2.89	2.88	.03
Maintenance Expense	3.07	3.05	3.10	-.35
Warranty Coverage on Solar Equipment	2.77	2.77	2.76	.05
Reliability of Solar System	3.63	3.64	3.61	.31
Damage Due to Water Leaks	2.64	2.51	2.84	-1.82
Effect on Salability of Home	3.33	3.17	3.59	-2.76**
Insurability of Home	2.92	2.65	3.33	-3.43**

*Responses could range from 1 (little concern) to 4 (great concern). The T-value tests for possible significant differences between the savings and loan association and other financier responses.

**Statistically significant at the .01 level.

the average, about the expected life of solar equipment and maintenance expenses associated with solar systems.

Responses between the savings and loan association and other financier groups were examined by conducting two-tailed t-tests of the difference between mean values. Two factors--effect of solar system on salability and insurability of homes--were of significantly higher concern to the other financiers group. We don't attach much importance to this finding except to note that it is consistent with the other financiers' less optimistic solar system feasibility expectations.[11]

Further insight into financier attitudes was generated through the following scenario. Respondents were informed that solar energy systems in single family residences would require initial costs or expenditures above the costs for conventional heating and cooling systems. Respondents then were asked to indicate the importance--little, some, much, or great--of certain factors if they were considering a mortgage loan request on a solar home. The results, computed in the same fashion as the data in Table 3, for each factor under consideration are presented in Table 4. For control purposes, some factors were similar to some of those presented in Table 3. Respondents again were highly concerned about evidence on the expected life of solar systems and about data on the expected performance (reliability) of solar systems.

Life-cycle and initial solar system costs also were considered to be of much importance to the respondents. The two groups were generally consistent in how they rated the importance of factors with the exception of

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[11]Attitudes toward salability (and loanability) of solar homes receive further attention in the form of a cost-related scenario later under the solar system costs topic.

TABLE 4. IMPORTANCE OF FACTORS IN MORTGAGE LOAN REQUESTS ON SOLAR HOMES

Factor	Average of Responses*			T-Values
	Total Responses	Savings and Loan Associations	Other Financiers	
Applicant's Annual Income	2.82	2.73	2.96	-1.41
Evidence on Expected Life of Solar System	3.26	3.22	3.33	-.90
Added Initial Cost of Solar System	2.95	2.86	3.08	-1.44
Life-Cycle Costs for Solar System	3.04	2.98	3.14	-1.17
Data on Expected Performance of Solar System	3.20	3.15	3.28	-.92
Data on Possible Damage Due to System Leakages	2.70	2.56	2.92	-2.61**
Educational Information from National Organizations	2.47	2.45	2.51	-.38
Solar Energy Education of Appraisers	2.76	2.74	2.78	-.26
Added Solar-Related PITI Requirements	2.63	2.47	2.93	-2.87**

*Responses could range from 1 (little importance) to 4 (great importance). The T-value tests for possible significant differences between the savings and loan association and other financier responses.

**Statistically significant at the .01 level.

data on possible leakage damage and added solar-related PITI requirements which were significantly more important to the other financiers' group. These differences are consistent with the salability and loanability concern expressed above, as well as, with the economic and technological feasibility expectations.

Solar Energy System Costs

Solar energy systems require larger initial expenditures relative to conventional heating and air-conditioning systems. Consequently, economic justification for a solar system rests on achieving lower operating costs (fuel cost savings adjusted for maintenance cost differences). This represents a life-cycle cost analysis. That is, larger initial outlays are offset by future savings.

In current practice, 37 percent of the respondents indicated that life-cycle costs (i.e., heating and cooling costs) receive important consideration in deciding whether to grant mortgage loans on single family residences. This is encouraging. However, willingness by all financiers to consider life-cycle costs is necessary if solar energy systems are to be competitive in the future with conventional heating and cooling systems.

One way of evaluating life-cycle costs is to determine the number of years it will take before savings from operation of the solar system will equal the initial cost of the system. Respondents were asked how fast would the payback (i.e., the time required to match operating savings with initial costs) have to be in order to economically justify a solar energy installation in a single family residence. The responses averaged 8.3 years--8.7 years for the savings and loan association responses and 7.7 years for the other financier responses. This is somewhat discouraging in that the Phase "O" studies by General Electric, TRW, and Westinghouse Electric suggest that such a payback period is not currently feasible.

Financier attitudes toward acceptable levels of initial solar system costs also were examined by expressing the added solar costs as a percentage of the price of a home. For homes costing between $30,000 and $40,000, financiers felt that 4 percent to 6 percent was, on the average, an acceptable percentage cost increase in order to make solar energy systems attractive to owners of single family residences. This level of initial solar system costs is not, however, currently attainable. Financiers did become more lenient as the price of homes increased. For example, financiers were willing to accept, on the average, added solar costs of 7 percent to 9 percent for homes costing $70,000 and above. Initial emphasis on introducing solar systems in more expensive homes would, however, probably result in a diffusion experience similar to that for central air-conditioning systems.

A cost-related scenario also was developed in order to further examine attitudes toward the salability and loanability of solar homes. The following question was asked. All things considered, how do you believe the incorporation of solar heating and cooling in a $50,000 to $60,000 single family residence would affect its salability and loanability if the solar installation costs $5,500? Financiers were divided in their responses. Forty-one percent felt that salability would be somewhat enhanced, whereas 33 percent felt that salability would be somewhat reduced. In terms of loanability, the responses were 40 percent and 23 percent, respectively. Thus, although the responses average out to no affect on salability and loanability, distinct differences of opinion exist.

Geographic Location Results

As noted earlier, responses were grouped on the basis of four regions--Northeast, South, Midwest, and West. The potential for solar energy applications differs markedly by geographical area according to the General Electric, TRW, and Westinghouse Electric Phase "0" studies. Responses across the four regions were examined in a fashion similar to that employed to test for differences in responses between the savings and loan association and other financier groups. However, because there were four groups, differences across mean values were examined through the application of analysis of variance tests instead of t-tests.

Average responses were found to be generally consistent across the four regions. Financier responses concerning solar energy knowledge, solar system feasibility expectations, and acceptable levels of initial solar system costs were similar. Responses pertaining to the factors listed in Tables 3 and 4 of this study were not significantly different by region (see Appendix 5). Attitudes toward possible subsidies and incentives also did not differ across the regions. Notable differences only existed in terms of payback attitudes. Respondents from the Midwest felt that, on average, payback periods of 10-11 years were justifiable. Averages for each of the other three regions were 7-8 years.

ATTITUDES TOWARD POSSIBLE SUBSIDIES AND INCENTIVES

Solar heating and cooling systems currently are not economically competitive with conventional heating and air-conditioning systems. Each of the Phase "0" studies recognized a need for incentives or subsidies in order to achieve rapid near-term diffusion of solar energy systems in single family residences. Several possible incentive and subsidy programs were formulated. In brief, subsidies or incentives can be directed at a number of levels--manufacturers of solar energy systems, home builders, financing institutions, and consumers or purchasers. At the end of the financial institutions questionnaire, financiers were asked to indicate at what levels would the best benefits (i.e., a greater rate of diffusion) be achieved relative to costs incurred. Financiers were inconclusive in their responses. Thirty-nine percent selected manufacturers as their highest preference, while another 37 percent ranked purchasers first. Home builders were ranked second in a large number of responses. Only efforts to be directed at the financing institutions ranked low.

Financiers also were asked how they would evaluate the importance of each of several subsidies and incentives if they were trying to stimulate the diffusion of solar energy systems.[12] The results are summarized in Table 5. As before, responses were recorded in the following fashion: 1 for little importance; 2 for some importance; 3 for much importance; and 4 for great importance. The respondents failed to identify any of the subsidies or incentives as being greatly important--possibly indicating some resistance to this approach for achieving competitive equality for solar heating and cooling systems. Research and development tax write-offs to manufacturers was the only incentive to approach a much important (3.0) average ranking.

Several incentives or subsidies received responses that averaged approximately 2.5 (i.e., the mid-point between some and much importance). Included were: Federal Government research and development grants to manu-

[12]Potential subsidies and incentives were identified and formulated after review of the three Phase "0" studies and after discussions with representatives of the U. S. League of Savings Associations, the Mortgage Bankers Association, the National Association of Home Builders, and the Federal Home Loan Bank Board.

TABLE 5. IMPORTANCE OF SUBSIDIES AND INCENTIVES IN STIMULATING DIFFUSION OF SOLAR HOMES

	Average of Responses*			
Subsidy or Incentive	Total Responses	Savings and Loan Associations	Other Financiers	T-Values
Government R & D Grants to Manufacturers	2.46	2.38	2.61	-1.24
R & D Tax Write-offs to Manufacturers	2.87	2.95	2.75	1.15
Property Tax Exemption or Credits to Purchasers	2.51	2.47	2.57	-.52
Federal Income Tax Credits or Deductions to Purchasers	2.44	2.32	2.65	-1.88
Government Ownership of Solar Production Facilities	1.30	1.29	1.31	-.22
Government-backed Product Warranty Insurance	2.20	2.14	2.31	-.88
Joint Industry-Government Funded Programs	2.21	2.12	2.38	-1.52
Solar Costs Included Under FHA Title I Loans	2.34	2.32	2.38	-.33
Below-market Interest Rates to Purchasers (Total Mortgage)	2.32	2.30	2.36	-.27
Below-market Interest Rates to Purchasers (Solar System)	1.85	1.86	1.84	.09
Below-market-rate Funds to Lending Institutions (by FHLBB)	2.27	2.24	2.33	-.39
Mortgage Purchase Commitments to Lending Institutions (by FHLBB)	2.58	2.45	2.79	-1.72
Government Subsidization of Home Builders (Absorption of Costs)	2.07	2.00	2.17	-.90

*Responses could range from 1 (little importance) to 4 (great importance). The T-value tests for possible significant differences between the savings and loan association and other financier responses.

facturers; property tax exemptions or credits to purchasers; Federal income tax credits or deductions to purchasers; and involvement by the Federal Home Loan Bank Board (and/or other governmental agencies) to provide home mortgage purchase commitments to lenders making mortgage loans on homes with solar energy systems. These possible programs would be directed at a number of levels, again indicating a lack of directional consensus on the part of financiers.

Financiers were particularly opposed to Federal government ownership of solar system production facilities as a means of stimulating diffusion of solar homes. Another plan judged to be of low importance would involve providing below-market interest rates to purchasers as a means of financing only the cost of the solar system. Federal government subsidization of home builders through the absorption of solar energy system costs also was ranked low in importance. Table 5 further indicates that average responses concerning the importance of subsidies and incentives did not differ significantly between the savings and loan association respondents and the other financier respondents representing mortgage banking firms, commercial banks, and mutual savings banks.

CONCLUSIONS AND RECOMMENDATIONS

Financial institutions will play an important role in the rate of diffusion of solar systems in single family residences. The major thrust of this study was the examination of attitudes of financiers toward the solar heating and cooling of buildings.

Personal interviews were conducted with representatives of the United States League of Savings Associations, the Mortgage Bankers Association of America, the National Association of Home Builders, and the Federal Home

Loan Bank Board. Additional information was gathered from 131 mail questionnaires received from savings and loan associations and other financier (mortgage bankers, commercial banks, and mutual savings banks) respondents who were well-experienced and in important decision-making positions. Major conclusions are:

1. Attitudes between the two broad groups of respondents--savings and loan associations and other financiers--usually were consistent. However, certain responses were characterized by less optimistic or more conservative opinions by the other financier respondents.

2. Responses were generally consistent across broad geographical areas--Northeast, South, Midwest, and West.

3. Nearly three-fourths of the respondents believed that solar energy would represent a feasible alternative energy source for the heating and cooling of single family residences within the next 10 years.

4. Financiers indicated a preference for making loans on solar homes (as opposed to other types of structures) and overwhelmingly preferred to have solar systems on new homes financed as part of the total mortgage loan on the home.

5. Respondents were particularly concerned about the reliability of solar systems and their effect on salability of single family residences. Substantial concern also was expressed about the expected life of solar equipment and the associated maintenance expenses.

6. Life-cycle and initial solar system costs were perceived to be of much importance to the respondents if they were considering a mortgage loan request on a solar home. Somewhat surprisingly, 37 percent of the respondents indicated that they presently consider life-cycle costs when evaluating mortgage loan requests.

7. Respondents felt that, on the average, a payback period (i.e., the time required to match operating savings with initial costs) of slightly more than eight years would be needed to economically justify a solar energy installation in a single family residence. However, financiers felt that an average initial solar system cost of 4-6 percent on a $30,000-$40,000 home (7-9 percent on $70,000 and above homes) was an acceptable percentage cost increase that would make solar energy systems attractive.

8. Differences of opinion exist concerning the impact of a solar system on the salability and loanability of a single family residence. A scenario, where a $5,500 solar system is added to a $50,000-$60,000 home, resulted in some respondents believing that

salability and loanability would be somewhat enhanced while others felt that salability and loanability would be somewhat reduced.

9. Incentives or subsidies may be necessary in order to achieve rapid near-term diffusion of solar systems in single family residences. However, based on a close scrutiny of the responses, there seems to exist some financier resistance to the use of incentives and subsidies to achieve near-term competitive equality for solar systems. Respondents supported research and development tax write-offs to manufacturers. On the other hand, financiers were particularly opposed to Federal government ownership of solar system production facilities.

At this time, solar heating and cooling systems are not economically competitive with conventional heating and air-conditioning systems. Initial solar system costs, as a percentage of the cost of a home, are above the cost increases deemed necessary by financiers to make solar systems attractive to owners of single family residences. Likewise, a payback period of approximately eight years does not seem to be presently feasible according to the Phase "O" studies by General Electric, TRW, and Westinghouse Electric. These facts and the findings of this study provide the basis for the following recommendations:

1. A system for educating financiers in the value of life-cycle cost concepts must be developed. A willingness by all financiers to consider life-cycle costs is necessary if solar energy systems are to be competitive with conventional heating and cooling systems in the future. Possibly much of the educational materials could be disseminated through the U. S. League of Savings Associations, the Mortgage Bankers Association of America, the National Association of Home Builders, and/or the Federal Home Loan Bank Board.

2. Test data need to be compiled and disseminated to financiers concerning the reliability, expected life, likely maintenance expenses, and possible leakage damages associated with solar systems. Such information would aid financiers in their decisions whether to finance single family residences equipped with solar heating and cooling systems.

3. Incentive and subsidy programs must be initiated by the Federal Government. Otherwise, we can expect solar energy diffusion to probably parallel the central air-conditioning experience in the U. S. A starting point might take the form of research and development tax write-offs to manufacturers and possibly property tax and Federal income tax concessions to purchasers.

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4. Further research on the potential benefit/cost trade-offs associated with various subsidy and incentive programs is needed. This would include identifying specific programs (and levels) that would provide for the recovery of initial solar energy system costs within an acceptable payback period.

APPENDIX 1. BRIEF DESCRIPTION OF SOLAR ENERGY CONCEPTS

SOLAR HEATING AND COOLING OF BUILDINGS

The future role of solar energy in heating and cooling buildings depends on a number of technological, economic, social, environmental, and institutional factors. This brief write-up focuses on current state-of-the-art concepts provided in a Ford Foundation study by Schoen and Weingart (November, 1973) and National Science Foundation studies by General Electric, TRW, and Westinghouse Electric (May, 1974).

I. Solar Energy Systems

Figure 1 contains a schematic diagram of a solar energy system utilizing a solar heated fluid and employing water heat storage. Both water heating and forced-air space heating capabilities are indicated, as well as an auxiliary or conventional back-up heating system.

The mounting of solar collectors on the roofs of single-family residences is consistent with current state-of-the-art developments. Architect renderings are available which show the ability to add solar collector panels to the roofs of traditionally designed residences and contemporary and vacation residences without altering the basic aesthetics. Figure 2 is an illustration of a residence of contemporary design with solar collector panels on the roof. This building is now under construction at Fort Collins, Colorado and will be both solar heated and cooled.

Two basic solar systems, given the current state-of-the-art, seem to offer the best near-term potential for use in single-family residences. One system would provide for solar heating (water and space) only. Such a system may or may not have a conventional compressor air-conditioning system added. A second basic system would provide both solar heating and cooling with the cooling function being provided by an absorption air-conditioning system.

Solar Heating Only

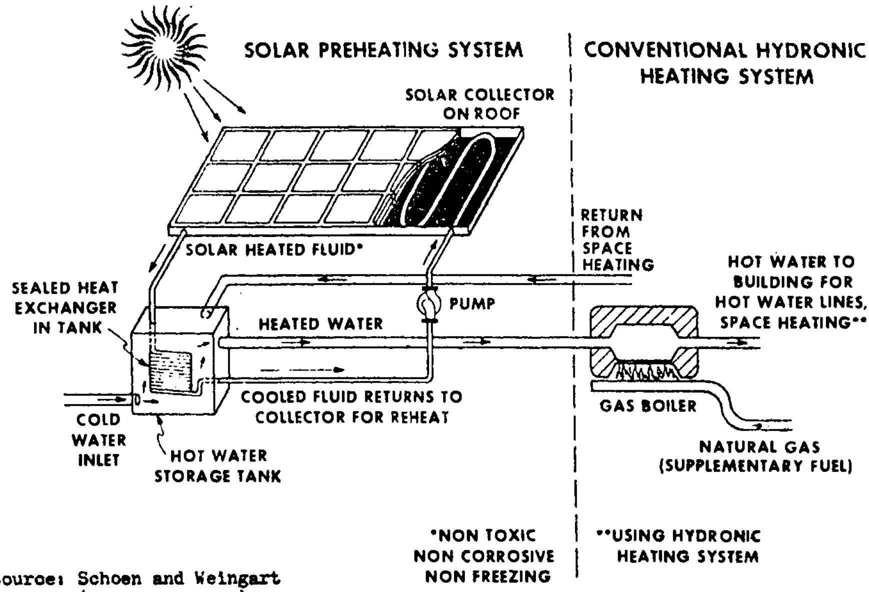
This would be the least complicated solar energy system. Figure 1 depicts such a system. In a solar heating only system, a choice exists between a system that utilizes air heating collectors and dry rock heat storage versus a system with water or other fluid heating collectors and water heat storage. At this point in time, it still remains to be determined which system will result in a lower cost-performance ratio.

An air system is not subject to possible fluid leakage problems. However, more power is generally required to move air through collectors and heat storage areas in contrast with the pumping of water. Air heating collectors also are somewhat less efficient than fluid heating collectors.

Solar Heating and Cooling (Absorption)

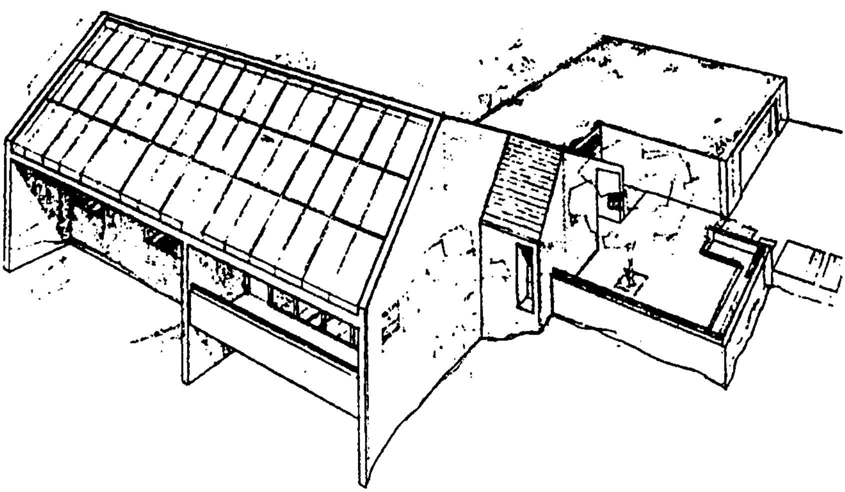
The use of solar energy to perform a cooling function is substantially more difficult than heating with solar energy. There is no available technology which permits an efficient use of solar energy to operate a conventional compressor air-conditioning system (i.e., there is no efficient method for converting solar energy to electricity to run an air-conditioner).

SOLAR ENERGY AND WATER HEATING/SPACE HEATING



Source: Schoen and Weingart (November, 1973)

Figure 1



Source: George Löf
Colorado State University

Figure 2

However, there exists substantial operating and manufacturing experience on the use of lithium bromide-water absorption air-conditioners. Such a system can utilize solar heat as a direct input in performing the air-conditioning function through an absorption process. Absorption air-conditioners, to date, have not been as successful as compressor air-conditioners because of higher costs and larger space requirements. They are, however, the most likely method for achieving solar cooling and may help produce cost economies through a more complete utilization of a solar energy system.

II. Solar Energy Economics

The economics of solar heating and cooling relative to conventional heating and cooling systems are uncertain at this point in time. This uncertainty will remain until substantial proof-of-concept-experiments have been conducted and evaluated.

Initial Costs

Flat plate collector panels are commercially available. The solar collector system will constitute the most expensive element of a total energy system. Additional initial costs will be incurred for piping and plumbing requirements and for a heat storage unit. A solar cooling system also would require additional initial costs for an absorption air-conditioner.

Operating and Maintenance Costs

Given the current state-of-the-art, it is a difficult task to try to estimate operating, repair, and maintenance expenses which will be associated with a solar energy system. Fuel costs will be lower under the solar system relative to a conventional system. However, at this time it is generally believed that maintenance expenditures will be relatively higher for the system utilizing solar energy.

Life-Cycle Costs

The relative costs involved in solar energy systems versus conventional heating and cooling (HVAC) systems can be placed in a clearer perspective when viewed on a life-cycle basis. That is, the higher costs associated with a solar energy installation will be offset, at least in part, by lower fuel costs over the life of the system. Critical to any life-cycle cost analysis are such factors as: 1) operating and maintenance cost "estimates" for a solar system; 2) the rate of increase in fuel costs for a conventional system; 3) the life expectancy of a solar system; and 4) the rate of discount which reflects the "time value of money."

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APPENDIX 2. QUESTIONNAIRE RESEARCH INSTRUMENT

Financial Institution Questionnaire

This questionnaire study is being conducted under a grant from the National Science Foundation. We are interested in the opinions and attitudes of people from financial institutions which are involved in the financing of single-family residences. On behalf of the National Science Foundation, we would appreciate your responses to the following questions.

1. Please check the type of institution you are employed by.

_____ Savings and Loan Association
_____ Mortgage Banking Firm
_____ Commercial Bank
_____ Mutual Savings Bank
_____ Other (please specify) ____________________

2. Please indicate:

a. Location of your institution (city and state) ____________________

b. Size of your institution (total assets of institution) ____________

3. Please indicate your present job position or title __________________

How many years have you been employed in the lending industry? _______

4. How knowledgeable are you about the solar heating and cooling of buildings? Please check one of the following descriptions:

_____ Have read numerous articles and/or other materials on solar energy.
_____ Have read some articles and/or other materials on solar energy.
_____ Have read only the materials attached to this questionnaire on solar energy.

5. In your opinion, in introducing solar heating/cooling systems in new construction, how would you rank the following structures on the basis of your industry's willingness to make loans on the solar energy systems? Please rank from 1 (highest preference) through 5 (lowest preference).

_____ A small office or professional building
_____ A single-family residence ($50,000 to $60,000)
_____ A condominium apartment
_____ A small apartment building
_____ A small industrial building

6. In your opinion is the idea of solar energy economics and technology feasible as an alternative energy source for the heating and cooling of single-family residences.... (check one)

_____ in the next 5 years
_____ 5 - 10 years
_____ 10 - 20 years
_____ beyond 20 years
_____ don't know

7. To what extent would the following factors be of concern to financial institutions' decisions to finance construction of single-family residences with solar heating/cooling systems? Circle the number which most closely represents your degree of concern with each of the following characteristics:

	Little Concern	Some Concern	Much Concern	Great Concern
a. expected life of solar equipment	1	2	3	4
b. fuel cost savings	1	2	3	4
c. maintenance expense	1	2	3	4
d. warranty coverage on solar equipment	1	2	3	4
e. reliability of solar system	1	2	3	4
f. damage due to water leaks	1	2	3	4
g. effect on salability of home	1	2	3	4
h. insurability of home	1	2	3	4

8. The installation of solar energy systems in single-family residences will require initial costs or expenditures above the costs for conventional HVAC systems. Assume that you have been asked to consider a mortgage loan request on a new single-family residence equipped with a solar heating and cooling system. How important would the following factors be to your decision? Circle the number which most closely represents your opinion concerning each factor. (Before rating each factor read down the list to form a tentative impression of their relative importance.)

	Little Importance	Some Importance	Much Importance	Great Importance
a. applicant's annual income	1	2	3	4
b. evidence on the expected life of the solar energy system	1	2	3	4
c. added initial cost of the solar system	1	2	3	4
d. life-cycle costs for the solar system	1	2	3	4

(continued on next page)

8. (continued)

	Little Importance	Some Importance	Much Importance	Great Importance
e. data on how well the solar system is expected to perform	1	2	3	4
f. data on the possibility of damage due to leakages, etc., in the system	1	2	3	4
g. educational information provided by national organizations (e.g., U. S. S & L League,. Mortgage Bankers Association, National Association of Home Builders, etc.)	1	2	3	4
h. real estate appraisers educated in solar energy concepts	1	2	3	4
i. additional PITI requirements due to solar installation	1	2	3	4

9. In order to make solar energy systems attractive to owners of single-family residences, what is your estimation of initial acceptable percentage cost increases? Please check the appropriate percentage increase for each price of home category.

	Single-family residences costing		
Acceptable percentage of added cost	$30,000 to $40,000	$50,000 to $60,000	$70,000 and above
1 - 3%	______	______	______
4 - 6	______	______	______
7 - 9	______	______	______
10 - 12	______	______	______
13 - 15	______	______	______
16 - 18	______	______	______
19 - 21	______	______	______

10. Solar energy systems require larger initial expenditures relative to conventional HVAC systems. Consequently, economic justification for a solar system rests on achieving lower operating costs (fuel cost savings adjusted for maintenance cost differences). This represents a life-cycle cost analysis. That is, larger initial outlays are offset by future savings.

A. In current practice, how important are life-cycle cost considerations in the mortgage loan decision process? That is, are heating and cooling costs important factors in mortgage loan decisions for single-family residences?

___never considered ___seldom considered ___always considered

B. In terms of solar energy installations, what would you consider the minimum annual fuel cost savings necessary to make solar energy systems attractive to owners of single-family residences? (check one)

Percent Savings	Percent Savings
___ 0-10%	___ 50-60%
___ 10-20%	___ 60-70%
___ 20-30%	___ 70-80%
___ 30-40%	___ 80-90%
___ 40-50%	___ 90-100%

C. One way of evaluating life-cycle costs is to determine the number of years it will take before savings from operation of the solar system will equal the initial cost of the system. In your opinion how fast would the payback (i.e., time required to match operating savings with initial costs) have to be in order to economically justify a solar energy installation in a single-family residence? (check one)

Number of years	Number of years
___ 1 year or less	___ 12 years
___ 2 years	___ 14 years
___ 4 years	___ 16 years
___ 6 years	___ 18 years
___ 8 years	___ 20 years
___ 10 years	___ over 20 years

11. All things considered, how do you believe the incorporation of solar heating and cooling in a $50,000 to $60,000 single-family residence will affect its salability and loanability if the solar installation costs $5,500?

a. its salability		b. its loanability	
Greatly enhance	___	Greatly enhance	___
Somewhat enhance	___	Somewhat enhance	___
Not affect	___	Not affect	___
Somewhat reduce	___	Somewhat reduce	___
Greatly reduce	___	Greatly reduce	___

12. In your opinion, how should the added costs of a solar energy system installed in a new single-family residence be financed? Please rank from 1 (highest preference) through 5 (lowest preference).

____ as part of the total mortgage loan (conventional, VA or FHA) on the home

____ under a separate second mortgage loan

____ with an FHA mortgage loan on the solar equipment

____ on an installment loan basis (similar to large appliances)

____ other (please specify) ______________________________

13. It has been suggested that in order to achieve an acceptable rate of diffusion of solar energy systems into single-family residences some form(s) of incentives or subsidies will be needed. These subsidies or incentives could be directed at a number of levels--manufacturers of solar energy systems, home builders, financing institutions, and consumers. In your opinion, at what levels would the best benefits (i.e., a greater rate of diffusion) be achieved relative to costs incurred. Please rank the four levels from 1 (highest benefit/cost expectation) through 4 (lowest benefit/cost expectation).

____ Manufacturers of solar equipment

____ Home builders

____ Financing institutions

____ Consumers or purchasers

14. In your opinion, if you were trying to stimulate the diffusion of solar energy systems, how would you evaluate each of the following factors as to its benefit/cost importance? Circle the number which most closely represents your opinion concerning each item. (Before rating each item, read down the list to form a tentative impression of their relative importance.)

	Little Importance	*Some Importance*	*Much Importance*	*Great Importance*
a. Federal government grants to manufacturers to encourage R&D in solar energy systems	1	2	3	4
b. Tax write-offs to manufacturers to encourage R&D in solar energy systems	1	2	3	4
c. Property tax exemptions and credits to purchasers of homes with solar energy systems	1	2	3	4

(continued on next page)

14. (continued)

	Little Importance	Some Importance	Much Importance	Great Importance
d. Federal income tax credits and/or deductions to purchasers of homes with solar energy systems	1	2	3	4
e. Government ownership of solar production facilities	1	2	3	4
f. Government-backed product warranty insurance	1	2	3	4
g. Joint industry/government-funded programs	1	2	3	4
h. Include solar energy installations under FHA Title 1 mortgage loans	1	2	3	4
i. Provide lower interest cost loans (relative to the going rate on homes using conventional HVAC systems) to purchasers of new homes with solar energy systems:				
1. Below-market interest rates on the total mortgage	1	2	3	4
2. Below-market interest rates only on the solar component	1	2	3	4
j. Involvement by the Federal Home Loan Bank Board and other governmental agencies:				
1. Provide below-market-rate funds to institutions making loans on homes with solar energy systems	1	2	3	4
2. Provide home mortgage purchase commitments to lenders making mortgage loans on homes with solar energy systems	1	2	3	4
k. Federal government subsidization of home builders through the absorption of solar energy system costs	1	2	3	4

THANK YOU FOR YOUR ASSISTANCE.

APPENDIX 3. TABULATED RESULTS OF QUESTIONNAIRES

1. Type of Institution:

	Number	Percent
Savings and Loan Associations (SL)	79	60.3
Other Financiers (OF)	52	39.7
Mortgage Banking Firms---19		
Commercial Banks --------18		
Mutual Savings Banks-----15		
Total	131	100.0

2a. Location of Institution:*

	Number SL	OF	Total	Percent
Northeast	16	18	34	26.0
South	26	11	37	28.2
Midwest (North Central)	26	10	36	27.5
West (including Southwest)	10	11	21	16.0
No Response	1	2	3	2.3
				100.0

*The classification of states by geographic region is presented in Appendix 4.

2b. Asset Size of Institution:

$Millions	Number SL	OF	Total	Percent
1-50	28	12	40	30.5
51-200	30	15	45	34.4
201 and over	21	18	39	29.8
No Response	0	7	7	5.3
				100.0

3a. Job Position or Title:

	Number SL	OF	Total	Percent
President*	39	11	50	38.2
Executive and Senior Vice Presidents	25	9	34	26.0
Vice President	7	13	20	15.3
Operating Officers	8	18	26	19.8
No Response	0	1	1	.8
				100.0

*Includes two savings and loan Board Chairmen.

3b. Years Employed in Lending Industry:

	Number SL	OF	Total	Percent
1-10	7	13	20	15.3
11-20	35	19	54	41.2
21-30	28	16	44	33.6
31 and over	8	3	11	8.4
No Response	1	1	2	1.5
				100.0

4. Knowledge about Solar Heating and Cooling of Buildings:

	Number			
	SL	OF	Total	Percent
Read Numerous Materials	3	1	4	3.1
Read Some Materials	61	41	102	77.9
Read Only Materials Attached to Questionnaire	15	10	25	19.1
				100.0

5. Preference for making Loans on Solar Energy Systems by Type of Structure:

Total Sample Preference	Small Office Building	Single Family Residence	Condominium Apartment	Small Apartment Building	Small Industrial Building
1 (highest)	20.6%	52.7%	3.1%	1.5%	9.9%
2	25.2	10.7	16.8	13.7	16.0
3	17.6	10.7	11.5	31.3	20.6
4	13.7	6.9	19.1	22.9	11.5
5 (lowest)	7.6	9.9	29.8	11.5	26.0
Incomplete Response	15.3	9.2	19.8	19.1	16.0

Number of Times Selected as Highest Preference

	Number			
	SL	OF	Total	Percent
Small Office Building	16	11	27	23.5
Single Family Residence	42	27	69	60.0
Condominium Apartment	0	4	4	3.5
Small Apartment Building	1	1	2	1.7
Small Industrial Building	7	6	13	11.3
			115	100.0

6. Likely Feasibility of Solar Systems for Single Family Residences:

	Number			
	SL	OF	Total	Percent
Within 5 years	19	6	25	19.1
5-10 years	44	24	68	51.9
10-20 years	8	6	14	10.7
21 and over	2	1	3	2.3
Don't Know	6	15	21	16.0
				100.0

7. Degree of Concern in Financing Solar Homes:

	Little Concern	Some Concern	Much Concern	Great Concern	No Response
a. expected life of solar equipment	2.3%	24.4%	41.2%	31.3%	.8%
b. fuel cost savings	6.1	26.0	38.9	26.7	2.3
c. maintenance expense	1.5	20.6	46.6	30.5	.8
d. warranty coverage on solar equipment	9.2	31.3	30.5	26.7	2.3
e. reliability of solar system	.8	3.8	26.7	67.2	1.5
f. damage due to water leaks	16.0	29.8	27.5	26.0	.8
g. effect on salability of home	3.8	15.3	24.4	55.7	.8
h. insurability of home	19.1	13.7	22.9	43.5	.8

Averages and Standard Deviations (in parentheses) for Each of the Factors
(Degree of Concern: Little=1; Some=2; Much=3; Great=4)

	SL	OF	Total
a.	2.94	3.16	3.02
	(.81)	(.81)	(.81)
b.	2.89	2.88	2.88
	(.91)	(.85)	(.88)
c.	3.05	3.10	3.07
	(.73)	(.81)	(.76)
d.	2.77	2.76	2.77
	(.98)	(.94)	(.96)

	SL	OF	Total
e.	3.64	3.61	3.63
	(.60)	(.60)	(.60)
f.	2.51	2.84	2.64
	(1.07)	(.97)	(1.04)
g.	3.17	3.59	3.33
	(.91)	(.75)	(.88)
h.	2.65	3.33	2.92
	(1.22)	(.93)	(1.16)

8. Degree of Importance in Considering Loan Requests on Solar Homes:

	Little Importance	Some Importance	Much Importance	Great Importance	No Response
a. applicant's annual income	6.1%	32.8%	33.6%	27.5%	0.0%
b. evidence on the expected life of the solar energy system	.8	12.2	47.3	39.7	0.0
c. added initial cost of the solar system	3.8	26.7	40.5	29.0	0.0
d. life-cycle costs for the solar system	1.5	22.9	45.8	29.0	0.0
e. data on how well the solar system is expected to perform	1.5	14.5	45.8	37.4	.8
f. data on the possibility of damage due to leakages, etc., in the system	3.1	41.2	37.4	17.6	.8
g. educational information provided by national organizations (e.g., U. S. S & L League, Mortgage Bankers Association, National Association of Home Builders, etc.)	12.2	42.0	29.8	14.5	1.5
h. real estate appraisers educated in solar energy concepts	7.6	29.8	39.7	21.4	1.5
i. additional PITI requirements due to solar installation	6.1	35.9	31.3	15.3	11.5

8. (continued)

Averages and Standard Deviations (in parentheses) for Each of the Factors
(Degree of Importance: Little=1; Some=2; Much=3; Great=4)

	SL	OF	Total		SL	OF	Total
a.	2.73	2.96	2.82	f.	2.56	2.92	2.70
	(.89)	(.93)	(.91)		(.81)	(.72)	(.79)
b.	3.22	3.33	3.26	g.	2.45	2.51	2.47
	(.75)	(.62)	(.70)		(.94)	(.83)	(.89)
c.	2.86	3.08	2.95	h.	2.74	2.78	2.76
	(.80)	(.90)	(.84)		(.86)	(.92)	(.88)
d.	2.98	3.14	3.04	i..	2.47	2.93	2.63
	(.78)	(.74)	(.77)		(.84)	(.79)	(.85)
e.	3.15	3.28	3.20				
	(.79)	(.67)	(.74)				

9. Acceptable Percentage of Added Cost Per Home for Solar System:

	$30,000-$40,000		$50,000-$60,000		$70,000 and Above	
	Number	Percent	Number	Percent	Number	Percent
1 - 3%	47	35.9	9	6.9	12	9.2
4 - 6	45	34.4	53	40.5	36	27.5
7 - 9	8	6.1	29	22.1	20	15.3
10 - 12	19	14.5	25	19.1	31	23.7
13 - 15	3	2.3	4	3.1	13	9.9
16 - 18	0	0.0	2	1.5	5	3.8
19 - 21	1	.8	0	0.0	4	3.1
No Response	8	6.1	9	6.9	10	7.6
		100.0		100.0		100.0

By Group	$30,000-$40,000 Number		$50,000-$60,000 Number		$70,000 and Above Number	
	SL	OF	SL	OF	SL	OF
1 - 3%	28	19	7	2	10	2
4 - 6	27	18	33	20	20	16
7 - 9	5	3	16	13	13	7
10 - 12	12	7	14	11	18	13
13 - 15	1	2	3	1	7	6
16 - 18	0	0	1	1	3	2
19 - 21	1	0	0	0	2	2
No Response	5	3	5	4	6	4

10a. Importance of Life-Cycle Costs in Current Mortgage Loan Decisions:

	Number			
	SL	OF	Total	Percent
Never Considered	4	7	11	8.4
Seldom Considered	49	22	71	54.2
Always Considered	26	22	48	36.6
No Response	0	1	1	.8
				100.0

b. Annual Fuel Cost Savings Necessary to make Solar Energy Attractive:*

	Number			
	SL	OF	Total	Percent
0 - 10%	0	0	0	0.0
10 - 20	19	9	28	21.4
20 - 30	29	23	52	39.7
30 - 40	9	7	16	12.2
40 - 50	8	2	10	7.6
50 - 60	4	6	10	7.6
60 - 70	2	0	2	1.5
70 - 80	1	0	1	.8
No Response	7	5	12	9.2
				100.0

*Several respondents indicated that their answers were highly dependent upon assumptions about fuel costs and initial solar costs. Thus, we caution the reader attempting to interpret this table.

c. Payback Period Necessary to Justify a Solar System:

	Number					Number			
Years	SL	OF	Total	Percent	Years	SL	OF	Total	Percent
1 or less	0	0	0	0.0	12	2	3	5	3.8
2	0	1	1	.8	14	2	1	3	2.3
4	10	6	16	12.2	16	0	0	0	0.0
6	19	19	38	29.0	18	0	0	0	0.0
8	11	7	18	13.7	20	3	1	4	3.1
10	30	11	41	31.3	Over 20*	1	0	1	.8
					No Response	1	3	4	3.1

*A value of 25 was used for purposes of computing averages. Average values were: total=8.31 years; savings and loan=8.71 years; other financiers=7.67 years.

11. Impact of Solar Systems on Salability and Loanability:

	a. Salability				b. Loanability			
			Number				Number	
	SL	OF	Total	Percent	SL	OF	Total	Percent
Greatly Enhance	7	4	11	8.4	3	0	3	2.3
Somewhat Enhance	33	21	54	41.2	32	20	52	39.7
Not Affect	5	6	11	8.4	22	14	36	27.5
Somewhat Reduce	28	15	43	32.8	17	13	30	22.9
Greatly Reduce	6	4	10	7.6	4	2	6	4.6
No Response	0	2	2	1.5	1	3	4	3.1

12. Preference for Financing Solar Systems on New Homes:

Number of Times Selected as Highest Preference

	SL	OF	Total	Percent
Part of Mortgage Loan	77	50	127	98.4
Second Mortgage Loan	0	0	0	0.0
FHA Mortgage Loan	1	0	1	.8
Installment Loan	0	1	1	.8
Other Method Specified*	0	0	0	0.0
			129	100.0

*Few respondents specified other methods, none were dominant in frequency, and all were ranked low in preference.

13. Preference for Directing Incentives or Subsidies at Specific Groups:

Total Sample Preference	Manufacturers	Home Builders	Financing Institutions	Purchasers
1 (highest)	36.6%	19.1%	3.8%	35.1%
2	15.3	41.2	6.9	19.8
3	20.6	19.8	19.1	24.4
4 (lowest)	15.3	4.6	52.7	11.5
Incomplete Response	12.2	15.3	17.6	9.2

Number of Times Selected as Highest Preference

	SL	OF	Total	Percent
Manufacturers	30	18	48	38.7
Home Builders	17	8	25	20.2
Financing Institutions	3	2	5	4.0
Purchasers	27	19	46	37.1
			124	100.0

14. Degree of Importance of Subsidy and Incentive Methods for Stimulating Solar Energy Diffusion:

	Little Importance	Some Importance	Much Importance	Great Importance	No Response
a. Federal government grants to manufacturers to encourage R&D in solar energy systems	16.8%	35.9%	24.4%	18.3%	4.6%
b. Tax write-offs to manufacturers to encourage R&D in solar energy systems	8.4	24.4	34.4	29.0	3.8
c. Property tax exemptions and credits to purchasers of homes with solar energy systems	23.7	22.1	26.0	22.9	5.3
d. Federal income tax credits and/or deductions to purchasers of homes with solar energy systems	18.3	32.1	32.1	14.5	3.1
e. Government ownership of solar production facilities	74.8	16.0	1.5	3.1	4.6
f. Government-backed product warranty insurance	29.8	32.8	20.6	14.5	2.3
g. Joint industry/government-funded programs	23.7	38.2	24.4	9.9	3.8
h. Include solar energy installations under FHA Title 1 mortgage loans	20.6	36.6	26.0	13.7	3.1
i. Provide lower interest cost loans (relative to the going rate on homes using conventional HVAC systems) to purchasers of new homes with solar energy systems:					
1. Below-market interest rates on the total mortgage	30.5	21.4	22.1	19.1	6.9

14. (continued)

	Little Importance	Some Importance	Much Importance	Great Importance	No Response
2. Below-market interest rates only on the solar component	41.2	29.8	18.3	4.6	6.1
j. Involvement by the Federal Home Loan Bank Board and other governmental agencies:					
1. Provide below-market-rate funds to institutions making loans on homes with solar energy systems	32.1	22.9	21.4	18.3	5.3
2. Provide home mortgage purchase commitments to lenders making mortgage loans on homes with solar energy systems	18.3	28.2	24.4	24.4	4.6
k. Federal government subsidization of home builders through the absorption of solar energy system costs	37.4	23.7	23.7	9.9	5.3

Averages and Standard Deviations (in parentheses) for Each Incentive or Subsidy
(Degree of Importance: Little=1; Some=2; Much=3; Great=4)

	SL	OF	Total		SL	OF	Total
a.	2.38	2.61	2.46	h.	2.32	2.38	2.34
	(1.00)	(.98)	(1.00)		(1.01)	(.91)	(.97)
b.	2.95	2.75	2.87	i. (1)	2.30	2.36	2.32
	(.94)	(.96)	(.95)		(1.14)	(1.15)	(1.14)
c.	2.47	2.57	2.51	i. (2)	1.86	1.84	1.85
	(1.14)	(1.08)	(1.12)		(.92)	(.88)	(.90)
d.	2.32	2.65	2.44	j. (1)	2.24	2.33	2.27
	(.93)	(1.00)	(.97)		(1.11)	(1.18)	(1.13)
e.	1.29	1.31	1.30	j. (2)	2.45	2.79	2.58
	(.67)	(.66)	(.66)		(1.11)	(.98)	(1.07)
f.	2.14	2.31	2.20	k.	2.00	2.17	2.07
	(1.05)	(1.03)	(1.04)		(1.02)	(1.06)	(1.03)
g.	2.12	2.38	2.21				
	(.94)	(.91)	(.93)				

APPENDIX 4. CLASSIFICATION OF STATES BY GEOGRAPHIC REGION

Northeast

1. Connecticut
2. Maine
3. Massachusetts
4. New Hampshire
5. New Jersey
6. New York
7. Pennsylvania
8. Rhode Island
9. Vermont

Midwest or North Central

1. Illinois
2. Indiana
3. Iowa
4. Kansas
5. Michigan
6. Minnesota
7. Missouri
8. Nebraska
9. North Dakota
10. Ohio
11. South Dakota
12. Wisconsin

South

1. Alabama
2. Arkansas
3. Delaware
4. (District of Columbia)
5. Florida
6. Georgia
7. Kentucky
8. Louisiana
9. Maryland
10. Mississippi
11. North Carolina
12. South Carolina
13. Tennessee
14. Virginia
15. West Virginia

West (Including Southwest)

1. Arizona
2. California
3. Colorado
4. Idaho
5. Montana
6. Nevada
7. New Mexico
8. Oklahoma
9. Oregon
10. Texas
11. Utah
12. Washington
13. Wyoming
14. Alaska
15. Hawaii

APPENDIX 5. QUESTIONNAIRE RESULTS BY GEOGRAPHIC REGION

Questionnaire Question Number	Average of Responses*				F-Ratio	Level of Significance
	Northeast	South	Midwest	West		
7a.	3.02	2.89	3.08	3.15	.547	.651
b.	2.88	2.69	3.03	2.95	.901	.443
c.	3.03	3.00	3.06	3.25	.501	.683
d.	2.85	2.47	2.78	3.15	2.335	.077
e.	3.65	3.61	3.56	3.75	.460	.710
f.	2.76	2.41	2.58	2.85	1.091	.356
g.	3.56	3.05	3.28	3.55	2.512	.062
h.	3.26	2.70	2.89	2.75	1.583	.197
8a.	2.97	2.70	2.69	2.90	.797	.498
b.	3.15	3.16	3.31	3.52	1.596	.194
c.	2.97	2.84	2.92	3.10	.440	.725
d.	2.82	2.86	3.19	3.29	2.855	.040
e.	3.21	3.11	3.17	3.38	.611	.609
f.	2.62	2.70	2.54	3.05	1.972	.122
g.	2.55	2.27	2.61	2.45	.981	.404
h.	2.74	2.59	2.77	3.05	1.166	.325
i.	2.77	2.56	2.56	2.74	.475	.700
14a.	2.61	2.38	2.41	2.35	.423	.737
b.	2.90	2.84	2.82	2.95	.102	.959
c.	2.52	2.36	2.74	2.40	.722	.541
d.	2.32	2.57	2.26	2.71	1.339	.265
e.	1.19	1.42	1.29	1.30	.666	.575
f.	2.19	2.38	2.00	2.24	.802	.495
g.	2.24	2.25	2.30	2.05	.338	.798
h.	2.16	2.30	2.35	2.62	.969	.410
i.(1)	2.03	2.51	2.29	2.33	.943	.422
i.(2)	1.93	2.03	1.62	1.81	1.285	.283
j.(1)	2.33	2.33	2.09	2.24	.353	.787
j.(2)	2.55	2.56	2.47	2.67	.143	.934
k.	2.13	2.11	2.09	1.76	.653	.583

*Responses could range from 1 (little concern or importance) to 4 (great concern or importance). The F-ratio tests for possible significant differences in mean across the four geographic regions. No variable was significant at the .01 level.

MATERIAL SUBMITTED FOR THE RECORD BY C. A. MORRISON, DIRECTOR OF RESEARCH, SOLAR ENERGY CONVERSION LABORATORY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLA., REFERRED TO IN HIS PREPARED STATEMENT FOLLOWS

SOLAR ENERGY CONVERSION RESEARCH & DEVELOPMENT AT THE UNIVERSITY OF FLORIDA

DR. ERICH A. FARBER, Professor & Research Professor of Mechanical Engineering and Director, Solar Energy & Energy Conversion Laboratory, University of Florida, Gainesville, FL 32601

Widespread concern with our energy situation and crisis, and what meeting the ever increasing demand of this energy does to the environment through pollution, prompted the writing of this paper. It presents the over-all activities of the Solar Energy & Energy Conversion Laboratory of the University of Florida rather than the technical details of one particular investigation.

The laboratory has looked into old methods of converting solar energy into the forms of energy needed, has used the present state of the art, and has pioneered in many areas of solar energy utilization.

It is obvious from all surveys and reports that we are using our fossil fuels at a tremendous and ever increasing rate so that in the not too distant future these supplies of energy, so vital to our present growth of civilization, will be depleted. For this reason it is of utmost importance that we look for other more permanent sources of energy and learn to use them before the dire need arises. Solar energy is readily available, well distributed, inexhaustible for all practical purposes, and has no pollution effects upon the environment when converted and utilized.

Our present usage of energy can be compared to a family or group living off their savings, stored in a bank, and being steadily depleted. This process cannot go on very long unless some "income" is added to the savings.

In the field of energy, the most abundant "income" is solar energy. This incoming energy was, usually in very in-efficient processes and over millions of years, converted into our fossil fuels. With these savings rapidly disappearing, we will have to learn to use this income directly in the form of radiant energy, by converting it into the forms of energy needed.

This conversion from solar energy into the desired forms should be done in the fewest possible steps and along the most direct route. This procedure will insure the most efficient way of doing this and will keep the equipment necessary simplest.

Solar energy has certain characteristics. It is intermittent, only available during the day in a particular location on the surface of the earth. In spectral character it approximates a black body source of about 10,000F, modified by gaseous layers of both the sun and the earth's atmosphere.

It arrives on the surface of the earth both as direct radiation and diffuse radiation. The former portion can be concentrated if it is desirable.

A knowledge of the specific properties of materials under solar irradiation will then allow the collection and/or concentration and absorption of this energy.

If night time operation or operation during bad weather conditions is necessary or desirable, storage has to be provided. For many applications this is not necessary. The energy could be stored in a conventional manner as potential energy (pumped water, etc.), as heat in hot water storage tanks or rock bins, as chemical energy utilizing chemical processes, latent heat or heat of fusion, etc.

In other words, the technology has been developed to convert and utilize solar energy. The economics and sociological acceptance has still to be worked out in many cases. These problems vary from region to region and therefore take on a local character to be worked out by the potential users.

To be most effective, local materials should be used in fabricating by local methods and labor fitting the economics and habits of the local civilization.

With this introduction of a general nature the paper will now go into some of the work done by one group. The best way to do this is to take you on a tour through the Solar Energy Laboratory of the University of Florida in the United States of America.

UF Solar Energy Laboratory

The University of Florida Solar Energy Laboratory is one of the largest laboratories of this kind and a tour through it will give an idea what such laboratories look like and the kind of work which is carried out in them. The work carried out at this laboratory is supported by work and persons all over the world and proper credit should be given to them. Fig. 1 presents the entrance, within the gate to the laboratory and two of the four buildings.

Stepping around these two buildings one can see some of the equipment of the laboratory which will be discussed in more detail in the paper and the following illustrations. Fig. 2 shows this equipment with engines of various types in the foreground, behind them collectors and concentrators of various types. On the left of the picture are a small solar air-conditioning system and two solar water heaters, a solar still and parabolic concentrators. Also visible are a solar power plant, a solar still, the solar furnace and solar calorimeter to investigate the solar properties of materials. In the background, partially visible, is a 5 ton solar air-conditioning piece of equipment.

Solar Properties

The first step in utilizing solar energy is to find materials which will withstand the exposure necessary in the equipment to be built. To do this we take some of these materials and expose them under rather realistic operating conditions to the weather and the sun. Fig. 3 shows different plastics exposed to the environment, stretched over cans which are filled with water or sand or wet soil, etc. If these materials deteriorate after a short time the investigation is terminated.

Those materials which, however, withstood this exposure test satisfactorily are then investigated in our Solar Calorimeter as to their reflection, absorption and transmission characteristics under actual solar irradiation.

The Solar Calorimeter, Fig. 4, can be oriented into any desired position; it can be made to follow the sun; it can simulate severe winter conditions or extreme summer environments. It is further instrumented with many, many thermocouples to be able to obtain complete heat balances. This instrument, the only one of its kind, is constantly used to investigate new types of materials such as

REPRINTED FROM FEBRUARY/MARCH ISSUE, BUILDING SYSTEMS DESIGN.

Fig. 1. Entrance to the University of Florida — Solar Energy Laboratory.

Fig. 3. Exposure test of some plastic films.

Fig. 2. View of some of the solar energy conversion equipment in the laboratory.

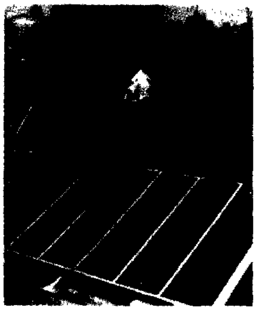


Fig. 6. Florida solar water heater.

Fig. 4. The solar calorimeter.

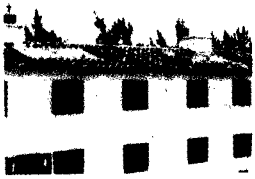


Fig. 7. Solar water heaters in apartment house.

Fig. 5. Experimental flat plate collectors.

Fig. 8. Swimming pool solar heater.

glasses with tinting or coatings, laminated glasses and plastic materials, venetian blinds, Thermopane windows, plastic bubbles for aircraft, fabric used for clothing, curtains and draperies, water cooled venetian blinds, etc.

With the properties determined, a selection can be made to obtain the best results in any desired application.

Solar Water Heating

In Fig. 5, five different flat plate collectors used for water heating are presented. They consist of a box with glass or plastic covers

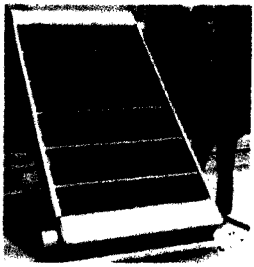


Fig. 9. Solar air heater.

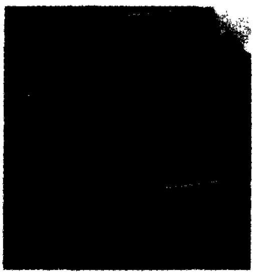


Fig. 10. Solar oven.

Fig. 11. Small solar still.

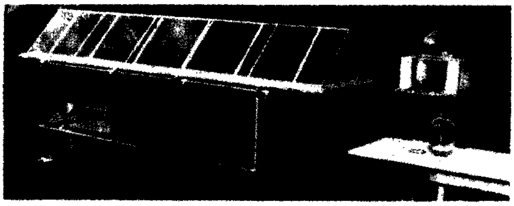


Fig. 12. Larger solar still, also able to collect rain water.

Fig. 13. Refrigerator, driven by solar energy.

Fig. 14. 5-ton solar air conditioning system.

Fig. 15. Small solar refrigeration system, front.

Fig. 16. Small solar refrigeration systems, back.

(one or more) with a metallic absorber element inside, which contains the water. This water is circulated to the small water storage tanks shown above. These absorbers can be compared with each other when exposed to the sun under identical conditions and for the same length of time.

Some of the absorbers have copper plates with copper tubes soldered into them, others are two flat plates riveted, crimped or welded together. The most efficient unit found consisted of two thin flat copper plates fastened together on the edges and providing a water space of about ¼ inch, with one glass cover and one inch of styrofoam insulation behind the plates. No plastic materials were found to be as good as glass since none of the ones we could find had the characteristics of glass, namely letting through the short wave radiation but not the long wave radiation. This characteristic of glass allows it to be used in the design of a solar trap.

Fig. 6 presents a typical Florida solar water heater. It consists of a sheet metal box, 4 feet by 12 feet, covered by a layer of glass. Inside the box is a copper sheet with copper tubes soldered to it in sinusoidal configuration and connected to an 80 gal. water storage tank. This system, rather common, is found satisfactory for a typical American family of 4 with automatic washing machine, etc. Under the copper sheet is one inch of styrofoam insulation. For satisfactory operation the bottom of the hot water storage tank must be above the top of the absorber to provide circulation without a pump.

Fig. 7 shows actual installations of this type in an apartment house in Florida with each apartment having its own unit to provide the needed hot water.

These standard units may be damaged if used in freezing temperatures and for this reason we developed a dual circulation system which eliminates this problem. It consists of two tanks, one inside the other. The outer tank, being connected to the collector, is filled with an antifreeze solution. The heat is then transferred from this solution through the wall of the inner tank to the water to be used. Since in this system the primary circuit operates at atmospheric conditions (the outer tank needs only a lid on it) the collector can be constructed much cheaper and lighter. For example, it may be patterned after the most efficient design mentioned earlier. Insulation covers the outside tank.

Swimming Pool Heating

Another type of heater which has interested many people in Florida is a swimming pool heater as shown in Fig. 8. It is one of the simplest ones and least expensive. It consists of a galvanized sheet, wrapped into plastic. The sheet is painted black (flat) like all the other absorbers. Water from the pool can be fed to these absorbers by the filter pump and then allowed to run down the front and back of the metal plate and drain back into the pool. It usually takes a collecting surface equal to the pool surface for raising the water temperature in the pool 10 degrees F. These absorbers can be constructed to form the fence around the pool which in many localities is required by law, and in addition can provide privacy.

House Heating

If the objective is to heat a house rather than water, it can be done by hot water circulated through baseboard pipes in a conventional hot water heating system. However, it is frequently more convenient or desirable to heat a building by hot air. Fig. 9 shows such an air heater, made up of overlapping aluminum plates, painted black on the portion exposed to the sun. About ⅓ of each plate is showing, the other ⅔ shaded by the plate above. They are put into a glass covered box. The air will enter this unit on the bottom and then, streaming between the hot plates, will pick up the heat and leave on top as hot air. The circulation can be produced either by free (or natural) circulation or by a fan.

All the above mentioned collectors are ideally facing South and inclined with the horizontal at an angle equal to the local geographic latitude plus 10 degrees. This gives a little higher collection efficiency during the winter when the days are shorter.

The air heater could be designed to form the wall of a building, let us say the East wall where it could produce hot air the first thing in the morning to take the chill out of the building the first part of the day.

Solar Baking

Another application can be a solar oven, Fig. 10, essentially a glass covered box facing into the sun. Cooking and baking temperatures can easily be reached with such a device. Periodic (about every 15 minutes) reorientation, due to the movement of the sun, is required. Flaps can be added as shown in Fig. 25 to provide some degree of concentration and thus bringing the things to be cooked up to temperature quicker. Very little heat is actually required for the cooking process, only a certain temperature for the required length of time. If one of these ovens is to be used in the late afternoon or early evening, the walls could be made thick, of clay or other materials which can store appreciable amounts of heat and thus remain warm long after the sun has gone down.

Solar Distillation

One of the major problems in many parts of the world is the lack of fresh water. Solar energy can, with very simple equipment, convert salt or brackish water into fresh and pure water. Fig. 11 shows a simple solar still, a metal box with slanting glass facing South. Inside the box is a pan on short legs, painted black and holding the bad water. The sun shining into this pan heats the water in the pan and vaporizes it. The vapor or steam then will, when coming in contact with the cold surfaces of the box, both the glass and the metal, condense, forming the fresh which runs down the sides in the form of droplets. This fresh water can then be collected for future use. About ½ lb. of water can be produced at an average per square foot per day.

Another larger still is shown in Fig. 12. The pan is covered by glass at about 45 degrees which forms most of the condensing surface. Glass is much better than plastic since it forms film condensation, letting the solar energy through without much difficulty. Plastics in general produce dropwise condensation, each droplet forming a little crystal which reflects much of the incident solar energy. This larger still is also designed to be able to collect rain water and, in some areas such as Florida, this can double the output of the still.

The best orientation of the still depends somewhat upon the angles of the glass but is generally East-West or somewhat NE-SW.

Solar Refrigeration and A/C

Another phase of our work is the use of solar energy for solar refrigeration and air-conditioning. At a number of international meetings it was pointed out that famine could be prevented in much of the world if the food which is raised during certain parts of the year could be preserved from spoilage, and thus preserved for use during the rest of the year. This requires refrigeration and for remote areas, or areas without electricity, solar refrigeration may well be the answer.

Some of our early work along these lines was to heat oil to rather high temperatures by concentrating solar energy and then circulating the hot oil around the generator of an ammonia absorption refrigeration system, Fig. 13. This picture is somewhat out of order since all the applications thus far dealt with solar energy in its natural state without concentration but it was put in here since it was actually our first attempt. We believe, however, that solar refrigeration without concentration holds much more promise since nonconcentrating devices can also utilize the diffuse portion of solar radiation, thus function even on cloudy days.

A number of small units were built before the 5-ton unit shown in Fig. 14. Flat plate collectors heat water which is then circulated to drive out the ammonia from the water in the generator of the system. This ammonia vapor is condensed and then expanded, providing the cooling effect by evaporation. After having done its work the ammonia vapor is reabsorbed, in the ammonia absorber of the system, into the water to repeat the cycle.

Figs. 15 and 16 show a smaller version of such a system with some improvements. The main one, combining the solar collector and the ammonia generator into one unit, eliminates the primary fluid and reduces the heat losses by providing a more direct path for the solar heat to get into the system and do its work. This small 4 x 4 foot unit can produce 80 lb. of ice on a good day.

It should be pointed out again that all the applications mentioned so far did not require concentration of solar energy, and therefore could utilize the diffuse portion of solar energy and work even on cloudy days.

The solar air-conditioning or refrigeration systems have an added advantage, that the demand and supply are in phase. When the sun shines hottest the need for refrigeration and air-conditioning is greatest.

Solar Energy Concentration

For some uses, however, higher temperatures than can be obtained with flat plate, non-concentrating collectors, are needed. If this is the case, then concentration is called for. Many different methods can be used for concentration, the simplest ones stationary in design but not as good, and the better ones requiring methods which allow them to follow the sun. Fig. 17 shows a simple high temperature absorber. It consists of a number of parabolic troughs oriented horizontally and with a pipe running down the focal line of the parabolas. The system of parabolic troughs is inclined at about the local latitude. Depending upon the diameter of the pipe, adjustment may or may not be needed during the year. The solar energy is reflected by the parabolic surfaces upon the focal pipe which, painted with a good absorbing paint (flat black), absorbs this energy and transmits it to the fluid inside the pipe. This device can easily produce hot water, steam or hot oil.

Some energy is lost during the early morning and the late afternoon hours with the above method of converting solar energy to heat because of shading, but the simplicity and stationary design have considerable advantages, both economically and because the units do not need much attention.

Solar Power Plant

If better efficiency is desired, then cylindrical parabolas can be used which are allowed to follow the sun. In the simplest form they can be made as shown in Fig. 18, a single parabola with a pipe at the focal line. This particular absorber is used to produce steam to operate a small steam engine, which in turn drives a small generator and lights up a light bulb, thus demonstrating what a solar power plant could look like. The 2 x 5 foot absorber is the equivalent of 500 watts of electrical heat.

A large cylindrical parabolic absorber is shown in Fig. 19 having dimensions of 6 x 8 feet with a glass covered focal tube. The glass cover reduces the losses from the heated tube. Depending upon the needs, different diameter tubes can be used. Copper has been found best, again painted with a good absorbing high temperature paint. This absorber is mounted on a rotating axis parallel to the earth's axis. It is adjusted to face East in the morning and then, by an electrically driven worm gear reduction unit, is made to follow the sun all day. Where electricity is not available, a heavy weight with a clock work timing unit can be used as well. The construcion of such a large device must be rather rigid since wind loads in windy areas may make it difficult to keep the unit directly facing the sun and to keep it from oscillating.

This unit has been used to produce steam for the operation of a fractional horsepower steam engine, to provide 800F oil to operate a solar refrigerator, etc.

Other methods of concentrating solar energy are lenses both of glass and other materials (including liquid lenses), but they are not widely used because of their cost in large sizes and their weight. However Fresnel lenses, specially made from plastic sheets, with grooves cut or embossed so as to focus the rays, can be produced rather inexpensively, are unbreakable, and can be of large size and light weight. The lens shown in Fig. 20 is of this type and can produce a temperature of 2000F.

A very effective way of concentrating solar energy is to take flat pieces of reflecting materials (for better results they can even be slightly curved) such as mirrors or reflecting metal surfaces, and orient them in such manner as to reflect the solar radiation on one spot. Front surface reflecting mirrors are giving better performance than, for instance, back silvered mirrors where some of the energy is absorbed in the glass. Very large concentrators of this type have been built with thousands of these mirrors used in some of the large solar furnaces in the world.

Solar Cooking

A few concentrating panels of this type are shown in Fig. 21, where three of them concentrated upon a board will make this board flash into fire. Such mirrors can also be set up in a different pattern like the one shown in Fig. 22 where the mirrors are set up into a circular pattern, heating the fluid in the jar at the focal region of the device.

If higher concentration, and thus higher temperatures, and smaller focal regions are desired, then either small mirrors are needed or continuously curved surfaces can be employed. In this manner excellent concentrating mirrors even of optical quality can be made but they are very expensive and there is a practical limit to the size of these configurations.

Two such mirrors of fair quality are shown in Fig. 23, the one on the left being strong enough to hold its shape by being properly formed, the one on the right being sup-

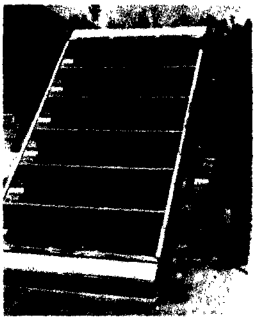


Fig. 17. Stationary high temperature absorber.

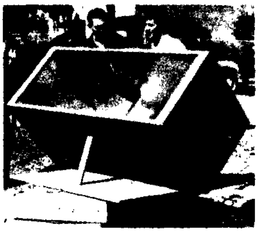


Fig. 18. Solar steam boiler of solar steam power plant.

Fig. 19. 6 x 8 cylindrical parabolic absorber.

Fig. 20. Plastic fresnel lens.

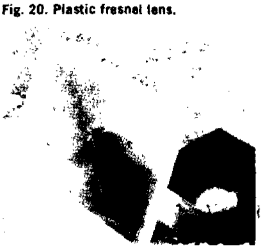


Fig. 21. Solar concentrating panels.

Fig. 22. Solar cooker.

Fig. 23. Parabolic solar concentrators.

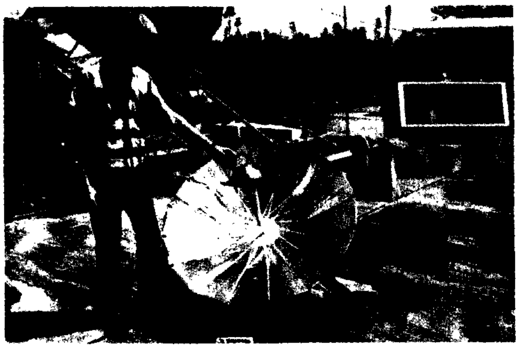


Fig. 24. Collapsible solar cooker.

Fig. 25. Solar oven and solar cooker.

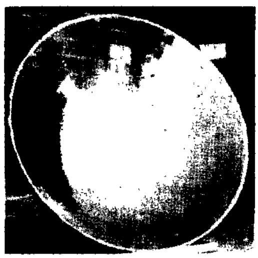


Fig. 26. Concentrating mirrors.

ported by ribs from wood in this case which are cut out forming parabolas. Then thin, highly reflecting metal sheets are held loosely to these ribs to allow for expansion when the metal sheets are slightly heated, thus avoiding distortion. This type of construction is especially important in large sizes. This type of construction was also used in the large parabolic cylindrical concentrator mentioned earlier.

The two concentrators of Fig. 23 were used as solar cookers where only a moderate amount of concentration is needed and too good a concentrator may burn holes into the containers used if great care is not taken. So, not-too-good quality is more desirable for this application.

If such concentrators are used for solar cooking, it may be desirable to design them for easy portability, thus either in sections which can be collapsed for moving, or of coated cloths of an umbrella design which can be folded when not in use. This type is shown in Fig. 24.

An oven and a cooker of moderate concentration are shown in Fig. 25. The flaps on the oven can be adjusted to regulate the degree of concentration needed. An oven of this design will shorten the cooking and baking time by bringing the food up to the desired temperature faster than the type mentioned earlier.

Higher concentrations than the surfaces previously discussed can provide is needed for high temperature work, solar engines, etc. For this purpose, the geometry has to be more perfect. Fig. 26 shows such a mirror of rather high quality giving high degrees of concentration, with the ultimate reached in the solar furnace, Fig. 27.

Solar Furnace

This solar furnace, with a 5 foot diameter mirror, can produce concentration ratios of almost 25,000 and temperatures of up to 7000 F.

Solar furnaces can be used for research where high temperatures and extremely pure, uncontaminated heat is needed. Materials can be enclosed in glass containers or plastic containers, surrounded by vacuum or any desired atmosphere and heated under very closely controlled conditions. Since the solar energy can be concentrated onto a very small region it is not necessary for the support of the sample to be able to withstand very high temperatures nor is it necessary for the glass or plastic container to be high-temperature resistent since the energy as it goes through this material is not yet concentrated to a high degree. See Fig. 28.

The furnace has been used to produce extremely high purity materials, to grow crystals of high temperature materials, Fig. 29, crystals non-existing in nature, to extract water from rocks and moisture-containing soils (work which may be of great importance when a Lunar station is going to be set up since many experts believe that the solar furnace will be an important tool on the moon), and it may be possible to produce materials on location instead of hauling them from the earth to the moon. We received a citation from the Air Force for this work, etc.

Mechanical Power

One of the largest programs in our laboratory is the conversion of solar energy into mechanical power. This is done by steam engines (one of them shown in Fig. 30) supplied with steam from the large cylindrical parabolic concentrator, Fig. 31. The combination shown will give about one quarter horse power, limited only by the concentrator and quantity of steam delivered by it.

A working model of a steam power plant is shown in Fig. 32, with the absorber and boiler shown from the front in Fig. 18, and the engine driving a generator and lighting up a small light bulb. The steam engine with a different type of absorber is also shown in Fig. 33. The small square boiler in this case must be used with the concentrators shown in Fig. 21. Other combinations and designs are possible and will work equally well, if designed properly.

We believe, however, that hot air engines have a much greater promise than steam engines for fractional horsepower requirements. They are safer, quiet and need only a source of heat, any source. These engines can be operated off solar energy during the day and, if power is needed during the night, by other sources of heat such as wood, coal, oil; or they can be operated by the heat produced from the burning of waste products such as trash, cow dung, etc.

Closed Cycle Hot Air Engines

There are two basic types of hot air engines. The closed cycle type encloses a certain amount of air which can be pushed back and forth by a plunger between hot and cold surfaces. When the air is in contact with the hot surfaces it is heated and thus increases the pressure in the engine and when in contact with the cold surfaces it is cooled, thus decreasing the pressure in the engine. A power piston is pushed down when the pressure in the engine is high and returns due to flywheel action when the pressure is low. So every down stroke is a power stroke. With proper timing of the power piston and the plunger, considerable amounts of energy can be produced.

These engines are inherrently slow-speed engines — a few hundred revolutions per minute — since it takes time to heat and cool the air. The heat transfer can be improved by either pressurizing the engine or filling it with gases such as hydrogen or helium. Also, a large surface regenerator will increase the performance of such engines but they become more complicated and much more expensive by such additions and refinements.

Fig. 34 shows a quarter horsepower engine with the displacer cylinder in horizontal position on top and the power cylinder directly underneath in vertical position. The blackened end of the displacement cylinder is heated and the other end cooled, in this case by a water jacket. Fig. 35 shows such an engine dis-assembled. The basic unit for this engine is a lawn mower engine but the engine itself is much simpler and less expensive since it does not require any valves, carburator or electrical system.

Another engine is shown in Fig. 36 in operation with a radiation shield around the hot end of the displacer cylinder. The concentrated solar energy can clearly be seen heating the end of the displacement cylinder. A five foot mirror is used with this engine which has to be moved about every 15 minutes to keep the energy concentrated on the engine. This movement is rather small and could be automated. Enough heat capacity is built into this engine so that if small clouds pass over the sun the engine will operate through the short intervals of shading.

These engines are not self starting and, after the engine surfaces are heated, must be given a push but will then take off on their own. This should be no handicap if compared with the attention a team of bullocks requires. A single man can operate a bank of these small engines, adjusting the mirrors periodically. In addition, no further land is needed as in the case when animals are used to raise the food they need.

Fig. 37 shows another one of the closed cycle hot air engines in operation and in Fig. 38 it is pumping water out of a ditch. The mirror shown with this engine is actually much better than needed but was used since it was available. It is an old mirror from the solar furnace which has been polished so many times that the reflecting surface is no longer very good. For engine operation the concentrator only has to be good enough to provide a spot of concentration of the size of the displacement cylinder of the engine, about 3½ inches in diameter for the engine shown.

A ½ horsepower engine, closed cycle, is shown in Fig. 39, which is designed to be used with solar energy and can be used directly without modification to burn wood, coal, or liquid fuels. If used with solar energy it is only necessary to open the big door shown and to concentrate the solar energy upon the end of the displacer cylinder inside the furnace box.

Open Cycle Hot Air Engines

The other type of hot air engine, the open cycle type, takes atmospheric air, compresses it, then heats it again by solar energy or other means and then expands the air and exhausts it into the open.

These engines have the advantage that the heating of the air and the speed of the engine are independent and so these engines can be made to run at much higher speed. This higher speed makes it possible to reduce the weight per unit power output but the engines so far built by us do not have as high conversion efficiency as the closed cycle engines. Fig. 40 shows one of these engines.

Both these types of hot air engines, but especially the closed cycle type, can be built without special equipment and with only the simplest types of machine tools. The timing for best performance is rather critical and should be adjusted carefully. Another critical parameter of the closed cycle engine is the clearance volume.

Our work was concentrated on fractional horsepower engines of the portable type which could be used for irrigation or to drive small machinery.

Solar Pump

There are other solar devices which can convert solar energy into mechanical energy but they are of less importance.

Fig. 41 shows a solar pump model, in this case made out of glass so that its operation can be observed. It has only two check valves and otherwise no moving parts. A boiler is connected by a straight and a U-shaped tube to a chamber with check valves at the inlet and outlet. The liquid in the boiler is vaporized, pushing liquid out of the system and, when the vapor reaches the bottom of the U tube, it suddenly streams into the other chamber filled with cold liquid where the steam rapidly condenses. While the steam is produced, the top check valve is open and liquid is pushed out. When the vapor condenses, the top check valve closes due to the vacuum produced and the bottom check valve opens, letting in more new liquid to be transported. This pulsating action can be smoothed into steady flow if an air chamber is provided past the top check valve.

Solar Turbine

Another method of converting solar energy into mechanical energy is by means of a turbine, a model of which is shown in Fig. 42 A vertical chamber with a turbine wheel in it is filled with a volatile liquid to just above the turbine wheel. The collecting surface has a cover with a small hole in the bottom of the chamber. The liquid will drain through this hole into the space below, will come in contact with the hot surface below and vaporize. The vapor will stream upward, forming a jet which, in turn, drives the turbine wheel. When leaving the turbine wheel it will come in contact with the cold surfaces of the upper part of the vertical chamber and condense, running down the walls and repeating the cycle.

For some applications it is more convenient to separate the steam generator from the turbine and the condenser.

Solar-Gravity Motor

Shifting of weights from one side to the other on a wheel or seesaw can do work. Fig. 42 shows a motor where a number of spheres, two at a time, are connected by tube and mounted on a wheel. The sun shining on one side will vaporize the liquid and the vapor streaming to the other side will condense. If properly designed, continuous motion can be obtained which can be used to pump water or do other useful work. The conversion efficiency and power output are rather small but may be sufficient for certain tasks.

Solar Reciprocating Engine

Fig. 44 shows another device for the conversion of solar energy into mechanical energy. It consists essentially of a column of water with bellows at the top. The system is completely purged of air. The end of the tube is heated by concentrating solar energy upon it or any other concentrated source of heat. This will vaporize the water on the end of the tube and force the column of water to the right, as shown in the picture. With vapor now in contact with the hot surface, the heat transfer is suddenly decreased tremendously and so the cooling effects are now greater than the heating and the vapor condenses, letting the column of water return to the left until it touches the hot end and the cycle repeats. Cooling of the lower end of the column of water will improve the performance. The moving column will make the end of the bellows move back and forth. This reciprocating motion can be coupled to a flywheel and transformed into rotary motion. This very simple little device is quite noisy, sounding like a small gasoline engine and can, by adjusting the pressure on the end of the bellows be made to run at different speeds, several hundred cycles per minute if desired.

Conversion to Electricity

If electricity is desired as the form of energy to be used it can be produced by converting solar energy into mechanical energy and then driving a conventional electric generator. More conveniently, the solar energy can be converted directly into electricity by one of the many solid state devices normally referred to as solar cells. Through the space program, great strides have been made in the photogalvanic conversion field utilizing silicon as the most common material. Two photogalvanic converters are shown, Figs. 45 and 46.

Thermoelectric conversion has also been investigated in our laboratory, using certain semiconductor materials as super thermocouples, as well as thermionic conversion, but not a great deal of effort was spent in these areas.

Sewage Treatment

Another project of interest is application of solar energy to sewage treatment. One phase of this work provided solar heating for sewage digesters. By heating these digesters and controlling the temperature for optimum efficiency, considerably more sewage can be

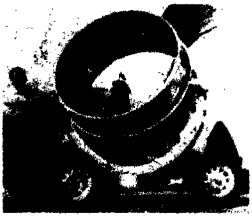


Fig. 27. 5-foot solar furnace.

Fig. 28. Calcium oxide target irradiated in solar furnace.

Fig. 29. Calcium oxide crystal.

Fig. 30. Small steam engine.

Fig. 31. Steam engine operated by solar energy (¼ horsepower).

Fig. 32. Solar steam power plant (see also Fig. 18).

Fig. 33. Solar steam power plant (see also Fig. 21).

Fig. 34. ¼ horsepower closed cycle hot air engine.

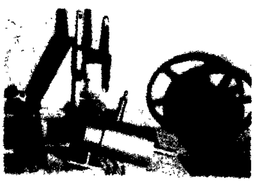


Fig. 35. Dis-assembled closed cycle hot air engine.

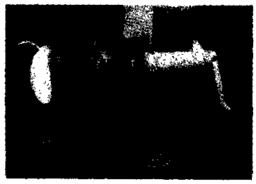


Fig. 36. Hot air engine operated by solar energy.

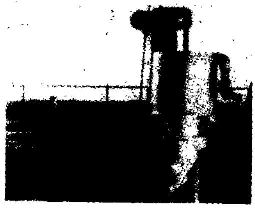


Fig. 37. 1/3-horsepower closed cycle hot air engine.

Fig. 38. Pumping water with solar energy.

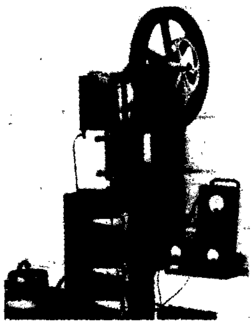


Fig. 39. ½-horsepower closed cycle hot air engine.

Fig. 40. Open cycle hot air engine.

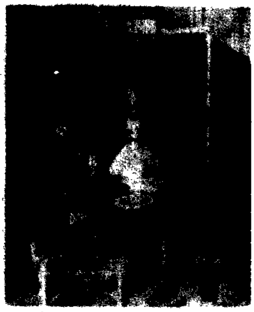


Fig. 41. Solar pump.

Fig. 42. Solar turbine.

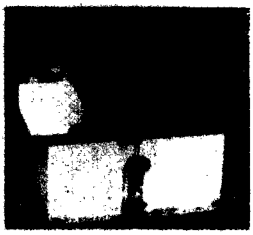
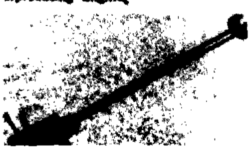


Fig. 43. Solar-gravity motor.

Fig. 44. Solar Thermo-Phase Shift Reciprocating Engine.



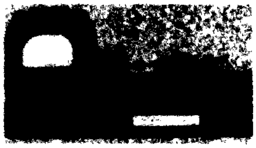


Fig. 45. Solar cells.

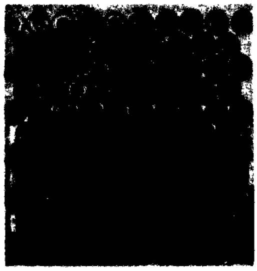


Fig. 46. Solar cells.

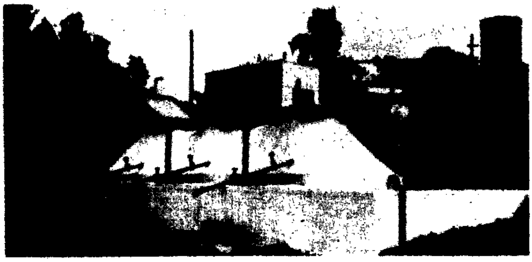
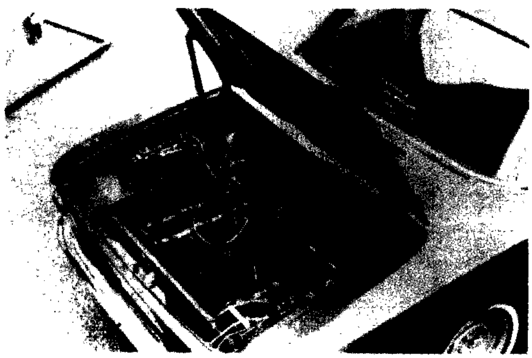


Fig. 47. Sewage digesters heated by solar energy.

Fig. 48. The solar electric car.

Fig. 49 (below) Solar electric car engine compartment.



handled by a given size plant. Many plants buy very expensive covers and collect the sewage gas and then burn it to heat the fluid in the digesters. Many of these plants even buy fuel and all this becomes a very expensive operation. Solar heating of these digesters proved relatively inexpensive by being able to use plastic sheets glued together to form an air mattress type cover floated on top of the digester. This in many cases provided enough of a solar trap to keep the digester at good operating temperatures in our region. As a matter of fact, one winter with rather severe and prolonged freezes, all the bacteria in the unheated digesters died and action stopped completely until they were restocked. During this same period the solar heated digesters survived and the bacterial action, even though slowed down during the extreme cold spells, picked right up again when the temperature of the digesters increased. The basic problem of heating here is the same as for swimming pools.

If the digester is designed more like a solar still, fresh water can be produced by distillation in addition to the digestion process, and the remaining sludge used for fertilization.

Transportation

The Solar Energy and Energy Conversion Laboratory has a solar-electric car which one of the staff members drives to work regularly under high traffic density conditions to obtain operating and performance data. This car, Fig. 48, has both NiCd and Pb acid batteries, Fig. 49. These batteries can be charged by converting solar energy either by solar cells or by a solar engine-generator system. The above with a 27 horsepower, 30 lb. motor can propel the car at 65 mph on a level road and gives it, under proper driving conditions, a range of over 100 miles. Special batteries already developed could increase the range fivefold.

If solar battery charging stations were set up like our present gasoline stations, where run-down batteries could be exchanged for charged ones, a truly energy-free and non polluting transportation system could be provided.

The Solar House

The University of Florida Solar House, Figs. 50 and 51, was built about 18 years ago to make it possible to put to use the devices and systems developed in our Solar

Fig. 50. The Solar House (east side).

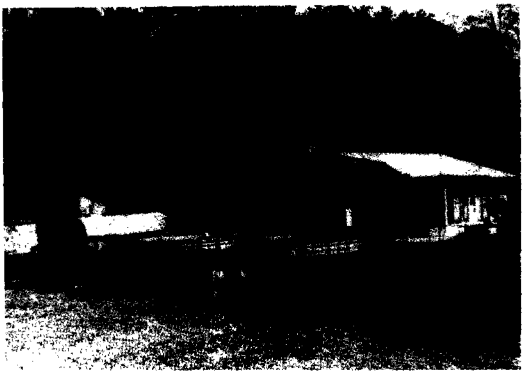


Fig. 51. The Solar House (west side).

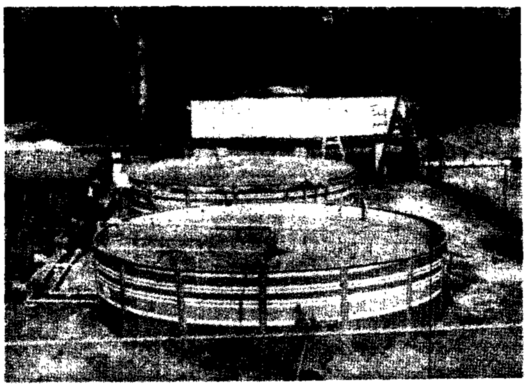


Fig. 52. Solar heated swimming pool.

Energy and Energy Conversion Laboratory. To form a data base for comparison, the house was first heated and cooled by a number of conventional methods with all modern conveniences provided. A graduate student couple always lived in the house so that all data were taken under actual occupancy conditions. Then the house was converted, step-by-step, into a solar house. After some of the equipment, such as the solar water heater, was installed, great interest was shown by visitors who wanted to see everything. Therefore, it was decided to set the solar equipment next to the house in clear view rather than hide it on the roof or underground, so that everyone could see what it looks like.

This house uses solar energy for more things than any other house. It has its domestic hot water provided by the sun, is heated by the sun, has a solar heated swimming pool, Fig. 52, has some of its liquid waste recycled to fresh water by the sun, Fig. 53, has some electricity generated by the sun to operate some lights, television, radio, and some small appliances, Fig. 54, and has the solar electric car. An air-conditioning system, similar to the ones designed, built and tested in the laboratory, is under construction to be put into the house soon. A solar stove and oven, looking somewhat like an electric range, is under construction. It will use hot oil in its coils rather than electricity. This allows cooking throughout the 24 hour day. Eventually, all energy requirements will be met by converting solar energy into the various forms needed.

The study of all the systems which have been and are used in this house allows a realistic comparison of solar systems with conventional systems, on both technical and economic bases.

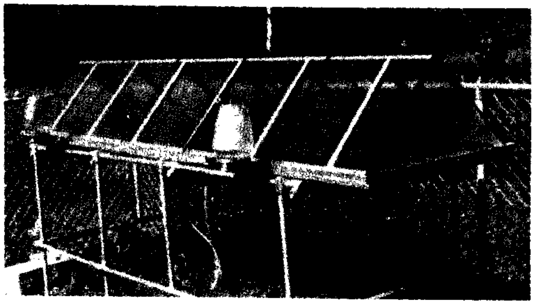


Fig. 53. Liquid waste recycling system.

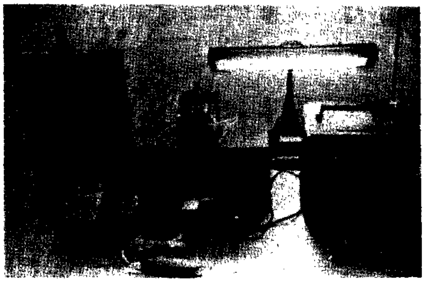


Fig. 54. Solar to electricity conversion unit.

Conclusion

The above discussion with a number of illustrations (we believe that pictures can tell a story much better) covers much of our work but by no means all of it. It presents the range of activities in our laboratory.

When solar energy utilization is contemplated, its availability and amount of supply, the requirements, the availability of materials and labor, as well as the economic considerations should be analyzed on a regional or local basis since large variations can occur from place to place on a global scale. The devices discussed and shown have different degrees of applicability in different areas.

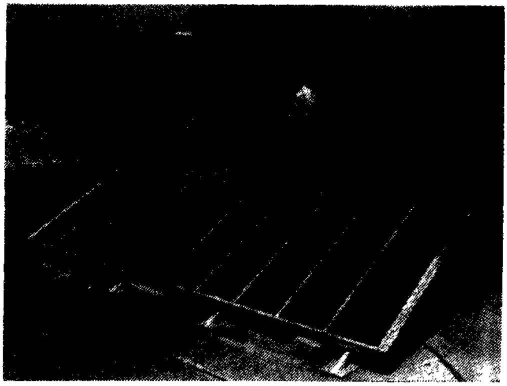
As an example, we recommended that an Army Post in Chile spread steel pipes on the sandy ground and hook them together into a number of parallel circuits to provide the hot water they needed. They had steel pipe, the labor and the sandy land. To recommend to them the Florida type solar water heater would have been the wrong thing to do since they did not have copper sheets, copper pipes and hot water storage tanks. Their problem was solved with local materials, under local conditions, and produced the desired results.

In closing I would say that solar energy, its conversion and utilization, will not solve all our problems, but it will be a great step in the right direction, by supplying needed energy wherever it can, without having adverse effects upon the environment and at the same time conserving our fossil fuels which can do much more for us than provide heat. The chemicals they contain can be used as preservatives, in medication, etc., so that the indiscriminate use of these resources for energy is unwise and a serious loss to future generations.

Acknowledgements

The Solar Energy and Energy Conversion Laboratory of the University of Florida was used as the basis for this paper but credit must be given to the many laboratories around the world and individuals who are engaged in the effort to utilize solar energy for the betterment of mankind. Their work supports ours through ideas and results as our work is helpful to them.

Thanks must be given to the faculty, students and staff of our laboratory who have over the years had an important part in advancing the state of the art of solar energy utilization and who have provided knowledge and results for others to build on. ΔΔΔ



SOLAR WATER HEATING

Dr. E.A. Farber
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Water can be heated by solar energy by many different methods, varying from the very simple to the very sophisticated, expensive, but more efficient.

One of the simplest methods is to take a tank and set it in the sun, or a pipe, or a garden hose spread out on the ground with the sun shining on it. It will provide very hot water in a relatively short time.

The more common method used in the United States is a flat plate collector which consists of a box which can be either wood or metal with a metal sheet inside to which tubes are soldered in sinusoidal arrangements spaced about four to six inches apart. The tubes are usually from 4" to 6" apart. The tubes are usually from 3/4" to 1" in diameter and there must be thermal contact between the plate and the tube. This is important so that the heat which is absorbed by the plate can easily flow to the tube and through the tube into the water. The tube-plate arrangement is painted with a good absorbing paint, usually commercial flat blacks are satisfactory.

The tube-plate arrangement is supported by point supports to reduce the heat losses and has either about one inch air space between it and the back of the box or has one or two inches of insulation in the box.

The box is covered by one or two layers of glass, depending on whether it is used in southern or more northern climates. It is important to reduce the heat losses further north. The glass should be one with low iron content which can be determined by looking at the cutting edge which should be colorless or light bluish and not green which indicates high iron content. Plastic sheets can be used instead of glass but do not have the trapping properties of glass meaning that the short wave radiation from the sun penetrates very readily while the long wave radiation given off by the hot surfaces does not. Also, plastics usually do not last as long due to the ultraviolet effect, the elevated temperature and the wind flexing.

In climates where freezing is not a problem, this collector can be coupled to the tank which contains the domestic hot water. If the tank is two feet or more above the collector, free circulation will take place and no pump is required. In many instances with the collector on the roof, the water tank protrudes through the roof and is camouflaged as a chimney. If it is, however, desirable to have the tank lower than the absorber, a small very inexpensive circulating pump is required. In freezing climates draining or a dual circulation system is required which means that the absorber is coupled to an outer tank which can have a lid and is insulated. The service hot water tank is submerged inside the outer tank. The right amount of anti-freeze is added to the water in the outer tank so as to prevent freezing for the particular, local, climatic conditions.

SOLAR WATER HEATING

The usual dimensions for a single family dwelling is four feet by twelve feet for the collector, and about a one hundred gallon service water tank. It is advisable to install a small electric booster, somewhat like a four thousand watt coil, thermostatically controlled so whenever the sun is unable to provide all the hot water needed in the house, a few times during the year, this booster can provide the difference.

Thousands of these solar water heaters have been operating very satisfactorily in the United States and millions of them around the world, and if properly designed, they will give very satisfactory results. Some studies made by our laboratory indicated that the break even point in the cost of the hot water is about two years. From then on the hot water provided by solar energy is free while other systems will have to be supplied with fuel.

The solar water heater or flat plate collector should be oriented facing south and inclined with a horizontal at an angle equal to the latitude plus 10 degrees. In this manner the collector will be more favorably oriented in the winter when the days are shorter and less favorably in the summer when the days are longer. In this manner it will collect about the same amount of energy all year around.

Some solar water heater installations have been in operation in the United States for over forty years.

SOLAR COOKING AND BAKING

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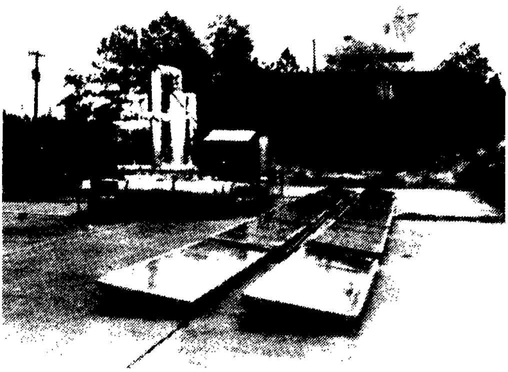
A number of different methods are available to use solar energy to provide the temperatures which are required for cooking and baking. One of the simplest things is taking a box which is insulated and has a single or double glass on one of its sides. When this side is pointed towards the sun, baking temperatures of several hundred degrees F can be reached inside that box. It can be used exactly like an oven in an otherwise heated stove. If the walls are made out of material which can store energy, the stove can be set out into the sun and absorbing energy all day, storing it in the walls, allowing cooking or baking for several hours after the sun has gone down.

Another method for cooking is through the use of a concentrator which can be a dish covered with reflecting surfaces such as a mirror, or even an umbrella covered with aluminum foil which will concentrate the solar radiation falling upon it onto a container which holds the food to be heated. A collector of this type of three to four feet in diameter will be able to prepare meals in the same time as another stove or oven. If the cooker is made out of an umbrella, it can be folded away when not in use, or could even be used as an umbrella when the sun does not shine.

The two types of systems, the oven and the cooker, described above can only be used outdoors. However, a third method by which oil, for instance, is heated in a concentrating type collector to very high temperatures of, 800 to 900 degrees F, can then be stored in a well insulated tank. A solar stove and oven, looking somewhat like an electric range, can be used twenty-four hours to do the cooking by circulating hot oil through the coils on the stove and in the oven instead of electricity. By controlling the amount of oil circulating through the coils, the temperature which is desired can be obtained.

A number of other methods similar to the ones described above, can be used for cooking or baking with solar energy.



SOLAR AIR CONDITIONING

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Gainesville, Florida 32611

A number of methods are available to provide solar air conditioning for a home or larger building.

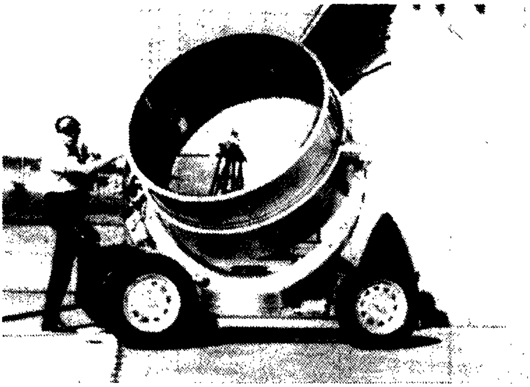
Solar energy can be converted to mechanical energy and then used to drive a compressor in the conventional compression refrigeration or air conditioning system. Solar energy can be used to provide steam and then use steam jet refrigeration or air conditioning. It seems, however, most promising to use the absorption refrigeration method.

In compression refrigeration only one component, namely the refrigerant, is used; thus, the system consists of a compressor, a condenser, an expansion valve and an evaporator where the actual cooling is done. By using two components, refrigerant and absorber, the compressor, which takes a considerable amount of mechanical or high cost energy, can be replaced by a small pump and a source of heat. Thus, a gas refrigerator or air conditioning system uses a gas flame and only a small circulating pump which requires negligible amount of energy to drive. Basically, the absorber liquid is the carrier for the refrigerant from low pressure to high pressure by absorbing at low temperature and then being pumped to high pressure and when heated giving off the refrigerant again. So by replacing the compressor in a single component system by an absorber, a pump, a generator and a heat source, the same effects are produced as with the compressor. If a three component system is used; then even the pump can be eliminated and only a heat source is required. Gas refrigerators are usually of this type, have no moving parts and require only a single source of heat. Our system for solar air conditioning is basically the same as a gas air conditioning or refrigeration system, but for the gas or oil flame, hot water is substituted.

Therefore, the solar system, which provides the domestic hot water and hot water for heating the house in the winter, can be used in the summer to provide the hot water to operate the air conditioning system.

Solar air conditioning has many things in its favor. One of the most important ones is that when the sun shines hotter, more air conditioning is required, thus the supply of energy to operate the system is in phase with the demand made on the system. Furthermore, the collectors which are usually placed on the roof of the house will actually shade the roof, thus requiring less air conditioning by intercepting the energy and not letting it get through the roof and into the house.

From this very brief description it can be seen that the ideal system is a solar system which provides hot water, heat for the house in the winter, and air conditioning for the house in the summer. In this manner, the same solar system is used all year around. The collectors can even be used for heating the swimming pool.



SOLAR FURNACES

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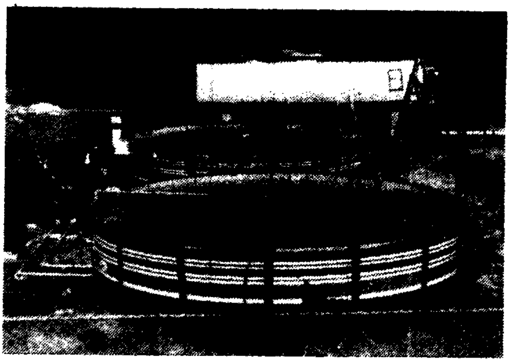
For many purposes pure heat and high temperatures are needed and for this purpose solar energy can be concentrated by either lenses or mirrors to produce these very high temperatures.

Equipment to do this is usually referred to as solar furnaces. The concentration can be provided by a large number of mirrors which reflect the sun on the same spot. The largest furnaces in France have been constructed in this particular manner. Smaller ones can be designed as continuous surfaces such as parabolic dishes as the ones shown in this particular picture. The sun shines into this mirror and is reflected onto a small target giving up to 25,000 times normal sunshine.

The target of the solar furnace can be supported by a relatively low temperature melting material and can be surrounded by a glass or plastic sphere. The solar radiation when it penetrates the glass sphere is not highly concentrated and, therefore, does not damage the glass due to high temperature, but heats the target to melting or vaporization temperatures. Temperatures which will melt and vaporize all known materials can be reached in this manner.

Our solar furnace has been used to extract water from rocks by vaporization and then selective condensation. It has also been used to produce high temperature crystals non-existing in nature. Thus, a solar furnace can be a very valuable research tool or it can be like the large furnaces in France, equipment which commercially produces tons of very highly purified materials needed by industry.



SWIMMING POOL HEATING

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Heating of swimming pools is an expensive proposition since swimming pools contain tremendous amounts of water, and thus, require very large amounts of heat to do the job. Swimming pools can be heated by means of solar energy over a period of years cheaper than by any other means; however, the initial equipment is still expensive except for one of the very simple methods.

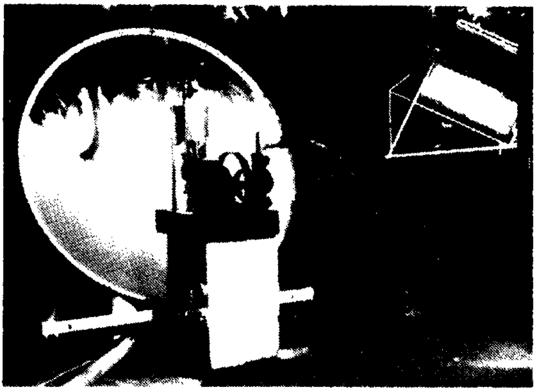
If a swimming pool, and it can be an olympic size swimming pool, is in the sun, then a relatively inexpensive method is to take a plastic transparent sheet and float it on the surface of the pool so that no air bubbles are trapped below the plastic. If air bubbles are under the plastic, droplets will collect on the plastic and act as little reflectors preventing the solar energy from penetrating into the water. By this relatively simple method, the average pool temperature will be increased by 10°F.

Other methods of heating swimming pools become more expensive. Large surfaces, roofs, etc., can be used to circulate the water and let it trickle down the surface which is heated by the sun. The warming water drains back into the pool. Concrete surfaces or slabs can be used for this purpose or metal sheets exposed to the sun which can be the fence around the pool to provide both solar heating for the pool and privacy for the swimmers. Fences in many areas are required by ordinance to be put around swimming pools, thus, the fence which at the same time is a solar collector will give the heating for the pool at a relatively low additional cost.

For each collector surface about equal to the pool surface area a 10 degree F temperature rise in the average temperature of the pool can be expected.

More sophisticated and more efficient solar collectors can be designed and used but their cost can hardly be justified unless these same collectors are also used for heating the house, heating the water, and possibly solar air conditioning.

The collectors for swimming pool heating can be made of plastic, however, it must be realized that the life of such systems will be shorter than the properly designed metallic equivalents.



SOLAR ENGINES

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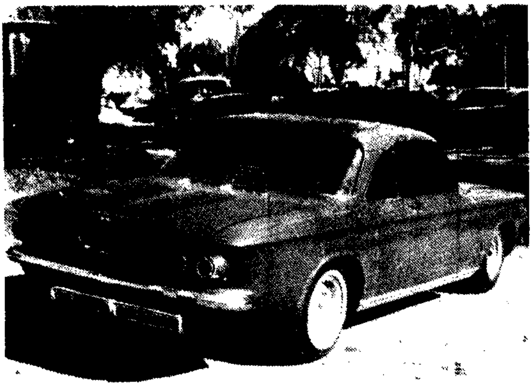
If mechanical energy is the end result required, solar energy can be converted to this form of energy by many different methods. Some of these methods utilize solar energy directly as it comes in, others require first concentration to obtain higher temperatures. The use of solar energy without concentration allows the utilization of the diffused radiation as well as the direct radiation it makes it possible to operate these engines even on cloudy days.

One method of converting solar energy to mechanical energy is to heat liquids to high enough temperatures to produce vapor and then use the vapor to operate steam engines or steam turbines. Depending upon the liquid used concentration may be necessary such as for water or if other liquids such as Freons are used flat plate collectors can be utilized.

If concentration of solar energy is available then hot air engines or hot gas engines of the sterling type can be operated. They fall into two classes, the closed cycle and the open cycle type engine. In the closed cycle engine the air or gas is contained in a power cylinder and a displacer cylinder. The air is shifted back and forth in the displacer cyclinder between hot and cold surfaces thus being heated and then cooled during each cycle. This builds up the pressure during the power stroke and lowers it when the fly wheel returns the piston to the upper dead center. In the open cycle engine the air is taken-in, compressed, then heated and exhausted through the engine. The advantage of the open cycle engine is that the heating rate and the speed of the engine are independent. However the closed cycle engines which we have built had a higher conversion efficiency of about 10%.

Other engines working on different principals have been built such as pumps, gravity engines, phase shift engines, etc.

All the engines mentioned above can be operated off any source of heat thus could be operated during the day from solar energy and if required during the night from other fuel sources.



SOLAR ELECTRIC TRANSPORTATION

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Gainesville, Florida 32611

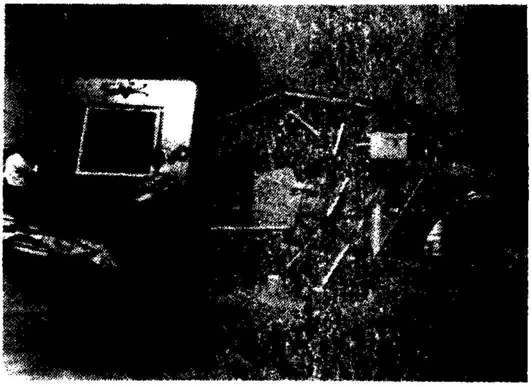
Since the philosophy of our laboratory has been to develop and demonstrate that solar energy can be converted to all forms of energy which we use in our daily life, a solar electric car has been built. This car has been designed to meet open road and urban traffic conditions. It is basically an electric car the batteries of which can be charged by electricity converted from solar energy.

The solar electric car is a converted Corvair with the engine replaced by a 27 horsepower surplus aircraft generator. Various batteries have been used in the past such as nickel cadmium and lead acid types. The car as shown above can operate at 65 mph and has a range of about 100 miles. Different batteries which are presently available on the market can extend this range considerably.

The switching of the voltage is controlled by the accelerator and the changing of the field excitation at the same time gives the car a smooth operation. The motor which propels the car is used as a generator when the car is slowing down thus feeding some energy back into the batteries. When the car is stopped at a stop light or in traffic, no energy is consumed from the batteries.

Dr. Schaeper, one of our staff members, drives this car as any other car would be operated to obtain in-traffic performance data.

Cars and trucks and buses similar to this one coupled with a network of solar battery charging stations instead of gasoline stations could provide a nationwide energy free and pollution free transportation system. Driving along when the batteries become discharged, you could drive your car into one of these solar battery charging stations and have the car's batteries replaced for charged ones. This should not take any longer than having the gasoline tank filled.



SOLAR PROPERTIES OF MATERIALS

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Energy Conversion Laboratory

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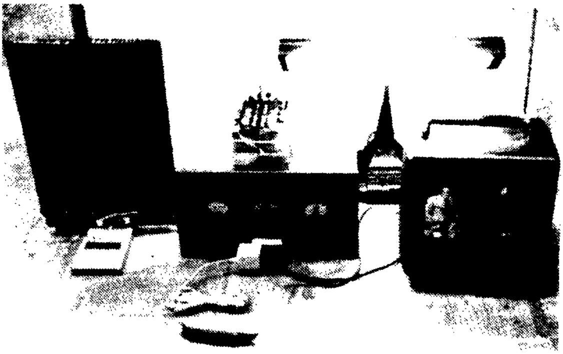
Gainesville, Florida 32611

The Solar Energy and Energy Conversion Laboratory has the solar calorimeter which is an instrument which can determine the solar properties of materials, namely, the reflection, absorption and transmission. Materials such as clear glasses, tinted glasses, plastics, laminated glasses, venetian blinds, draperies, glass brick, etc. have been investigated and their properties determined. Many of the results obtained with this instrument are published in the Guide of the American Society of Heating, Refrigeration, and Air Conditioning Engineers.

The instrument can be oriented in any direction desired, thus simulating south walls, east walls, west walls, north walls or horizontial roofs, etc. It can be made to follow the sun if that is desired. The radiation from the sun, the radiation from the ground, and hundreds of temperatures can be monitored with this instrument.

It might be worthwhile to mention that the behavior of materials under solar irradiation is different from the behavior under low temperature or normal irradiation.

The laboratory also has exposure test facilities to investigate the effect of weathering since materials used in solar energy work must be able to withstand the environmental climatic conditions.



ELECTRICITY FROM SOLAR ENERGY

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University of Florida
Gainesville, Florida 32611

If electricity is needed many methods can be employed to convert solar energy to this form of energy and a number of these will be described below.

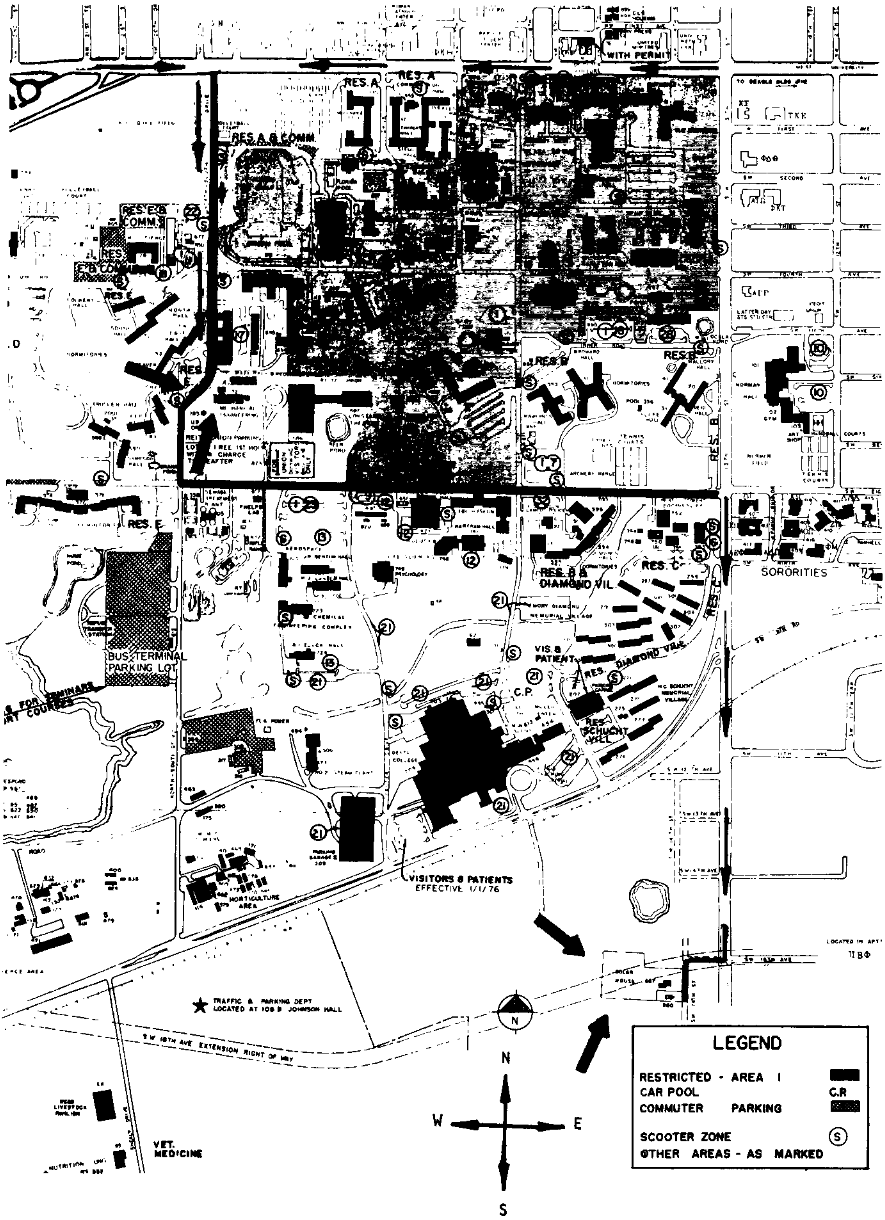
One method of converting solar energy to electricity is by means of solar engines converting solar energy first to mechanical energy and then having these engines drive generators to produce the electrical energy. This method seems at the present time to be the most economical method of producing electricity from solar energy.

Another method which is used in our satellites is the conversion of solar energy, to electricity by solid state devices or the solar or silicon cell. The semiconductor material doped properly is able to convert solar radiation into direct current electricity. This form of electricity can be stored in batteries and at the proper time if so desired converted 110 AC since most of our equipment is designed to operate from this type and operate television sets, lights, small appliances, etc. as shown in the picture above. Unfortunately the solar solid state conversion equipment at the present time is very expensive such as this panel shown in this picture which costs about $30,000. Many people are working at the present time on trying to reduce the cost of these solid state solar to electricity conversion devices.

Two other methods that have been considered are the thermo-electric conversion which basically uses two dis-similar materials joined together and if heated on one of the junctions makes an electric current flow. The efficiency of these devices at the present time has not been very high and the stability of some of the materials not too good.

Thermonic conversion which is based on the principle of heating a material to high temperatures so that electrons are given off and collecting these electrons on a plate close to the first one has also been tried. But some of the difficulties of heating and cooling as well as electron collection have not yet been solved satisfactorily.

So even though a number of methods of converting solar energy to electricity at this time have been developed none of these seem to be economically competitive with conventional methods at this time for on-earth applications.


WITH PERMIT
RES. A
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RES. E & COMMS.
RES. E
RES. B
RES. C
RES. B & DIAMOND VIL.
DIAMOND VIL.
RES. SCHUCHT VIL.
VIS. & PATIENT
C.P.
SORORITIES
BUS TERMINAL PARKING LOT
VISITORS & PATIENTS
EFFECTIVE 1/1/76
HORTICULTURE AREA
TRAFFIC & PARKING DEPT
LOCATED AT 108 B JOHNSON HALL
VET. MEDICINE
N
W
E
S
LEGEND
RESTRICTED - AREA I
CAR POOL C.R
COMMUTER PARKING
SCOOTER ZONE
OTHER AREAS - AS MARKED

SOLAR EQUIPMENT MANUFACTURERS

(This list does not indicate an endorsement of any one of the manufacturers by us)

Arkla Industries
Evansville, Illinois

Amcor Export Co., Ltd.
P.O. Box 2850
Tel Aviv, Israel

Beasley Industries Ltd.
Bolton Avenue, Devon Park
South Australia
IMPORTED BY
Solar Energy Research Center
P.O. Box 17776
San Diego, CA 92117

Beutel's Solar Heater, Inc.
1527 North Miami Avenue
Miami, FL 33136
(305) 822-6268

CSI Solar Systems Division
12400 - 49th Street North
St. Petersburg, FL 33732

Coleman Roofing Company
Miami, FL

D & J Sheet Metal Co.
10055 N.W. 7th Avenue
Miami, FL
(305) 757-7033

Deko-Labs
P.O. Box 12841
Gainesville, FL 32604
(904) 372-6009

Discon Industries
Pompano Beach, FL

E & K Service Company
16824 - 74 Avenue N.E.
Bothell, Washington 98011

Edmund Scientific Company
300 Edscorp Bldg.
Barrington, N.J. 89109

Energex Corp.
481 Tropicana Road
Las Vegas, Nevada 89109

Energy Systems, Inc.
El Cajon, CA

FAFCO, Inc.
138 Jefferson Drive
Menol Park, CA 94025

Fred Rice Productions
6313 Peach Avenue
Van Nuys, CA 91401

Free Heat
P.O. Box 8934
Boston, Mass 02114

Fun & Frolic, Inc.
P.O. Box 277
Madison Heights, Michigan 48071

Garden Way Labs
P.O. Box 66
Charlotte, VT 05445

Helio Associates, Inc.
8230 E. Broadway
Tucson, Arizona 85710

Hitachi America Ltd.
437 Madison Avenue
New York, N.Y. 10022

62-322 O - 75 - 13

Hitachi Hi-Heater
Hitachi Chemical Co., Ltd.
4, 1-Chome
Morunouchi, Chiypda-Ku
Tokyo, Japan

International Solarthermics Corp.
Box 297 Nederland
Nederland, CO 80466

Intertechnology Corp.
Warrenton, Virginia

J & R Simmons Construction Co.
2185 Sherwood Drive
South Daytona, FL 32019

Kalwall Corp.
1111 Candia Rd.
Manchester, N.H. 03105

Lifeguard Filtration Systems
Ft. Lauderdale, FL

Olin-Brass
Olin Corp.
E. Alton, Illinois

PPG Industries, Inc.
One Gateway Center
Pittsburgh, PA 15222

P.R. Distributors
1232 Zacchini Avenue
Sarasota, FL 33577
(813) 958-5660

Ram Products
Sturgis, Michigan

Revere Copper & Brass, Inc.
P.O. Box 151
Rome, N.Y. 13440

Reynolds Metal Company
2315 Dominguez Street
Torrance, CA 90508

Rho Sigma
5108 Melvin Avenue
Tarzana, CA 91356

Robbins W.R. & Sons Roofing
1401 N.W. 20th Street
Miami, FL 33142
(305) 325-0880

Rodgers & MacDonald
3003 N.E. 19th Drive
Gainesville, FL 32601
(904) 377-7883

SAV Solar Heater
IMPROTED FROM
Fred Rice Productions, Inc.
6313 Peach Avenue
Van Nuys, CA 91401

Silves Limited
7 West 14th Street
New York, N.Y. 10011
(Improted from Israel)

Skytherm Processes & Engineering
2424 Wilshire Blvd.
Los Angeles, CA 90057

Sol-Therm Corp.
7 West 14th Street
New York, N.Y. 10011

Solar Design & Engineering
Tampa, FL

Solar Development, Inc.
West Palm Beach, FL

Solar Dynamics, Inc.
4527 E. 11th Avenue
Hialeah, FL 33013

Solar Energy Company
P.O. Box 614
Marlboro, Mass. 01752

Solar Energy Company
Crossly Window Corp.
Miami, FL

Solar Energy Components, Inc.
1605 N. Cocoa Blvd.
Cocoa, FL 32922
(305) 632-2880

Solar Energy Products Company
Avon Lake, Ohio

Solar Energy Systems
1243 South Florida Avenue
Rockledge, FL
(305) 632-6251

Solar Energy Systems, Inc.
Newark, Delaware

Solar Energy Systems of Florida
616 N. Ingraham Avenue
Lakeland, FL 33801
(813) 688-8806

Solar Home Systems
Willoughby, Ohio

Solar, Inc.
206 Center Road, Page Park
Ft. Myers, FL
(813) 936-7474

Solar Power Company
42 Edna, Route 4
Port Richey, FL

Solar Power Corporation
Braintree, Mass.

Solar Power Corporation
930 Clocktower Pky.
Village Square
New Port Richey, FL 33552

Solar Sales, Inc.
Miami, FL

Solar Systems Division
12400 49th Street, North
St. Petersburg, FL 33732

Solar Systems, Inc.
1802 Dennis Drive
Tyler, Texas 75701

Solar Systems of Largo
2525 Key Largo Lane
Ft. Lauderdale, FL 33312

Solar Water Heater Co.
9951 S.W. 38th Terrace
Miami, FL 33155

Solarex Corporation
Rockville, Maryland

Solaron Corp.
4850 Olive Street
Denver, Colorado 80022

Solartec, Inc.
Lakeland, FL

Solec Company
No Address

Spectrolab
Division of Textron
Sylmar, California

Stampco, Inc.
4549 St. Augustine Road - #13
Jacksonville, FL 32207
(904) 737-6144

Sunhay Enterprises
1505 E. Windsor Road
Glendale, California 91205

Sundu Company
3319 Keys Lane
Anaheim, California 92804

Sunsource
9606 Santa Monica Blvd.
Beverly Hills, CA 90210

Sunsystems, Inc.
Eureka, Illinois

Sunwater Company
1112 Pioneer Way
El Cajon, California 92020

Sunworks, Inc.
669 Boston Post Road
Guilford, Conn 06437

Superior W.J. Service
P.O. Box 706
Holly Hill, FL 32017

Tranter, Inc.
735 E. Hazel Street
Lansing, Michigan 48909

Unit Span Architectural Systems, Inc.
6606 Variel,
Canoga Park, California 91303

Youngblood Company, Inc.
1085 N.W. 36th Street
Miami, FL 33127
(305) 635-2501

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The Solar Electric Car — Urban Vehicle Performance

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ABSTRACT

The solar electric automobile under discussion here is part of the urban vehicle project of the Solar Energy and Energy Conversion Laboratory of the University of Florida, concerning itself with the generation of pollution free power for city transportation.

The test bed vehicle, a converted GM Corvair, which is driven through the city daily, has a novel transistorized field excitation system for variable speed control and regenerative braking to improve the overall power conversion efficiency.

Performance data and experiences with this potential pollution free vehicle are presented.

1. Introduction

A part of the University of Florida Solar Energy and Energy Conversion Laboratory's program to provide the forms of energy needed in our daily life by converting solar energy includes the solar electric car.

Providing the energy needed for transportation from solar energy, first of all uses our only energy income and does not deplete our fixed resources which are classified as savings. Furthermore, the use and conversion of this energy is pollution free since it does not put anything into the environment which is not already there. Solar energy falling upon the earth becomes heat whether it is used in this conversion or not.

It is believed that this type of transportation, especially for urban traffic can solve many of today's serious problems, such as pollution. A network of solar battery charging stations like today's gasoline stations could replace run-down batteries in the travelers' cars with charged ones. This exchange would not take more time or effort than filling a tank with gasoline. While the batteries are at the station they can be recharged by solar energy. A proper distribution of such facilities could provide the travelers' needs on a nationwide basis.

2. Electric Propulsion

Electric propulsion is not new but today the picture for electric automobiles has very much changed. Recent developments in high current power transistors and silicone controlled rectifiers, combined with a new generation of electro-chemical systems such as the lithium-sulphur battery, have brought the "electric" into focus again as an effective means to combat air pollution.

If the electric car is charged from conventionally produced electricity it will not eliminate pollution but first reduce it by more efficient processes of conversion and secondly transfer it to less critical areas, such as moving it from the heart of cities to the countryside. If solar energy is converted to electricity to charge the electric cars' batteries then pollution can be eliminated.

Surveys have shown that 99% of all trips and 80% of the total passenger car mileage is for travels less than 160km in length. Our solar electric car can easily meet these requirements. Fig. 1 and Fig. 2.

An earlier article described the performance of the car with MiCd batteries which were not specifically designed for this use, (1), and the performance was much below the present. Some circuit changes in the controls have been made as well as specially designed Lead-Acid batteries were obtained suited for this type of operation.

To extend the range of operation without having the networks of battery charging stations as mentioned above, various attempts have been made by others. These modifications required extra batteries or the addition of a combustion generator plant. Several companies who tried this shelved these

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concepts because of weight, technical and economic limitations. (2).

Our investigation has concentrated on totally pollution-free propulsion through the use of solar electric power. In order to evaluate urban electric car requirements, conversion efficiency, component reliability and traffic safety, commensurate with cost, size, and weight, a production model GM Corvair was converted into the electric traction test-bed vehicle.

3. Traction Motor and Transmission

The traction motor replaces the original combustion engine and is directly coupled to the existing four-speed transmission without the use of a clutch. The motor is 6 pole, separately excited, a DC machine rated at 48 volts and 400 ampere, weighing 30kg.

Traditionally, series motors have been used for propulsion work with good success, because of self-regulating torque and speed characteristics under varying road conditions. However, in order to recover the kinetic energy of the vehicle and make regenerative braking practical a separately excited DC motor is convenient. In heavy urban traffic the vehicle range can be extended by as much as 25%. (3). In addition, with solid state field control the following advantages have been obtained:

1. Torque — speed characteristics of the Series DC motor through armature current feedback.
2. Continuous speed control above the base speed by simple field weakening.
3. High efficiency at reduced armature voltage since the full field excitation can be maintained.
4. Lower fadeout speed of regenerative braking because field can be maintained independent of speed.
5. The motor requires only two power terminals.
6. Motor reversal obtainable by only a small DPDT field relay.
7. Simple field excitation controlled through a low power series transistor regulator.

Dynamometer tests have shown that the motor efficiency reaches a maximum of 0.83 at 200 amperes and then gradually falls off to 0.70 at 600 amperes. At this point the motor develops approximately 27 horsepower at the driveshaft.

Fig. 1. The University of Florida Solar Electric Car

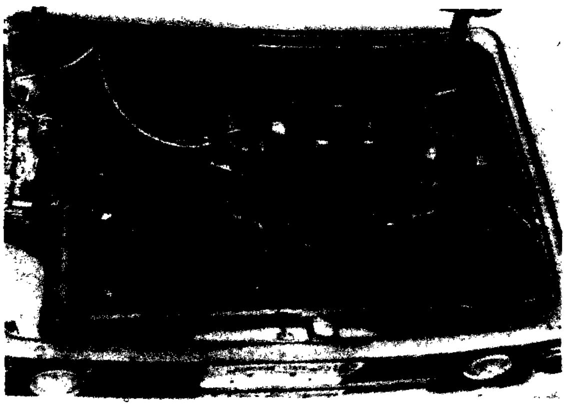


Fig. 2. The Engine Compartment of the Electric Car

4. Propulsion Battery

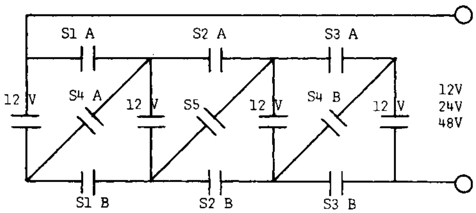
The propulsion battery, a lead acid type, consists of four units, each twelve volts. There are two units in the engine compartment and another two in the trunk. Each twelve volt battery, weighing 60kg, has a capacity of 180 ampere-hours at the 20 hour rate. However, this capacity decreases appreciably; 90 AH at the one hour rate and to 56 AH if the battery is discharged at 150 A. Therefore, the total available propulsion energy is a strong function of the discharge current ranging from 39 WH/kg maximum, down to 21 WH/kg.

5. Field Control Battery

The field excitation battery is composed of 30 NiCad cells, providing 36 volts at 24 AH. This battery not only furnishes the power to the motor field, but also serves as the power source for an on board DC to AC transistor power inverter to produce 110 volts, 400 cycles. This AC is used to energize the axial vane blower for forced air cooling of the propulsion motor. The same power inverter transformer produces twelve volts which, after rectification and filtering, furnishes the DC for the regular 12 volt system of the car to operate headlights, horn, windshield wipers, etc.

6. Control Circuit

Five solenoid power switches are used to control the armature voltage. Four of the switches are DPDT and one is an SPST. The purpose of this system is to connect the propulsion battery unit in different parallel and series combinations to produce three different armature voltages, namely, 12, 24, and 48 volts. This allows the individual battery units to be discharged equally. Fig. 3. During charging, all batteries are placed in series. The power solenoids are activated by microswitches, controlled by a cam plate which is mechanically coupled to the accelerator linkage of the car. A diode switching logic is part of the control circuit. It electrically interconnects the microswitches with the power solenoids and the motor field circuit such that the field excitation relay is energized whenever the solenoid switches are. Fig. 4.



Solenoid closed	Propulsion Voltage
S1, S2, S3	12V
S1, S3, S5	24V
S4, S5	48V

Fig. 3. Armature Voltage Control Circuit

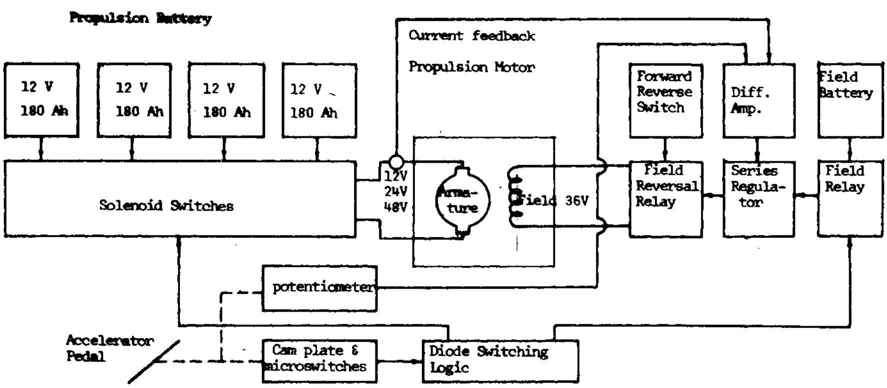


Fig. 4. Complete Control Circuit

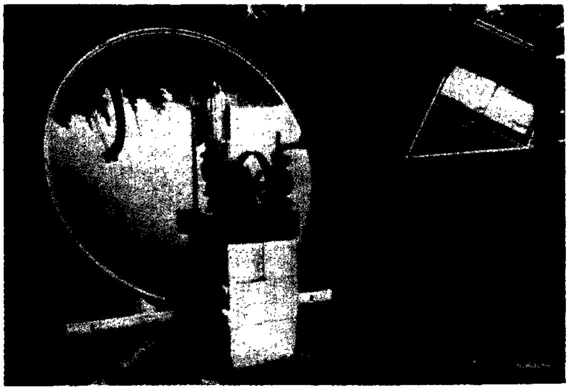


Fig. 5. 140 Watt Sterling Engine

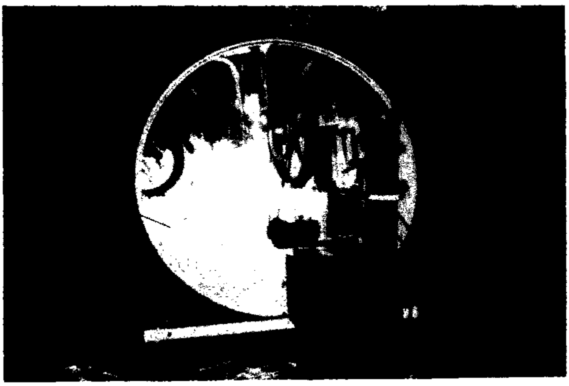


Fig. 6. 1000 Watt Sterling Engine

The field excitation voltage is a function of both the armature current and the voltage derived from the potentiometer coupled to the accelerator linkage. Both signals are combined in a differential amplifier. The output of this amplifier controls the power transistor series regulator in the motor field circuit.

The combination of three armature voltages and the variable field excitation in conjunction with the four-speed transmission provides great flexibility of speed control in dense urban traffic and on the open highway. During the regenerative braking the traction motor acts as a shunt generator with variable field control. Regeneration is maintained as low as four miles per hour. At this point the regular hydraulic brakes bring the car to a complete stop.

7. Power Sources for Battery Charging

Two sources of power are used for the vehicle at present, namely, solar energy and regular 110 volt AC. To produce solar electric power the conversion in the Solar Energy & Energy Conversion Laboratory is first solar to mechanical power and then mechanical to electrical since silicone solar cells are not yet economical for terrestrial applications. (4). We use Sterling cycle hot air engines in conjunction with generators to produce electricity. Fig. 5. (5). The output from the various engines is from 145 watts to 1000 watts. Fig. 6. The Sterling cycle engines use parabolic concentrating collectors to intercept the sunshine. (6). The solar radiation impinging on the surface of a five foot collector is about 1825 watts. From this amount the smaller hot air engine converts 145 watts into electricity. The simpler solar silicone cells would have produced about 160 watts for the same amount of incident radiation. However, the price of the solar cells would have been about 28 times that of the Sterling engine system.

8. Discussion of Performance

The solar electric car is driven in regular city traffic, 32km on the average every work day. The accumulative road distance on the present set of Conrex lead acid batteries is 3,200km. Each test run is approximately 8km. The maximum speed is 97km per hour on a level road with a tire pressure of 3 atmospheres. At a speed of 40 km per hour the car will travel a distance of 88 km.

Data have been collected on the efficiency of the solenoid speed controller. The measured electrical losses were 400 watts at 95 km/hr. and only 8 watts at 40 km/hr., yielding efficiencies of 98% to better than 99.7%. At urban speeds the controller is therefore practically loss-less. In very congested traffic with many and long idling periods while waiting for traffic light changes, the electric car consumes no power at all.

Road data shows that very little power is expended to propell a compact car. Our solar electric Corvair uses only 3 HP at 40 km/hr. and 6 HP at 60 km/hr, common urban speeds for most cities. With present day lead acid batteries it is possible to attain a range between 90 and 160 km on one charge.

Fig. 7 and Fig. 8 show actual current versus time plots under actual driving conditions. Fig. 7 shows the battery switching in first gear and then second, third and fourth gear operation. Fig. 8 shows field excitation switching as well as regeneration.

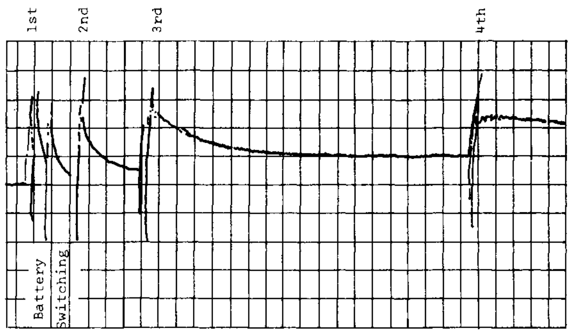


Fig. 7. Solar Electric Car Performance

9. Closure

The experience of the performance of the solar electric car has demonstrated the usefulness of such means of transportation, especially for urban traffic to provide low pollution or pollution-free transportation without depleting our fossil fuel resources.

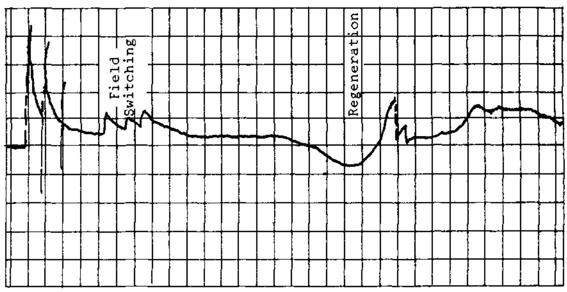


Fig. 8. Solar Electric Car Performance

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Solar Swimming Pool Heating

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ABSTRACT

In connection with the University of Florida Solar House and right next to it are two above ground 21,000 liter swimming pools.

One of these pools is used as reference and the other is being heated by solar energy. Both pools are instrumented with close to one hundred thermocouples each to determine temperature distributions and gradients on a continuous basis.

The performance of the solarly heated pool is presented in this paper in reference to the identical unheated pool. In this manner the true effectiveness of the solar heating can be evaluated.

1. Introduction

Many swimming pools have been built in the United States next to private homes for family recreation. Since the water in these pools drops to temperatures which make it uncomfortable for use, even in the southern part of the country, a good portion of these pools are provided with heaters.

Since, however, the use of gas or oil for this purpose is very expensive, (several hundred dollars per month in some cases) heaters installed for swimming pool heating are rarely used.

In recent years there has been tremendous upswing in interest to use solar energy for the purpose of heating swimming pools. Since very little information is available to evaluate the effectiveness of solar heating of swimming pools, two identical small pools were set up next to the University of Florida Solar House, a project which has the objective to evaluate the feasibility of providing our daily energy needs and forms by converting solar energy, our only energy income, and do this without pollution or otherwise affecting the environment.

To obtain a true evaluation, a comparison, it was necessary to use two identical pools — one unheated and the other heated — by various methods utilizing solar energy.

2. Swimming Pool Heating

The University of Florida has an outdoor swimming pool, Olympic size, which is heated and kept at about 28 C all year around. This pool is used for swimming and life-saving classes, for practice by the University of Florida Swim Team and for recreational swimming. A tremendous amount of energy is used every day during the heating season to keep this level of comfort. Steam from the University power plant is used for this purpose.

Early studies were made on this swimming pool to see just what it takes to heat swimming pools. No absolute comparison was possible, however, since we could not say for certain what the pool temperature would have been, had it not been heated.

For the above reasons it was decided to set up two identical pools, one unheated and used as standard, and the other a solarly heated swimming pool to obtain a true comparison of the effectiveness of the heating by solar energy. Very little work has been done previously on solar swimming pool heating and none with two pools next to each other for real comparison.

Some work done by the University of Florida Solar Energy & Energy Conversion Laboratory on solarly heated sewage digesters can be considered related to this problem. (1).

The pools were set up on a north-south line close together but still separated so as to prevent shading of one by the other.

At the beginning both pools were compared with each other on an unheated basis to assure that they behave the same with respect to the environmental conditions. This established, the solar heating was started. A number of times during the actual testing the heating of the pools was switched from one to the other to ascertain that the effects measured are not characteristics of one pool as compared to the other. It was found that both pools behaved in the same manner under the same operatint conditions.

3. Test Pool Arrangement

As mentioned above, the two pools, each 4.6 m in diameter and 1.25 m deep, were set up on a north-south line, separated just enough so that they will not affect each other. Fig. 1.

In Fig. 1 it can be seen that the rear pool is heated by solar energy by having a sheet of transparent plastic floated on it. The front pool which is the south pool is not heated, but is has the capability of being heated by the flat plate solar collectors which are part of the house heating system Fig. 2.

To heat a swimming pool by such collectors would be quite expensive but if a heating system like this is available for house heating then it can at times be used for swimming pool heating when the demand by the house does not require their total capacity. Relatively little heat is needed from this system but it can be used to boost the pool temperature to the desired level.

In Fig. 1 the instrumentation is also visible, consisting of many thermocouples which are led to a recorder which monitored them. Both pools have identical instrumentation. Behind the pools is the hot water storage tank for the house heating system and it will also drive the air-conditioning system of the house when it is installed.

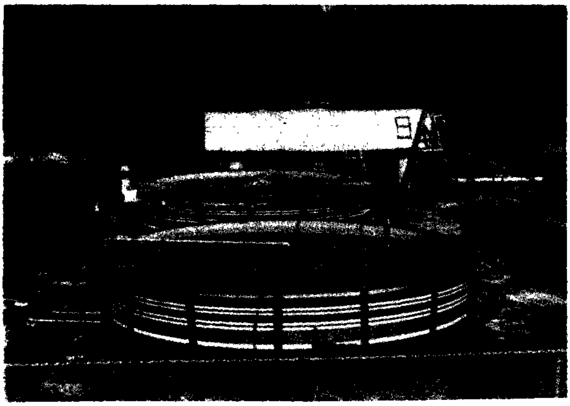

Fig. 1. Experimental Swimming Pools

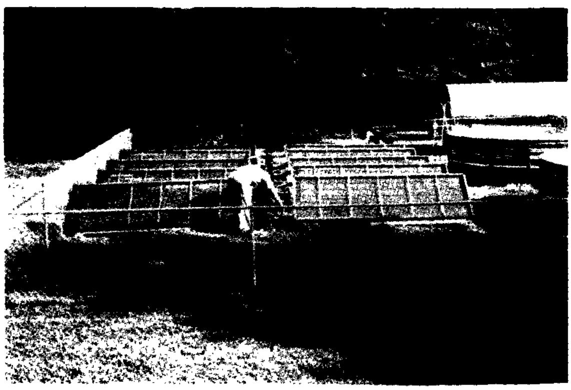

Fig. 2. Flat Plate Solar Collectors

4. Solar Energy Collection and Pool Heating

A number of different methods of collecting the energy for pool heating have been tried, and they have been investigated both theoretically and experimentally.

The simplest method used was to float a plastic sheet right on the water, then the use of two sheets (separated), bubble plastic, and the flat plate collectors were investigated.

Other methods which were used earlier on sewage digesters are also applicable and can be used as guides since they essentially heated a large body of water of swimming pool dimensions. (1).

Fig. 3 presents the average energy collected by the swimming pool throughout the year, and the average temperature gain of the unheated (or better, not heated by special methods) pool. The variation throughout the year is mostly due to the number of sunshine hours per day with the seasons, which is shown in Fig. 4.

A small effect is the change in angle of the sun with the seasons. The sun is lower in the winter and higher in the sky during the summer.

The energy absorbed by the water in the pool raises the temperature of the water during the day but the losses reduce the rise rate during the day and the temperature actually drops during the night.

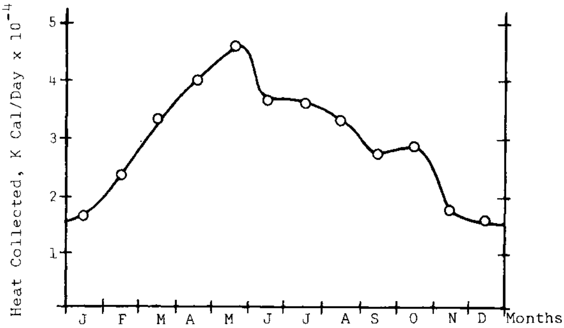

Fig. 3. Energy Collected by Unheated Pool (Average for One Year)

5. Temperature Gain Per 24-Hour Day

As long as the heat gain or temperature rise of the pool during the day is larger than the temperature drop during the night the water in the pool will register a net gain in temperature. As the temperature of the pool rises the heat losses increase and finally the temperature gain during the day will equal the temperature loss during the night.

The actual average gain for the unheated pool at equilibrium condition is slightly less than 2 C. Thus the temperature will at an average at equilibrium rise 2 degrees during the day and then drop back again two degrees during the night.

The solarly heated pool has the heat losses reduced by the various methods employed and thus finds an equilibrium temperature at a

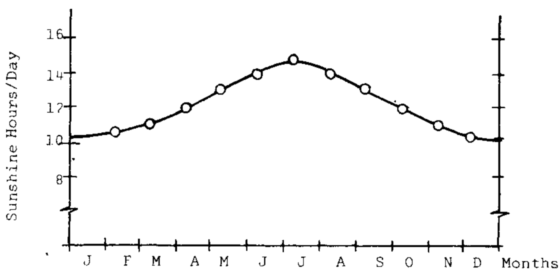

Fig. 4. Sunshine Hours per day or hours per day the sun is above the horizon (30° N Latitude)

higher level. Fig. 5 presents the average temperature gain during the 24-hour day.

6. Average Pool Temperature Throughout the Year

The theoretical analysis and experimental verification gives the results presented in Fig. 6.

Shown is the average air temperature which controls with its humidity the heat losses from the pool and the average temperature of the unheated pool throughout the year. Given also is the average temperature throughout the year of a pool heated by a single transparent sheet of plastic floating on it and what can be done to the pool temperature if the flat plate collectors are used during the worst time of the year.

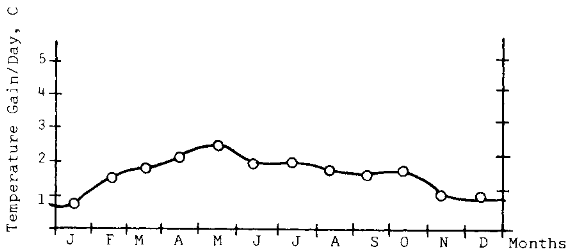

Fig. 5. Average temperature gain of unheated swimming pool per day

7. Discussion and Closure

If we take the temperature of the University pool as the desired comfort level, namely 28 C, it can be shown from Fig. 6 that this temperature is reached in about the middle of May and lasts until about the first of October. This will indicate that the swimming season can be considered with this pool in Gainesville from about May to October. During this time, this temperature may be exceeded at an average by as much as 4 C.

A single sheet of plastic floating on the pool and only removed while the pool is used will raise the average temperature of the pool slightly less than 6 C. This does not seem like much but it will allow swimming in the pool at the desired comfort condition one month earlier and still allow swimming 1½ months later than the unheated pool would allow. Thus by this method the swimming season of this pool is extended by 2½ months.

If the flat plate collectors of the solar house heating system are used as partial boosters, their total capacity not needed, the temperature of the pool could be kept at the comfort level all year around. This dual use of the flat plate collectors gives something extra which normally, when they are installed for the heating system, is not expected of them.

This above discussion presented the overall behavior of the solarly heated swimming pool with relatively simple means of heating.

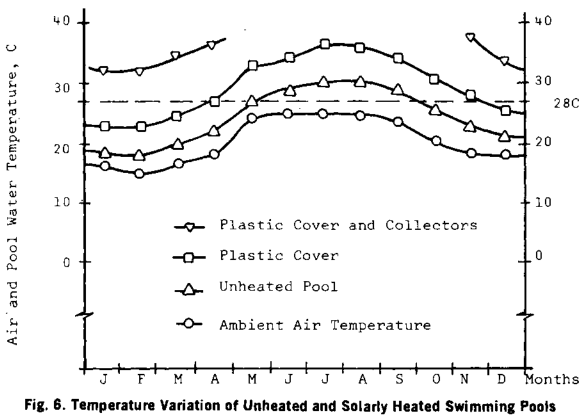

Fig. 6. Temperature Variation of Unheated and Solarly Heated Swimming Pools

In addition to the above, double plastic covers, bubble plastics, etc. were investigated and the detailed behavior of the pool studied. The temperature distributions in both the heated pool and the unheated pool were determined theoretically and checked experimentally, when the circulating filter pump was running and when it was not, and the pool was heated by free convection currents and cooled by them. The detail is interesting from an academic point of view for a better understanding of what actually takes place in the pool during a typical 24-hour period for a perfect day, a cloudy and rainy day.

This detail, however, is of little interest or value to the family who wants to extend the swimming season of their own swimming pool.

The actual average pools are deeper than the ones used for this study, but, at the same time, their losses are smaller on a relative size comparison since they are better insulated by being in the ground or having a thicker wall if above ground.

In closing it might be said that the study on solarly heated sewage digesters as well as this study on solarly heated swimming pools has demonstrated that the application of solar energy for heating the pools will be able to appreciably extend the swimming season by relatively simple and inexpensive means.

If the house has a solar heating system, the flat plate collectors can be used to give a year around swimming season by using them as partial boosters. If desirable such heaters could naturally be added just for the purpose of providing the topping for the pool.

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A Solar Powered V-2 Vapor Engine

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ABSTRACT

This paper describes a self starting, fractional horsepower vapor engine coupled to flat plate solar absorbers so that operation is possible at relatively low temperatures with refrigerants as the operating fluids.

The engine consists of a V-2 arrangement of two double acting cylinders which exhaust into a chamber which surrounds the whole engine and is connected to the condenser which can be air or water cooled. A small pump returns the condensed liquid to the flat plate solar collectors which generate the vapor for the engine.

The design of the engine makes it self starting as soon as vapor is supplied to it. Every piston movement constitutes a power stroke, and about ¼ horsepower is produced with trichloromonofluoromethane (R-11) for operating temperatures of 72 C and 27 C at about 500 rpm.

1. Introduction

In connection with the solar energy to mechanical power conversion project of the University of Florida Solar Energy and Energy Conversion Laboratory many engines have been built and evaluated. Most of them require concentration of solar energy to obtain the temperatures needed for operation.

Among them are steam engines, both single and double acting, which utilize a 2 x 2.5 m cylindrical parabola for concentration of the solar energy upon a glass covered vapor generating tube at the focal line. This unit has to follow the sun and is driven either by an electric synchronous motor or by a clockwork controlled heavy weight. This system needs setting in the morning, but then operates all day without attention.

Another group of engines used in this conversion of solar energy to mechanical power are hot air engines. The solar energy is concentrated with 1.5 m diameter parabolic mirrors onto the hot end of the displacer of closed cycle engines or the heater of open cycle engines to provide the temperatures needed for operation. (1, 2, 3).

The above methods work, but they can utilize only the direct radiation from the sun and not the diffuse portion, thus cannot work on cloudy days. These engines are not self starting since all of them were only one cylinder types. Multicylinder arrangements can overcome this problem, but at the cost of size and complexity.

The present engine was designed to operate at temperatures which can be produced with flat plate solar collectors, utilizing such fluids as Freons with the desired physical characteristics in low temperature vapor systems. Furthermore, the present engine, the subject of this paper, has two double acting cylinders, set in a V arrangement and is, therefore, self starting and every movement is a power stroke. The engine is described more in the following pages.

2. Low Temperature Solar Power System

The low temperature solar power system consists of flat plate collectors which convert solar energy into heat, producing temperatures up to 100 C and can, if the right fluid is used, produce vapor. The vapor is then allowed to flow to an engine, the V-2 vapor engine in this case, where this energy is converted into mechanical power. From there, the vapor moves to a condenser where it is changed back to liquid. A small liquid circulating pump brings the liquid back to the flat plate solar collectors or vapor generators. (6, 10).

Fig. 1 presents a schematic sketch of the system the detail of which is given below.

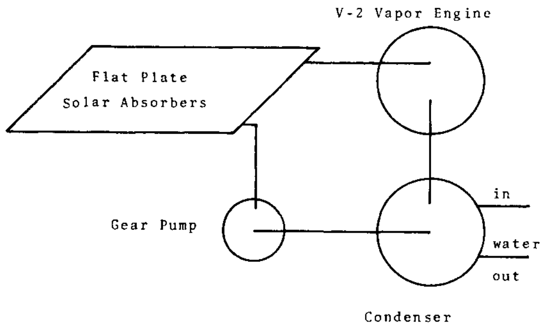

Fig. 1. Schematic Sketch of Low Temperature Solar Power System

The total system is basically not different from other vapor systems such as steam power plants, except that the operation occurs at low temperatures, temperatures which can be obtained with flat plate solar collectors. A number of fluids can be used in this system. Trichloromonofluoromethane (R-11) seemed to be most readily available and best suited for this purpose.

A detailed description of the main components of this system is given below with main emphasis upon the V-2 solar vapor engine.

3. The Flat Plate Solar Collectors and Vapor Generators

Rather than using an optimized design of the flat plate solar collectors for this system, some which were available in the laboratory were used. These same solar collectors are now used for heating the University of Florida Solar House and they were used earlier to operate the 5 ton solar air-conditioning system of the University of Florida Solar Energy and Energy Conversion Laboratory. Three of the units shown in Fig. 2 were used for the work described here.

Because of the design of these flat plate collectors a small vapor accumulator is necessary to allow the vapor to separate from the liquid before feeding it into the engine. Absorbers designed like one of units used with the compact solar refrigerator or ice machine, which is intended to generate

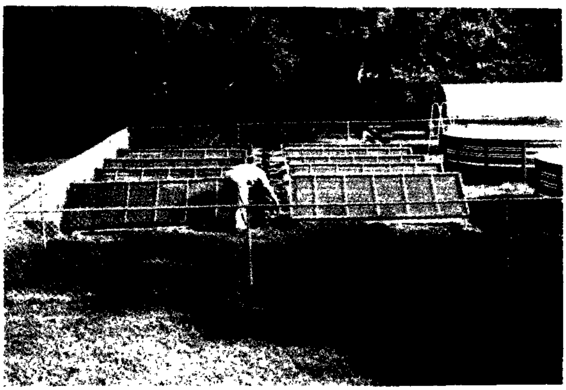

Fig. 2. Flat Plate Solar Collectors

vapor, eliminate the need for this part. (7, 8, 9, 10).

The flat plate solar collectors have a collecting area of 2.8 m^2 each and have an average collecting efficiency for the day of over 50 percent.

4. The V-2 Solar Vapor Engine

The self starting V-2 vapor engine consists of two cylinders, each having an inside diameter of 51 mm. The two cylinders are oriented at 90 degrees to each other. Fig. 3 and Fig. 4. The piston in each cylinder has a stroke of 39 mm. Slide valves control the vapor flow in and out of the cylinders admitting vapor for 90 degrees of the flywheel rotation and exhausting it for 140 degrees.

The 25 cm tall, 35 cm wide and 23 cm deep engine is mounted in housing, 40 cm in diameter and 25 cm deep. Fig. 5.

The vapor is fed to the engine through the housing. The vapor after it has produced work is exhausted into the housing surrounding the engine. In this manner any leaks which may be present are not critical since the housing catches all vapors exhausted and escaping. From the housing the vapor flows to the condenser.

The total displacement of the engine for one revolution is 305 cc.

The engine is speed controlled by a centrifugal flywheel governor which regulates the vapor flow to the engine and can be adjusted to give the speed desired for operation.

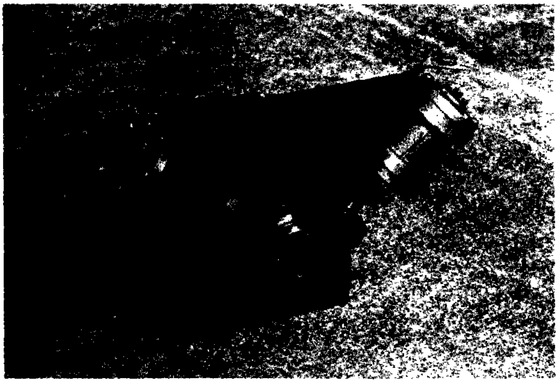

Fig. 3. V-2 Solar Vapor Engine (Back)

Fig. 4. V-2 Solar Vapor Engine (Front)

5. Condenser

The condenser used in connection with this engine is a cylinder 76 cm in diameter and 61 cm long. It has an inlet and an outlet for cooling water. In this cylindrical container are 7 coils of 2.5 cm diameter pipe giving a total length of 13.5 m. In this pipe the vapor is condensed.

An air condenser could be designed, but since water was readily available it is used for cooling.

6. Pump

The pump is a Cole-Palmer Model 7004-92 gear pump which has a flow rate capacity of 4.5 liters per minute at engine speed and

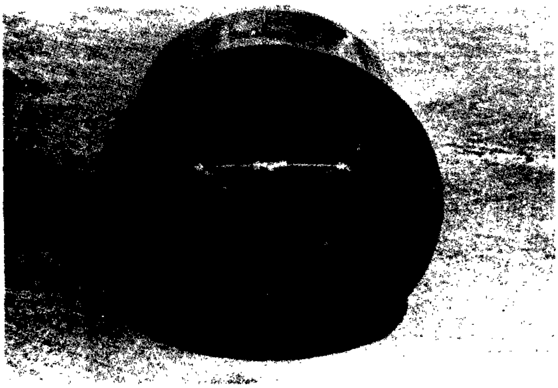

Fig. 5. V-2 Solar Vapor Engine in Housing

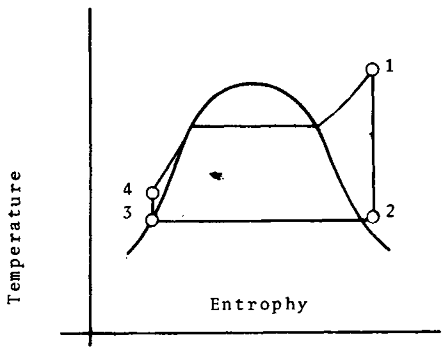

Fig. 6. Low Temperature Solar Power System Cycle (T-S)

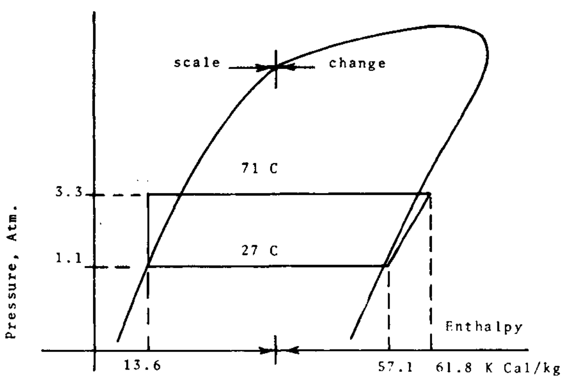

Fig. 7. R-11 Solar Power System Cycle on P-H Plane

produces a pressure rise of 4 atmospheres.

7. Discussion and Performance Evaluation

Having discussed the components of the system to allow the generation of mechanical power from solar energy with flat plate solar collectors, the operating characteristics will now be presented. Again, the main emphasis is on the literature on a number of occasions.

The operating conditions and an ideal system T-S diagram is shown in Fig. 6. The processes through the various components of the system are shown. 1-2 indicates the expansion of vapor through the engine which converts some of the energy into mechanical work. 2-3 indicates the state changes which occur in the fluid when it is moving through the condenser. 3-4 is an indication of the pump action, raising the pressure to that of the solar vapor generators. 4-1 completes the cycle of the system and presents the changes which occur in the flat plate solar collectors and vapor generators.

This same cycle is presented for a specific fluid, R-11 or dichloromonofluoromethane, in Fig. 7 on the P-H plane. Conservative operating conditions were selected which can readily be obtained by such systems. 72 C vapor is delivered by the flat plate solar collectors and 28 C liquid by the water cooled condenser. The pressures corresponding to these temperatures are moderate, not requiring special designs.

The conditions inside the engine cylinders, on one side of the piston are indicated in Fig. 8. Values of pressure and volume are given. The cycle is idealized and the corners are not rounded as they are in the real case. (12)

Finally, Fig. 9 presents the actual performance of the engine with supply pressures held constant at 2.36, 2.70, 3.04 and 3.40 atmospheres, pressures which correspond to R-11 sat. temperatures of 51, 56, 60 and 65 C respectively.

The curves are typical of engine performance. Maximum speed is reached at no load and as the load is increased the speed drops. If the power output is plotted against revolutions per minute (rpm) a maximum power point is shown on each curve.

Curves for temperatures and pressures higher than those presented here could be given, but they cannot as easily be reached dependably over a considerable part of the day.

From the discussion and the performance data shown, it is seen that flat plate solar collectors and vapor generators can drive vapor engines when the proper working fluids are employed. The use of flat plate solar absorbers utilizes both the direct and the diffuse portion of solar radiation and thus, allows operation on less than perfect days.

Furthermore, the combination of two cylinders in a compact V arrangement makes this engine self starting which is a distinct advantage when intermittent clouds cover the sky.

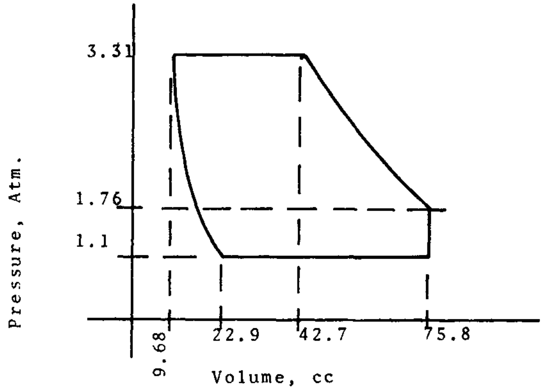

Fig. 8. P-V Diagram of the V-2 Vapor Cycle Engine Using R-11

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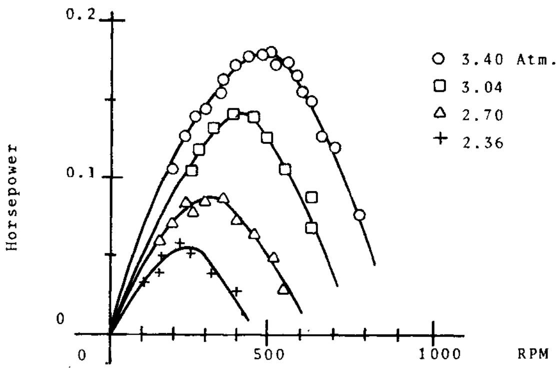

Fig. 9. Performance Curves of the V-2 Solar Powered Vapor Engine

The University of Florida Solar House

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ABSTRACT

The University of Florida Solar House, which is a thoroughly instrumented test house to investigate heating systems, air-conditioning systems, hot water systems, air quality in the house under actual lived in conditions, has now been partially converted into a solar house. This allows a true comparison of solar and other systems.

At the present time solar energy supplies the hot water, heats the house, heats one of the swimming pools, recycles part of the liquid waste, and supplies some electricity for radio, TV, lights, and small appliances. In the near future air-conditioning and cooking will be added.

1. Introduction

Approximately two years ago the conversion of the University of Florida Test House into a solar house was started. This was done step by step as time and funds permitted.

The reasons for utilizing this house were many and among the most important ones were that information existed over the last 16 years as to how different conventional systems performed in supplying the hot water, heating, air-conditioning, the energy for cooking and other activities while monitoring the air quality in the house.

All the data in this thoroughly instrumented house was taken while a married student couple lived in this house with all the modern conveniences provided.

In the early stages of the project, walls, windows, and insulation in the house were changed to evaluate their performance and later the systems serving the house were evaluated i.e.; oil, gas and electricity were used at different times, to provide the energy to water heaters, air-conditioners, heat pumps, cooking systems, etc. Over-head or attic air distribution systems with different diffuser outlets were compared with under floor distribution systems.

These years of data and experience, under actual lived in conditions, give a wealth of information and a firm basis for absolute comparisons of different systems serving the same house under the same conditions.

2. The Solar House

The house is a conventional, typical block construction dwelling similar to many found in Florida and elsewhere. It has three bedrooms, two baths, kitchen, living and dining rooms, utility and laundry rooms, and a carport with closed in storage space. The laundry room, besides holding the washing machine and dryer, is used for all the instrumentation monitoring the many activities and systems of the house.

Figure 1 shows a SW view of the house which is oriented E to W. The road approaching the house comes from the E so the solar equipment is not seen until one walks around the house.

All the solar energy equipment which is installed in the solar house was developed and evaluated in the University of Florida Solar Energy Conversion Laboratory.

The first unit which was added to the house was the solar water heater. The collector was put on the roof with the hot water tank behind it. The first visitors to the solar house were disappointed that they did not see the solar equipment, and it was too hazardous to take them up on the roof. For educational reasons it was decided to place the rest of the solar energy conversion equipment next to the house in the open, rather than to incorporate it in it, so that visitors can walk around the equipment, touch and photograph it and, in general, get a good idea what such equipment is like.

Further, two swimming pools were added, one heated by solar energy and the other as standard for comparison; a house heating system with a large storage tank, above ground rather than buried with plans to use the solar waste recycling system; a small solar energy to electricity conversion unit; and a solar-electric car which is part of the over-all system. In the near future solar air-conditioning, refrigeration and cooking will be added.

3. The Solar Water Heater

The solar heater is shown in Figure 2. It consists of a 5.2 m^2 solar collector and a 380 liter well insulated hot water storage tank. (See references 1, 2, 3, 4, 5, 6)

The solar absorber is a galvanized sheet metal box having 2.5 cm of Styrofoam insulation inside in the back. In front of the insulation is a copper sheet with two parallel circuits of sinusoidally arranged tubes soldered onto it. Both sheet and tubes are painted with a good absorbing paint. The box is covered by glass having good solar energy transmitting properties.

The hot water delivered by this unit flows by free convection to the hot water storage tank which is well insulated to reduce heat losses.

4. The Solarly Heated Swimming Pool

To truly evaluate the effectiveness of heating the swimming pool by solar energy, two identical pools were installed, 4.6 m in diameter and 1.2 m deep. One was heated by various methods utilizing solar energy and the other was used as standard for comparison. Figure 3.

Both pools were well instrumented with many thermocouples in each. One pool, the unheated one, was left to itself. The other was heated by solar energy in a number of ways. The simplest method was to float a transparent sheet of plastic on its surface. Two sheets of the air-mattress design do a better job, or bubble sheet can be a reasonably good collector and a good inhibitor to heat losses. The solar absorbers of the house heating system described below were also used at times to heat one of the pools. The latter system is economical only as a combination between house and pool heating.

The simple plastic sheet could keep the average pool temperature 11 degrees above the average air temperature and 6 degrees C above the unheated pool temperature. Utilizing the house heating absorbers, the pool temperature could be kept about 22 degrees C above the average ambient air temperature.

5. The Solar House Heating System

The solar house heating system is basically a hot water system which was selected over the air heating system, since the former is easier to use as the front end of a solar air-conditioning system. Ten

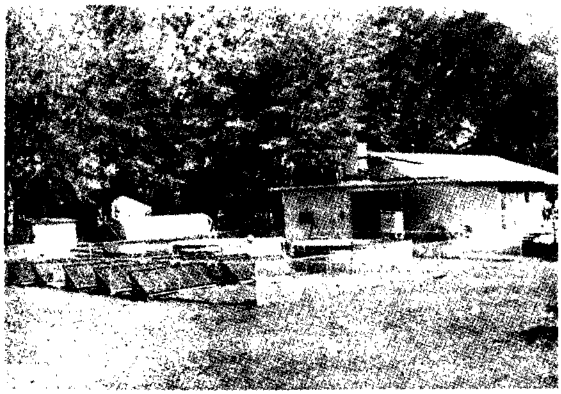

Fig. 1. The University of Florida Solar House

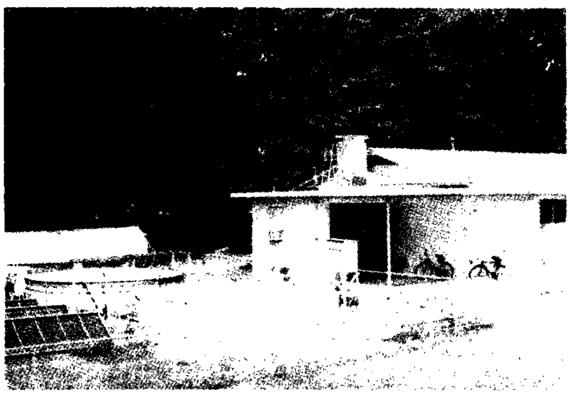

Fig. 2. The Solar Water Heater

solar absorbers, similar to the one used for the solar hot water system, comprising 33 m^2 of absorbing surface provide hot water which is stored in a 11,400 liter tank with 10 cm insulation around it. Figures 3 and 4.

Water from the storage tank is circulated by a small pump through the baseboard heating system in the house as required to keep the temperature of the house at the desired value. 43 m of baseboard heaters can deliver 15,000 K Cal per hour with supply water of 56 C, which is the design load for the house to meet the maximum heat requirement under extreme conditions in Gainesville, Florida. With the water hotter, more heat can be delivered and cycling controls the actual amount of heat delivered.

The baseboard heaters are shown in Figure 5. The flow rate through the solar absorbers can be controlled, so as to deliver water at the desired temperature, storing it in the upper part of the storage tank. The delivery to the house is thermostatically controlled.

The storage tank is larger than actually needed, but was used to allow long time storage to carry the house through bad weather conditions. 11,400 K Cal can be delivered to the house for only 1 C water temperature drop in the storage tank.

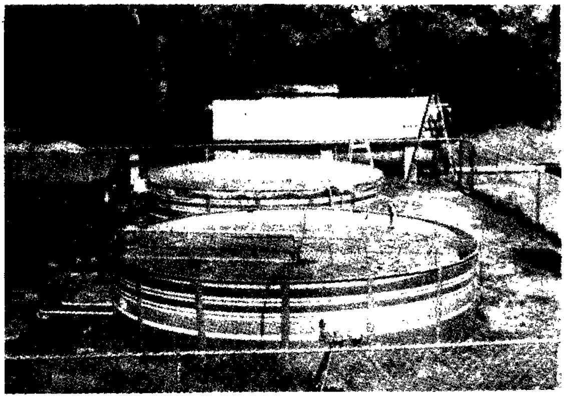

Fig. 3. Solarly Heated Swimming Pool

6. Liquid Waste Solar Recycling Plant

Since fresh water is becoming more and more difficult to obtain and is also getting more expensive, a small liquid waste solar recycling plant has been added to the house. This solar distillation unit, Figure 6, has a liquid holding tray area of 2.2 m^2 and can produce up to about 11 liters of fresh water on a good day. This unit is also designed to collect rain water which, in Gainesville, just about doubles the output. (7)

This plant is not able to handle all the liquid waste of the house, but one could be built any desired size depending upon the recycling requirements.

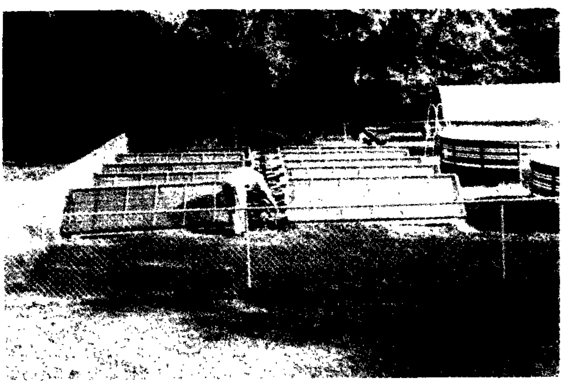

Fig. 4. Solar Heating System Absorbers

7. Solar-Electric Conversion Unit

Most of the energy today in a house is used for water heating, house heating, and air condi-

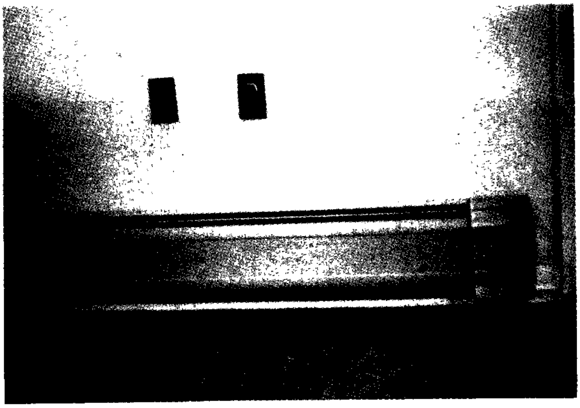

Fig. 5. Baseboard Heating Units

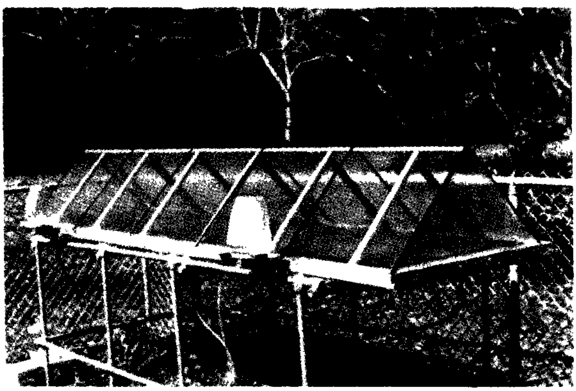

Fig. 6. Liquid Waste Solar Recycling Plant

tioning. The real need for electricity is only a small fraction of the total energy requirement. It is really only needed for radio, TV, lights, and some small appliances. Figure 7 shows the small unit used to convert solar energy, by means of solar cells, into DC electricity and store it in NiCd batteries. The energy from the batteries is then converted as needed by a DC to AC solid state converter to operate lights, radios, TV and small appliances. The cost of this unit is certainly not competitive at this time, but it demonstrates the feasibility of providing electricity.

8. Solar Air Conditioning, Cooking, and Refrigeration

When the solar house heating system was designed, it was done so that the solar absorbers and the storage system can be used to drive a specially designed air-conditioning system during the cooling season. The hot water is used in the winter for heating the house and in the summer for air conditioning. A number of systems have been designed in the University of Florida Solar Energy & Energy Conversion Laboratory which can be used in this manner. (See references 8, 9, 10, 11) The systems operate with as low as 50 C water.

The air distribution system to be used with the solar air-conditioning system is already in the house, so only the absorption system has to be added. It is being designed so as to fit the needs of the house. It is planned to add air conditioning as the next step.

After the air conditioning is incorporated into the solar house, a concentrator from the Solar Energy Laboratory will be moved to the house to provide oil at very high temperature which will be stored in a tank. This oil will then, as needed, be circulated around burners of a stove and in an oven so as to allow cooking very similarly as with an electric stove. The electric elements are replaced by coils of copper tubing.

Such an experimental system was operated a number of years ago in our Solar Energy and Energy Conversion Laboratory. At that time, the hot oil was used to operate a refrigerator in which the gas flame was replaced by a hot oil bath. A better and more effective solar refrigerator has, however, been developed since.

9. The Solar-Electic Car

The solar electric car of the Laboratory is not part of the solar house as such but can be considered as part of a system providing the energy requirements for a family, both in the house and the necessary transportation. All this is from solar energy directly and pollution free.

For this purpose solar energy is converted at the present time, into mechanical work by a hot air engine which in turn drives an automobile generator which can charge the batteries of the electric car. This type of conversion from solar energy to electricity is much less expensive than the use of solid state conversion. (12)

A network of "filling stations" each having such converison systems and using them to charge up banks of batteries could, instead of filling the gas tank of a car with gasoline, exchange run down batteries for charged ones to provide the needs of the traveler.

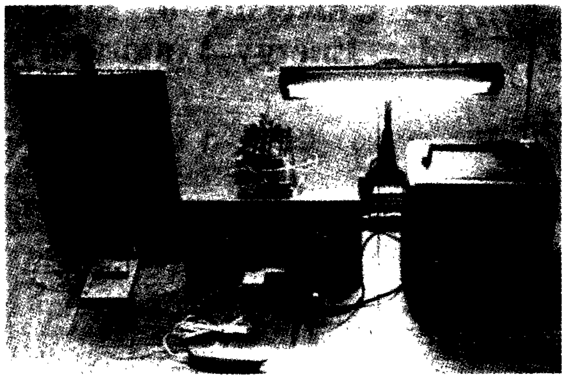

Fig. 7. Solar-Electric Conversion Unit

10. Discussion and Summary

Much more information could have been given if space limitations had not prevented this. (13)

The solar house has now gone through almost two years of being provided by solarly heated water, by a solarly heated swimming pool, being heated by solar energy, having some of its liquid wastes recycled and having some electricity provided on an experimental and demonstration basis. Some of the different systems are reported upon separately in other papers presented at this conference.

The water heating system performed satisfactorily, providing the hot water requirements for the household. The heating system, even though it was not operated all the time at optimum condition, showed that it could provide the heating requirements for the house. Originally it was operated manually and later automated. The heating system was also operated differently to study its characteristics; such as heating all the water in the storage tank to an achievable temperature or only heating a portion to a much higher temperature. The latter was necessary when peak requirements were necessary to be met in the early morning hours during extrme cold snaps.

No difficulty was observed with the recycling plant or the solar to electricity conversion unit.

The air-conditioning system is under study now as well as the solar cooking system. The units which have previously been designed and evaluated in the University of Florida Solar Energy and Energy Conversion Laboratory are being redesigned and modified to fit the requirements of the house. When time and funds permit, they will be incorporated into the operation of the house.

The solar-electric car, which is driven by a staff member to work every day to gain operating data and experience of such transportation under urban traffic conditions, rounds out the problem of providing the energy needs for a family from solar energy.

This is the first time that the University of Florida Solar House has been written up, and to the best of our knowledge, this house incorporates more uses of solar energy than any other in existence. It is mainly intended as a demonstration unit to show how solar energy, our only income of energy and the only pollution free energy source, can be used to satisfy our present energy requirements and needs.

In closing, it might be said again that not all the conversion methods are economically competitive at the present time, but the ones which are should be used as soon as possible wherever they fit in to prevent the wasteful and indiscriminate use our energy resources. Such waste is unwise and a loss to future generations.

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ABSTRACT

The Solar Energy and Energy Conversion Laboratory of the University of Florida is one of the largest of its kind. It is the home of the Solar Calorimeter, and among its activities are the determination of solar properties of materials, solar water heating, solar swimming pool heating, house heating, air conditioning and refrigeration, solar cooking and baking, solar distillation, high temperature applications — solar furnaces, solar power generation both mechanical and electrical, solar sewage treatment and liquid waste recycling, solar-electric transportation, etc.

The laboratory has a solar house where many of the devices developed in the laboratory are being used and their performance observed. It also has a solar-electric car which is driven by a staff member daily to obtain in use performance information.

1. Introduction

Since our civilization is built upon energy resources which have to be classified as savings (fossil fuels are stored solar energy), and these resources are limited, it was decided about two decades ago to establish at the University of Florida a Solar Energy and Energy Conversion Laboratory. Its mission was to study the feasibility of providing our energy needs by conversion of solar energy, our only energy income. This source is readily available, well distributed and does not add anything to the environment when converted into other forms.

The Solar Energy and Energy Conversion Laboratory of the University of Florida is one of the largest laboratories of this kind. It has pioneered in almost all phases of solar energy utilization and is the home of the Solar Calorimeter which provides almost all the information on solar characteristics of fenestrations published in the Handbook of the American Society of Heating, Refrigerating and Air Conditioning Engineers, which is used by architects and engineers.

The objective is to provide the forms of energy which are needed for our daily life by the conversion of solar energy in the simplest manner, using the fewest possible steps along the most direct route. The activities of the laboratory cover: the determination of solar properties of materials, solar water heating, solar swimming pool heating, house heating, air conditioning and refrigeration, solar cooking and baking, solar distillation, high temperature applications — solar furnaces, solar power generation both mechanical and electrical, solar sewage treatment, liquid waste recycling, solar-electric transportation, etc.

The laboratory has a Solar House where many of the devices developed in the laboratory are being used and their performance is observed. It also has a Solar-Electric car which is driven by a staff member daily to obtain in use performance information.

In the following some of the larger projects are discussed.

2. Solar Properties of Materials

The solar laboratory has extensive facilities to study the solar properties of materials, the most flexible instrument being the Solar Calorimeter, Fig. 1, which is essentially a well instrumented black cavity which allows the mounting of materials to be studied as shown. Extensive instrumentation allows the measurement of income energy of high- and low wave length radiation, convection and conduction, and delicate heat balances provided by hundreds of thermocouples. The instrument can be oriented in any desired position with respect to the sun, simulating walls and inclined or flat roofs, or it can be made to follow the sun.

A small weather station and an instrument building go with this instrument. It is possible to simulate winter conditions by use of a refrigeration system and summer conditions by means of electric heaters or ambient conditions if desired. Utilizing the real sunshine rather than artificial sources has been found of considerable value since simulations did not seem to be too reliable.

Materials such as glasses (plain, tinted, coated, laminated, multilayered), plastics (transparent and translucent), glass brick, venetian blinds (some of them water cooled), drapery materials, sun screens of all kinds, etc. have been investigated. (See references 2, 3, 4, 5).

Actual air movement blowers on the instrument can simulate wind conditions for the tests.

Photospectrometers, hot and cold boxes, etc. are also available.

The solar radiation is monitored continuously and this laboratory is the only inland station in Florida with a solar irradiation record of more than two decades.

In addition to the determination of solar properties, the laboratory has exposure test facilities to evaluate the weathering properties of materials. This is often done before studying the materials in detail. Two 1.5 m diameter solar furnaces are used for high temperature work.

Once the true properties of materials are known the best can be selected for the conversion of solar energy into the required forms.

3. Solar Refrigeration and Air Conditioning

One of the real needs is the ability to preserve food. This can

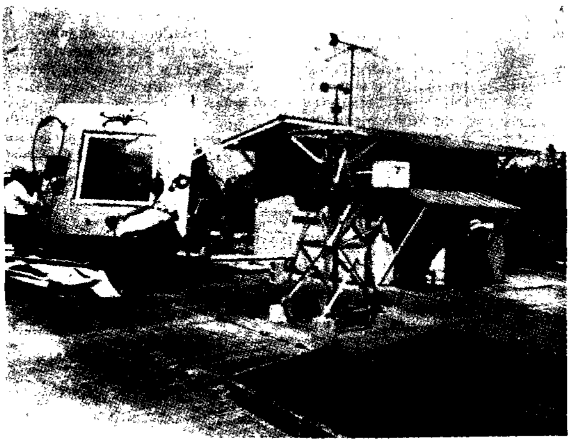

Fig. 1. The Solar Calorimeter

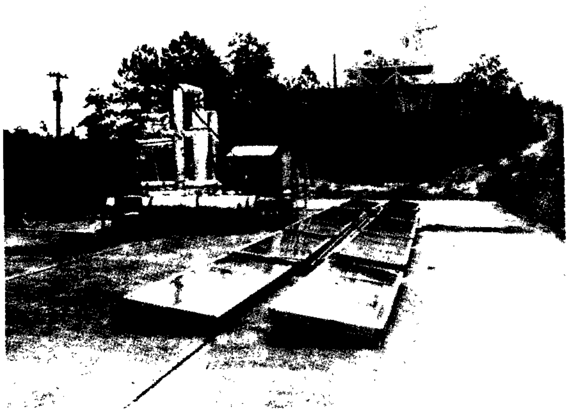

Fig. 2. Five Ton Solar Air Conditioner

be done by solar refrigeration which is ideally matched to the energy supply. Cooling is needed most when the sun shines hottest. Solar energy can be used to drive an engine and then a compressor to provide compression refrigeration, or the heat from solar energy can be used in an absorption refrigeration system. These and a few other systems have been developed in the laboratory.

Steam jet refrigeration was also tried at one time, and oil heated by the sun was used to replace the gas flame of a gas refrigerator. These methods worked but were not considered the best since they required concentration and thus could not utilize the diffuse portion of the solar energy and would not work on cloudy days.

For this reason the emphasis was put on flat plate solar collectors providing the energy to operate absorption refrigeration and air-conditioning systems.

Flat plate solar absorbers heat water which is the energy source for absorption refrigeration or air-conditioning systems. In an ammonia-water system the heat drives the ammonia from solution. The ammonia is then condensed and the liquid expanded. This makes it very cold and able to absorb heat, thus providing the cooling. The warmed vapor is reabsorbed in the water and circulated back to start its cycle over again.

The above process can be carried out intermittently or continuously.

Fig. 2 shows a 5 ton air-conditioning system, Fig. 3 a small solar ice machine which can produce as much as 36 kg of ice on a good day. (2,7,8).

Storage can be provided in the form of hot water, ammonia or ice. The latter has the advantage that it can be moved to different locations and therefore service other than just the immediate area.

The ice machine as a 1.3 x 1.3 m solar collector which serves at the same time as the ammonia generator, not requiring solar water heaters. Its conversion is slightly better since no heat is lost in heat exchangers.

A water driven air-conditioning system is the easiest to combine with a solar heating system permitting double use of many parts.

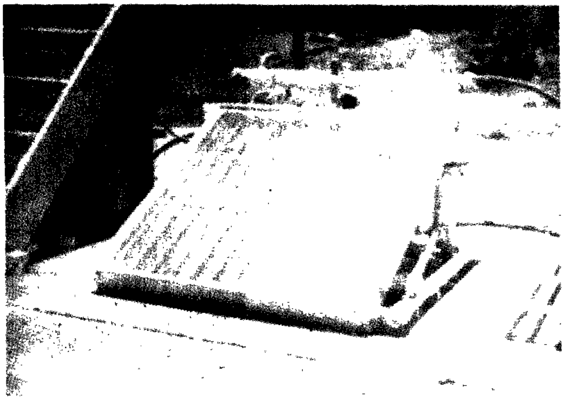

Fig. 3. Compact Solar Refrigerator

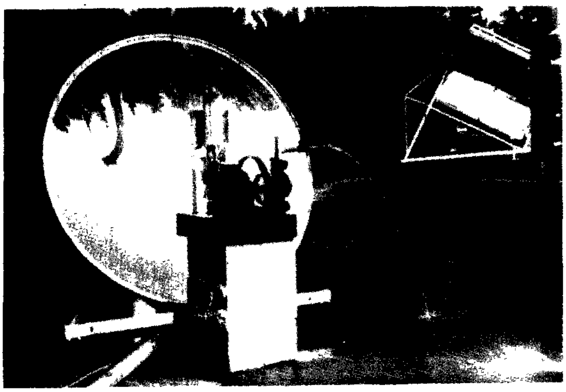

Fig. 4. Closed Cycle Hot Air Engine

4. Solar Power Generation

A rather extensive program in the laboratory deals with power generation. Many engines of different designs and operating on different principles have been designed and evaluated. Some of them do not have moving parts. However, at this time it seems that the vapor and hot air engines have the most promise.

A number of fractional horsepower vapor engines and hot air engines have been built and used to pump water, drive machinery, or drive electric generators to charge batteries for night use or for transportation in the solar-electric car.

The closed cycle hot air engine shown in Fig. 4 can develop about ⅓ horsepower, the limitation not being the engine but the concentrating mirror which is about 1.5 m in diameter. A larger mirror would allow the engine to put out more power. These engines only need a source of heat and therefore can be operated with wood, coal, gas or oil, if nighttime operation is required.

In the closed cycle hot air engine the enclosed air is alternately heated and cooled when brought in contact with the hot and then the cool walls. When the air is hot the pressure is high and the power piston is pushed down; when the air is cool the flywheel returns the power piston against low pressure. A plunger moves the air back and forth between the hot and cool walls. (2,9,10).

In the closed cycle engine the speed of the engine is controlled by how fast the air can be heated and cooled. To separate the speed of the engine from the heat transfer characteristics open cycle engines were designed. Fig. 5 pictures one of those engines.

In the open cycle hot air engine the air is taken in and compressed. It is then moved through a heater where it reaches high temperatures. From the heater it flows through the engine where it is expanded, doing work, and then exhausted to the atmosphere. The engine and the compressor are coupled together. By this method the engine speed and the heat transfer characteristics are independent.

The above two engines require concentration of solar energy and thus need rather good days for operating. Vapor engines have been designed and built which use flat plate absorbers to generate vapor at relatively low temperatures and use it in vapor cycles. The V-2 vapor engine is described in detail in another paper presented at this conference.

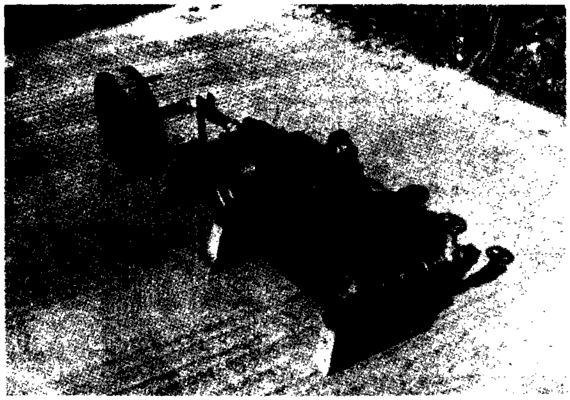

Fig. 5. Open Cycle Hot Air Engine

Fig. 6. Solarly Heated Sewage Digesters

5. Sewage Treatment and Liquid Waste Recycling

Among other applications of solar energy is sewage treatment. It was found that solar energy can be used to keep the sewage digester temperature up to provide more efficient bacterial activity. In this manner the sewage handling capacity of digesters can be considerably increased. Fig. 6 pictures solarly heated sewage digesters which were used in the study.

With fresh water becoming scarce, liquid waste recycling was studied and a small solar distillation unit was installed at the University of Florida Solar House to demonstrate the feasibility of this process. The 2.1 m^2 unit is able to produce up to 11 liters of fresh water on a good day. It furthermore can collect rain water which, in Gainesville, doubles the output. The liquid waste recycling unit consists of a tray holding part of the effluents from the house. The sun shining into this pan vaporizes the water and the steam condenses on the cool glass cover, runs down and is collected in troughs and finally in storage bottles. (2,11).

6. The University of Florida Solar House

Many of the devices developed in the Solar Energy Laboratory have been and are installed in the Solar House, Fig. 7, and observed under actual operating conditions. A married graduate student couple lives in the house which is presently supplied with water heated by the sun, has a solar heating system, a solarly heated swimming pool, a small liquid waste recycling plant and a small solar energy to 110 volt AC conversion unit which allows the operation of lights, radio, TV and small appliances. Air conditioning and a solar cooking unit will be added in the near future. (2).

Fig. 7. The University of Florida Solar House

7. The Solar Electric Car

Fig. 8 pictures the University of Florida Solar-Electric car which is driven every day to work by a staff member and is evaluated under actual urban traffic conditions. The batteries can be charged by solar energy with a hot air engine-electric generator system. (2,12).

Fig. 8. The University of Florida Solar Electric Car

8. Closure

Much more research and development work carried out in our laboratory could be cited but space does not permit this. It has been shown that all forms of energy required in our daily life can be provided by the conversion of solar energy and some of the methods are more competitive with conventional methods today than others. The references will give more detail on this.

As time goes on and the conventional fuel sources become more expensive, the economics of solar energy will become more and more favorable. For this reason it is believed, by the writer, that we will move from a fossil fuel society to an interim nuclear society and ultimately by necessity to a solar society. Then we will truly derive our needs from our energy income.

9. Bibliography

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