The Role of Government in Solar Energy Development: A View from the Northwest

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August 1978

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THE ROLE OF GOVERNMENT
IN
SOLAR ENERGY DEVELOPMENT:
A VIEW FROM THE NORTHWEST

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EXECUTIVE SUMMARY

The federal government has played a major role in the development of America's energy industry throughout the last half century, primarily through such measures as incentive, regulatory, and research and development programs. In the Pacific Northwest it has also been a leading producer of power, as developer of the federal hydroelectric system administered by the Bonneville Power Administration. This report describes the recent efforts made by governments at all levels to include solar energy as a regional and national resource.

A combination of federally-subsidized low-cost hydro-power (an indirect solar resource) and low radiation levels in Seattle has led many observers to describe the Northwest as a region inhospitable to on-site solar heating units. Such conclusions mislead, however, for they omit reference to low-cost passive designs and to areas where both radiation levels and energy costs are higher than that found in Seattle.

In Section I several economic feasibility studies of solar heating in the Northwest are described. They conclude that, at prices greater than (approximately) \$10 per square foot installed, active solar systems will not yield payback periods short enough to be attractive to the average homeowner. (In other words, they will not be "economically feasible.") In 1978 commercially available systems appear to be selling well above this price. Examples of passive solar homes, on the other hand, suggest that a \$5 per square foot cost is attainable. A comparison of solar retrofit in the Seattle and Boise areas emphasizes the need for conservation and points out the savings

which can accrue to an attached greenhouse design when compared with active solar systems. The need for further analysis is critical, however, including performance monitoring for a wide variety of active and passive systems and locations.

Section II develops the case for federal assistance to the solar industry and consumer. A discussion of marginal costs suggests that solar heating in the Northwest could displace new generating requirements at one-half to two-thirds less cost to the utility. Additional peak generating capacity is not likely to be required, given the availability of hydro storage and constraints on rapid solar penetration imposed by slow turnover in systems and equipment. Without a solar subsidy, however, homeowners charged the average cost of hydroelectric power will find the use of expensive solar systems to their disadvantage.

The solar industry is at present competing as a "free market" player in a heavily subsidized industry. The federal government assisted the oil, natural gas, hydro, nuclear, and coal industries with incentives of nearly \$130 billion during the years 1916-1976. By comparison, the solar industry received \$900 million. Areas proposed for federal involvement in an attempt to correct this imbalance are investigated, including direct federal expenditures of \$500 million in FY 79, passage of energy conservation and solar tax credits, passage of a regional power plan for the Northwest, passage of legislation deregulating the price of natural gas and oil, and assistance in an industry-led effort to establish solar system standards and model solar codes. Among the indirect benefits to the U.S.

of pursuing a solar development strategy that have been suggested are: increased employment for American workers; allocation of renewable, low-cost power to developing countries and reduction of the threat of nuclear proliferation; improvements in the U.S. balance of trade position and a related drop in the inflation rate.

Section III details the solar-related activities undertaken by the Northwest states of Oregon, Idaho, Washington, and Montana. Factors contributing to the diversity of programs are: the energy awareness of citizens and their lobbying effectiveness at the state house; the initiative supplied by individual legislators; the funding available to the state energy offices, itself a function of both administrative and legislative priorities; the ability to channel non-state funds (i.e., federal) into alternate energy programs; and the extent to which the general public feels solar can make a contribution in their state.

Renewable energy programming is at its highest in Montana, where 1.875 percent of the state's coal severance tax has been set aside for education, research, and development of renewable energies. This has accounted for an annual program budget of approximately \$1 million. The Oregon legislature has been a national leader in adoption of solar incentive measures. Nonetheless, the Oregon as well as Idaho and Washington non-incentive solar programs are primarily dependent upon federal funds for continuation. Western SUN, a federally-funded regional solar commercialization center to be headquartered in Portland, will play a key role in future state solar funding and, therefore, project prioritization.

Another area of state influence upon solar development is through the rate-setting powers of state public utility commissions. Approval of rate structures which discriminate against solar customers would toll the death-knell for widespread use of solar energy. Such discriminatory measures have been proposed, however, based upon utility concerns for peak generating requirements imposed by solar users without adequate storage capacity. Solar proponents respond that, until widespread adoption of solar systems can occur, the problem is manageable and should not be used to deter those solar systems which can be built in the near term. There will be lead time for storage solutions to develop prior to actual disruption of the utility delivery system.

The final section addresses roles which municipal governments may play either to encourage or to deter the widespread use of solar heating systems. Two major issue areas discussed are the possible impact of building code provisions on solar installations, and the legal guarantee of solar access or solar rights. The section also addresses public and private land use planning controls which are not related directly to solar access, such as regulation of building design and aesthetics. There is a brief discussion of property tax exemptions for solar systems, in particular the difficulties involved in valuing these systems. A final discussion deals with demonstration and community development projects which are sponsored and/or initiated by municipal governments. Examples range from cities striving for

total energy independence through widespread development of solar technologies to a variety of small construction and education projects designed to provide low-income families with solar heating.

The discussion on building codes addresses several issues, including solar market fragmentation due to local variability in codes, difficulties for owner-builders, and the potential for costly regulatory delays involved in solar system compliance with code provisions for new materials and systems. Several examples are given of specific code provisions which could affect passive designs. It is stressed that municipalities should review the impact of their mechanical, plumbing, and building code requirements on various solar system configurations in order to determine the extent of the need for regulatory revision. A number of examples are given of solutions which are currently being implemented, including model solar codes, local ordinance amendments, and statewide code studies. Building codes adopted in New Mexico and in Davis, California are described in greater detail, as each of their unique approaches strongly encourages use of passive design and other energy conserving construction techniques.

Solar access deals with the legal guarantee that a solar property owner will receive uninterrupted sunlight crossing adjacent property. The extent of the shading problem, and therefore the need for regulatory action at this time, has not been fully determined. Nevertheless, many partial solutions have been proposed for implementation in the public

and private sectors, by local, state and federal government. Each of these solutions, including solar easements, zoning revisions, and solar building permit procedures, is described briefly. Examples of approaches which have been implemented at state and local levels are also described. The large diversity of possible solutions suggests a need to focus on and thoroughly develop several of the more widely useful approaches. Valuable direction may be provided by two major federally-funded studies which deal with solar access in developed and in new neighborhoods. These studies are due for completion in late 1978.

One difficulty encountered by local assessors and others concerned with the market value of solar systems stems from their recent appearance on the housing and commercial markets. Another problem arises from the dependence of a solar system's value on long-term energy and economic returns in the context of escalating energy costs. An alternative to assessment based on market value is proposed. This valuing mechanism, based on average system efficiencies and an adaptation of rate of return analysis, would provide for valuation of solar systems in terms of productivity rather than cost.

INTRODUCTION

The material presented in this paper has been developed to supplement the introductory solar workshops presented by Battelle-Northwest to architects, builders, and other interested professionals in the Northwest states. It was funded by the U.S. Department of Energy's Conservation and Solar Applications Division, Technology Transfer Branch.

The summer of 1978 finds the role of government in solar energy development in transition. The Carter Administration is developing a "Domestic Solar Policy", and Congress is debating the wisdom of the Administration's overall energy package. Held as hostage is a popular tax credit measure for energy conservation and solar purchases. At the state level, program planning is poised on the edge of a major new solar thrust to be provided by Western SUN. This regional solar energy commercialization center will provide project funds for individual state efforts to get solar utilization on its way, when the center itself gets on its way. Operations scheduled for June 1978 may begin in late fall. Locally, governments are being faced with demands for solar access and building code ordinances, either as part of a larger comprehensive plan or as separate pieces. They are being asked to demonstrate their own commitment to renewable energy and conservation measures by incorporating these features into their own public structures.

The roles which "government" plays in the development of energy resources, including solar, are so numerous as to make their detailing a work of massive proportions. We hope, therefore, that this overview will bring to the reader an awareness of the pervasiveness of the governmental influence, the importance of trying to shape the policies which define that influence, and an interest in pursuing these issues further through the various references which are cited.

I. AN ECONOMIC OVERVIEW

As a new technology attempting to enter the heating and conditioning market, solar systems have been constrained not only by their unfamiliarity but by their economics. This is especially true in parts of the Northwest where the hydroelectric rates are as low and the resource itself as seemingly abundant as anywhere in the nation. Therefore, to make even modest inroads into either the new or the retrofit building markets a solar system must prove both reliable and inexpensive.

Experience to date has been dominated by the "active" solar heating system; that is, one which uses mechanical means and separate storage areas by which to distribute and "stockpile" the solar radiation it has collected. Because such systems have identifiable elements useful only to the solar heating system itself, their costs have been directly quantifiable. National and regional economic feasibility studies without exception have used these systems to estimate the competitive positions of solar versus conventional heating units. Because of the complexity of active systems, the results of these studies indicate that, at present commercial prices, solar heating is not cost effective in the Northwest.

Such conclusions are incomplete and inaccurate, however, until consideration of passive solar designs has been made. A passive design incorporates the collector and storage areas into the structural elements of the building (e.g., windows, walls, floors, etc.) and distributes the heat thus captured in the living area itself by means of natural heat flow (radiation and convection). Being structural components, the constituent parts of a passive system are difficult to cost-quantify. Nonetheless, definitional attempts have been made to isolate the passive costs from the rest of the building's value, particularly for the purpose of setting

eligibility criteria for solar tax credits. The experience of Northwest homeowners suggests that passive systems properly designed can be cost effective at today's electric rates.

The material presented in this section references the major publications available today on the economics of solar heating in the Pacific Northwest. It has included discussion of the one study known to the author which attempts to compare the economics of passive and active systems. Many more such comparisons are needed for the various climatic areas and solar system designs that are represented in our region before firm conclusions can be drawn, however.

There has been no attempt to select the "better buys" from among specific system types, although variations in cost and effectiveness are to be expected. As in any consumer purchase, the buyer is urged to comparison shop and to consider such items as ease of installation, maintenance costs, service warranties, and product guarantees before selecting a system.

Feasibility Studies Since 1970

In 1970, G.O.G. Iof["] and R. A. Tybout¹ published the first in-depth evaluation of the economic viability of cost-optimized solar heating systems in different locations throughout the country. Since 1975 other major studies,² based upon a simulation model developed at the University of Wisconsin combining climatic data with equipment characteristics, have restructured the analysis to include more realistic and comprehensive parameters of collector costs, escalating conventional prices, interest rates, maintenance expenditures, income tax brackets, etc. In 1977, a state-by-state study prepared for the Joint Economic Committee of Congress used a Los Alamos simulation model of solar performance for an air-type collector

system and assumptions of fixed installation costs.³

In each of the preceding studies, the Pacific Northwest, as represented by fuel costs and insolation levels for the city of Seattle, was found to be uncompetitive with electric heating except in the event that solar system costs installed equalled \$10 per square foot or less. At present, costs of commercial systems installed generally vary between \$20 to \$30 per square foot for an active collection system. Owner-built collector systems may approach the \$10 range, although these are likely to be simple thermosyphon hot water units. Design parameters for a passive system of space heating, which can cost substantially less than \$10 per square foot of collector area,⁴ were not considered in the performance analysis of the previously-mentioned feasibility studies.

The Hydroelectric Subsidy

In many regions of the country solar systems installed at commercial prices are competitive at present with electric resistance heating. For these electric customers, rates increased dramatically over the last five years as utilities faced rapidly escalating fuel costs for their baseload, oil-fired generating plants.

In the Northwest, however, hydroelectric energy (an indirect form of solar power) supplies area consumers with among the cheapest power in the country.⁵ Created in 1937, the net federal investment in the Northwest power market through the Bonneville Power Administration (BPA) has totaled \$5.5 billion in the construction, operation, and maintenance of 28 hydroelectric power projects with a generating capacity of nearly 14 million kW.⁶ Additional capacity of 5,800,000 kW is under construction. This early financial assist from the federal government gave Northwest customers their first taste of the benefits that flow from a combination of federal incentives and solar energy. Because of this historic support,

however, later and more costly applications of on-site solar technology are least competitive with electric rates in the BPA service area.

Recent Northwest Studies

With such consistently unfavorable findings as those reviewed from national studies, the Pacific Northwest has been widely "written off" in terms of the inroads which solar heating and/or hot water applications can be expected to make in its future energy supply. Unfortunately, this perception is held not only by solar model builders outside the area, but also by most residents and potential consumers of the region itself. The figures found in the studies cannot be questioned, of course, for in many areas of the Northwest the consumer does indeed pay among the lowest electric rates in the country. Solar "paybacks" on expensive systems therefore occur only after many years of use, even with assumptions of low maintenance costs and long life. Persons installing such systems today, as a consequence, do so for reasons other than anticipated economic return from the system.

The conclusions are misleading, however, in their use of Seattle-area data as representative both of Northwest climate and Northwest fuel prices. In fact, there are many combinations of higher or lower insolation levels and higher energy costs throughout the region. They also mislead when they imply that \$10 per square foot of installed collector is at present unattainable and only in the longer time frame may be achieved. The analysis of each of the previously cited studies dealt only with active solar systems, whereas both computer simulations and actual operating experience indicate that typical passive systems are as capable as their active counterparts of carrying 50 to 60 percent of building heating loads in the "Seattle/Northwest" area.⁷ The economics of passive solar systems are not so clearly

defined, however, as that developed in the active system studies, because use of the building shell as collector and storage makes system cost quantifying difficult. Nonetheless, proponents suggest that costs can be reduced considerably below that required for the collector/distribution/storage network associated with active systems.

Ecotope/Seattle City Light. A study prepared in the fall of 1977 by the Ecotope Group for Seattle City Light appears to be the first documented attempt to quantify cost comparisons and payback periods for conservation and passive solar systems in the Maritime Northwest climate.⁸ Existing residences in the City Light service area were studied, with present fuel consumption used as the basis for estimating energy savings to be contributed by "super" conservation measures and a proposed passive solar, attached greenhouse design. Building upon this City Light study, Ecotope then prepared the materials presented in Tables 1 and 2 for the DOE/Battelle Solar Technology Transfer program. This latter material expands the comparison to include the energy savings contribution that an active air system could be expected to make if installed in place of the attached greenhouse.

In reviewing these Ecotope tables, the following points should not be overlooked:

- (1) Conservation is a necessary first-step in the design of any solar system.
- (2) The percent of heat supplied by a passive system is comparable to that which an active system will contribute.
- (3) The installed cost of the attached greenhouse design is considerably less than a moderately-priced active, air-type collector system.

Table 1

COMPARATIVE ANALYSIS OF CONSERVATION AND SOLAR SYSTEMS
SEATTLE CLIMATE
(4725 HEATING DEGREE DAYS)

Case #1: Small Home/Remodel 1300 square feet
Present fuel use: 91 mBtu Present fuel cost: \$281/year

System	Capital Cost	Fuel Cost Savings	% Energy Savings	Payback period
Maximum conservation	\$1530	160	57	8 years
Passive Solar	2940	90	32	18 years
Active Solar	6500	110	39	23 years
Conservation/Solar (passive)	4900	210	75	15 years
Conservation/Solar (active)	8100	225	80	18 years

Case #2: Large Home/Remodel 2700 square feet
Present fuel use: 187 mBtu Present fuel cost: \$560/year

Maximum Conservation	\$4950	390	70	10 years
Passive Solar	6650	140	25	21 years
Active Solar	14,500	156	28	27 years
Conservation/Solar (pass.)	12,600	500	89	15 years
Conservation/Solar (act.)	20,400	510	91	19 years

Case #3: New Construction 1600 square feet
Fuel use (FHA standards): 128 mBtu Fuel cost (FHA): \$384/year

Maximum Conservation	\$1270	190	50	6 years
Passive Solar	5200	145	38	20 years
Active Solar	8000	155	41	23 years
Conservation/Solar (pass.)	6500	322	84	15 years
Conservation/Solar (act.)	9500	326	85	18 years

Assumptions: Fuel cost Escalation (present value) 9%
Interest 9% Inflation 6%
Term: 15 year (Remodel); 30 year (New)

Table 2
COMPARATIVE ANALYSIS OF CONSERVATION AND SOLAR SYSTEMS
BOISE CLIMATE
(5750 HEATING DEGREE DAYS)

Case #1:* Small Home/Remodel (Boise Climate) 1300 Square Feet
Present fuel use: 104.4 BMTU Present fuel cost: \$490.00/yr

System	Capital Cost	Fuel Cost Savings	% Energy Savings	Payback Period
Maximum Conservation	\$1530	302	62	5 years
Passive Solar	2940	162	19	13 years
Active Solar	6500	183	22	19 years
Conservation/ Solar (passive)	4900	398	81	10 years
Conservation Solar (active)	8100	410	83	14 years

Case #2:* Large Home/Remodel (Boise Climate) 2700 Square Feet
Present fuel use: 165MBTU Present fuel cost: \$775.00/yr

Maximum Conservation	4950	545	70	8 years
Passive Solar	6650	185	24	19 years
Active Solar	14,500	201	26	26 years
Conservation/ Solar (passive)	12,600	690	89	13 years
Conservation/ Solar (active)	20,400	704	91	17 years

* Cases 1 and 2 are similar to the Seattle examples in Table 1; however, the structures analyzed have a more efficient building envelope (12%) and thus a smaller heat bill in the existing condition. As a result the payback periods are somewhat higher and the potential savings lower than would be found if identical retrofit conditions had been assumed.

Case #3: For this case (new construction), a well-designed solar home should be better adapted to the particular heating and solar climate of Boise. Therefore direct comparison with the Seattle structure would be inaccurate and misleading and has not been calculated here.

Assumptions: Same as in Table 1

(4) Although the Boise climate is more severe than Seattle's, the higher fuel costs and winter radiation levels in Boise bring reduced payback periods to solar investors in that Idaho City.

(5) The importance of climate-specific solar design cannot be underscored enough, particularly with passive systems. When optimizing for climate, a new construction design for Portland should not be repeated in Spokane or Bozeman, for example, although the basic floor plan may incorporate very similar features. Certain cost differentials may therefore be involved, and these variations must be recognized in making cost comparisons between regions.

(6) The figures for percent energy savings in each case are estimated. The "super conservation" and solar technologies had not been retrofitted to the structures; therefore, no actual performance data was available for the analysis.

(7) The payback periods appear long. However, the housing consumer does not ordinarily purchase housing services on the basis of payback periods; rather, on his/her ability to make the overall monthly house payment (including utilities). Solar-related amenities (e.g., a solarium or greenhouse addition; energy-efficient or other unique design features; radiant heat comfort; etc.) may well justify slightly higher monthly payments, if such are involved. Furthermore, the solar amenities may substitute for other high-cost features found in conventional homes, therefore incurring no additional costs to the solar homeowner.

The value of the Ecotope analysis is particularly high when one considers that its focus included retrofit applications. It is in the existing housing market that the greatest energy-saving potential lies, given the slow turnover rate and the large volumes involved. (For

example, less than one percent of the housing stock is replaced in the Seattle City Light service area each year by new construction.) Yet, it is also the most difficult market to penetrate with solar applications, because of improper orientation, inadequate design, and poor solar access. The attached greenhouse concept appears to be more readily adaptable to design limitations presented by existing structures than such passive systems as the thermal wall or direct gain.

Useful as the case study approach of the Ecotope work is, further analysis must be made in terms of actual performance monitoring, cost comparisons of various types of passive designs, a more detailed estimate of active system costs, and adaptation over a wider range of climatic areas. In addition to expansion of the single-family residential solar cost studies, the whole area of commercial and multifamily structures has yet to be evaluated in terms of solar applications, their integration into new and retrofit designs, and their cost effectiveness.

Interagency-Region X. A study prepared in 1977 by the Region X and Richland Operations offices of the U.S. Department of Energy and the Environmental Protection Agency is the first to specifically treat the variations found both in climate and in regional electric prices in the Pacific Northwest.⁹ Its section on regional radiation resources found that the Seattle climate is on average a slightly more suitable solar heating area than such places as Spokane, Washington and Great Falls, Montana, when average daily solar radiation during the heating season is divided by the heating season's average monthly heating degree-days for these areas. Furthermore, when measured in these terms, it is even 15 percentage points better than such other northerly cities as Schenectady, New York; Chicago, Illinois; and Madison, Wisconsin. In areas of the Northwest which have

both greater winter radiation levels and a moderate heating season, such as Richland, Washington; Medford, Oregon; and Boise and Twin Falls, Idaho; the Seattle ratio predictably drops approximately 20 percentage points behind. These figures, coupled with the solar heating load simulations developed by the University of Oregon (see Footnote 7), lend theoretical support to the experience of solar pioneers in the Pacific Northwest, who have found that solar heating does work, and work well, in spite of the national misconception.

The Region X study did not address the economic feasibility of a given solar system in any one area. Instead, it used F-Chart analysis to cost-optimize active system design over a range of electric prices, from one to five cents per kWh and over a range of system costs, from \$5 per square foot to \$30 per square foot. For any given location or single-family energy use (hot water, new or retrofit; hot water and heating, new or retrofit), the reader could then determine the years-to-break-even given existing energy costs or any projected increase in "real" energy prices. In Seattle at electric rates of one cent per kWh, an active heating and hot water system would pay back in 8 years at a square foot cost installed of \$5 (a cost which at present only passive systems can meet). In other cities analyzed, expenditures of \$5 per square foot would pay back in even shorter periods of time for cost-optimized systems (designed to meet at least 40 percent of the energy load). However, for system costs of \$20 per square foot or more (generally believed to be the lower limit of commercially-available active systems in 1977), a hot water and heating payback period of less than 15 years would require an equivalent electric rate structure of three cents per kWh or more in all areas studies.

The conclusions of the DOE study for the Northwest region were

surprising to many in their assertion that solar heating systems have the potential for cost effectiveness in the "dark, rainy winters" of the Pacific Northwest. Particularly to those interested in passive solar design, a tentative conclusion that passive could be cost effective at today's electric rates, although unquantified, was heartening. To those faced with solar applications that are not rock-bottom cheap, however, the study only reconfirmed the suspicion that solar heating at present utility costs will take years to pay back. If economics is the only criteria for adoption, then the unsubsidized Northwest solar market is still limited except in those areas where energy costs are relatively high.

WSU/Northwest Energy Policy Project. Conclusions similar to the Region X study were reached in an energy policy report prepared by Washington State University for the Pacific Northwest Regional Commission.¹⁰ At present electrical rates and fossil fuel costs, neither an active solar collector unit nor a solar-assisted heat pump were found to be competitive with conventional fuels. The potential cost competitiveness of passive applications, while not quantified, was considered an exception to this finding.

REFERENCES TO SECTION I

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2. Arthur E. McGarity. Solar Heating and Cooling: An Economic Assessment. 1975. Available from the U.S. Government Printing Office, Washington, DC 20402. Stock Number 038-000-00300-3.

Energy Research and Development Administration, Division of Solar Energy. An Economic Analysis of Solar Water and Space Heating. November 1976. Available from the U.S. GPO. Stock Number 060-000-00038-7.
3. William D. Schulze, et al. The Economics of Solar Home Heating. January 1977. A study prepared for the use of the Joint Economic Committee. 95th Congress, 1st Session: Joint Committee Print. Available from U.S. GPO.
4. Three passive solar homes in the State of Washington provide a reference for comparison. (1) In Western Washington, the 1500 sq. ft. Strickler home utilized direct gain windows, nighttime insulation, bermed construction on the north, east, and west walls, and rigid polystyrene on the exterior of its concrete walls to provide over two-thirds of its winter heating requirements. The backup heating system of two free-standing electric heaters had an operating cost of \$5 per month during the 1977-1978 heating season. Because the solar elements were so integral to the design of the home, no extra expense was attributed to the solar heating system. The entire cost of this very livable and pleasant home was \$18 per square foot in 1976. (2) A second home in Western Washington incorporated 12" of concrete wall and glazing into an otherwise frame construction to utilize a Trombe wall system for winter heating. Electric baseboard backup for this 1800 sq. ft. home cost \$4 per month, with an additional two cords of wood consumed in a Fisher fireplace. Construction costs for the Trombe wall were \$6 per square foot, including concrete, labor and glazing. (3) The Eastern Washington Parry home of 1675 square feet has been designed to provide over 60% solar space heating, also by means of a Trombe wall. The house has not yet been occupied during a heating season, so operating costs are unknown. The overall housing cost met the \$35 per square foot criteria of the average price of new housing in the area. The costs attributed to the Trombe wall were approximately \$5 per square foot.
5. The 1976 ERDA/MITRE report referenced in Footnote 2 estimated, for example, that the cost of delivered heat to the electric consumer (in dollars per million BTU) varied by a factor of nearly three in the Seattle and Dallas/Fort Worth areas. The Dallas consumer paid the second least expensive rate of the 13 cities studied, with customers in other areas facing even higher relative prices: rates nearly four times greater in Washington, DC, Los Angeles, and Miami; five times larger in Boston; and eight in New York City. The differential in oil prices (again in \$/MM Btu for delivered heat) from city to city was barely noticeable. Even in natural gas the widest

variation was less than a factor of three.

As a point of reference, the lowest fuel prices used in the ERDA/MITRE study, and the areas in which they were found, are as follows:
ELECTRICITY-\$2.79 - Seattle; OIL - \$4.08 - Dallas/Ft. Worth; GAS - \$1.87 - Bismarck. (Table A-II, Page A-5).

6. B.W. Cone, et al. An Analysis of Federal Incentives Used to Stimulate Energy Production. March 1978. Page 157. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151. Stock Number PNL-2410, UC-59.
7. J.D. Balcomb, et al. "Passive Solar Heating of Buildings." Page 18. Printed in R. P. Stromberg, et al. Passive Solar Buildings: A Compilation of Data and Results. August 1977. Available from NTIS. Stock Number SAND 77-1204.

E. Mazria, M.S. Baker, and F. Wessling. "The Performance of Passive Solar Heated Buildings in the Pacific Northwest." 1977. Included in the passive supplementary materials distributed at the DOE/Battelle workshops for architects and builders. Available from Ellwood Werry, Battelle-Northwest, Richland, WA 99352
8. Ecotope Group. Solar/Conservation Remodel Candidates for Seattle City Light. November 1977. Available from the authors for \$8.00. Ecotope Group, 2332 East Madison, Seattle, WA 98112.
9. U.S. Department of Energy (Region X and Richland Operations Offices) and U.S. Environmental Protection Agency, Region X. Solar Energy for Pacific Northwest Residential Heating. May 1978. Available from U.S. DOE Region X, 915 2nd Avenue, Federal Building Room 1992, Seattle, WA 98104.
10. Washington State University. Energy Conservation Policy - Opportunities and Associated Impacts. Study Module I-A of the Northwest Energy Policy Project. Funded by the Pacific Northwest Regional Commission, 1205 Washington St., Vancouver, WA 98660. Available from NTIS.

II. FEDERAL POLICY ISSUES IN SOLAR ENERGY DEVELOPMENT

Until recently the only role played by the federal government in solar energy development was to ignore it while continuing support of the oil, natural gas, coal, and nuclear power industries. Following the 1973 oil boycott, however, a direct solar assist in terms of research and demonstration projects was begun. Since then public information programs at the state and local levels have benefited from federal funding, and a fledgling "commercialization" effort in support of the solar heating and cooling industry is presently underway. The potential contribution that use of the sun's energy can make toward meeting U.S. energy needs is now recognized by both legislators and administrators in our nation's capitol.

This section discusses several of the issues surrounding federal commitment to an accelerated program of solar development. As the government continues to debate a national energy policy, the early momentum of the solar industry falters while customers wait for assurance of federal tax credits. The economic outlook for solar in the Northwest presented earlier will be greatly enhanced if the promised conservation and renewable tax credits are forthcoming. Another federal action that is likely to impact directly upon solar economics and utilization in the Northwest is resolution of the debate over new rate structures for the federal regional power system.

An Increasing Marginal Cost Economy and Solar Competitiveness

An investment in solar energy, if expensive, does not make present economic sense to many Northwesterners. But even if they buy a less expensive system, can they be assured it will last through the anticipated

payback period and operate as efficiently as projected? Their solar-heated homes are actually energy production units. They are being asked, however, as the industry is still moving up its learning curve and fluctuations are occurring in manufacturing quality, design characteristics, and installation practices, to bear the full risk of their investment. Society has not yet institutionalized a "reward" mechanism for on-site solar energy producers in the manner that it did for the petroleum and natural gas extractive industries.

Is there any societal value in doing so? The incremental cost of adding new energy units to the existing power system suggests that there is. To the homeowner looking at gradually increasing average electric costs over the next 15 years, the future "incremental cost" of continuing to use electric heat may be lower than the payback period on an investment for solar heat. To the utility, on the other hand, the combined capital and operating costs required to bring future energy units into the system will have substantially higher costs, per btu produced, than the homeowner's solar investment. Assuming that increased solar usage results in decreased power plant expansion requirements, then the society would benefit by reduced overall capital requirements if homeowners invested in that which would be individually uneconomic.

In Table 3, which illustrates the historical increase in energy costs, fuel costs for heating oil and natural gas are given as they appear to the end user of each fuel.¹ Electricity costs over the three time periods, on the other hand, illustrate the large differential between the average cost of hydro-generated electricity, the cost of power generated by thermal plants of recent construction, and the cost of power generated by plants ordered today with an expected completion date of 1985.

Table 3

FUEL COSTS--PAST, PRESENT AND FUTURE

<u>Past</u> ¹	<u>\$/mmBtu</u>
Oil (1950)	1.57
Gas (1960)	1.00
Electricity (hydro, 1970)	2.30
<u>Present</u> (Seattle 1977) ¹	
Oil	4.70
Gas	4.75
Electricity (thermal) ²	7.90
<u>Future</u> (1985)	
Oil ³	7.60
Gas ⁴	7.60
Electricity (thermal) ⁵	14.00 - 15.00
<u>On Site</u>	
Conservation	1.50 - 3.00
Heat pumps ⁷	5.00 - 6.50
Solar passive	4.50 - 8.50
Solar/conservation (passive)	3.00 - 5.00
Solar active	7.00 - 13.00
Solar/conservation (active)	5.50 - 10.00

¹Figures developed from survey of Seattle suppliers

²Reference plant: Portland General Electric (PGE) Trojan nuclear plant

³Price to Northwest consumers expected to increase to level of present world price

⁴Canadian gas agreement with U.S. calls for natural gas cost to equal world oil prices by 1983.

⁵Reference plants: Washington Public Power Supply System (WPPSS) Satsop nuclear plants, on line 1985.

⁶For the methodology used in deriving these figures, see Ecotope's study for Seattle City Light (Footnote 8)

⁷Seattle City Light estimate

By comparison, the dollar investment per million btu's for on-site generation from solar/conservation technologies can be seen to be larger than the cost of hydro, but competitive with the cost of present thermal power plants and well beneath the investment required for future generating plants. To the extent, then, that electricity is used for heating residential and other structures when solar units could supply a major portion of that heat, there is potential for deferred construction of new, higher-cost electric power plants.

A recent analysis by George Hinman of Washington State University supports this assumption by suggesting that the presence of excess peaking capability in the Northwest provides a natural base in which to integrate an intermittent energy source such as direct solar or wind power.² The storage problem associated with solar in many other regions of the country can be resolved through the use of hydroelectric power "stored" behind the dams until peak demands require generation. Therefore, through the prudent administration of two solar resources, one direct and the other indirect, the Northwest could continue to experience relatively low power costs as the higher capital and operating costs of new thermal plants is deferred.

Large-scale conversion to on-site solar heating and hot water applications will not occur, however, if the economics to the individual home or building owner remain unfavorable. Subsidies to the adopter of solar systems would therefore be in order. The Hinman paper suggests that funding could be provided through a surcharge of 0.5 mill per kWh to hydroelectric customers of the Bonneville Power Administration, who currently purchase at an average price of about 3.5 mills per kWh. 3.5 mills is a factor of nine below the cost of new thermally-generated power.

Congressional energy committees are presently considering a new

regional power bill which proposes to revise the rate structure of the Northwest's federal power supply system and to set an investment preference policy for conservation and renewable energy resources. Under this system BPA would continue to distribute energy from federal hydro projects, but it would be given additional authority to finance conservation and renewable energy programs, to build power plants using renewable resources, and to buy electricity produced in private power plants. Residential customers of investor-owned utilities would be eligible to receive low-cost federal electricity.³

Opposition to the Senate Energy and Natural Resources Committee bill has come from public utilities, who feel that the "preference clause" assuring low-cost public power to public utility customers is in jeopardy. Other opponents fear that it does not allow sufficient public input to BPA decision-making--and that the bill was hastily drafted and requires careful review of details. Private utilities appear satisfied in principle, concerned about specifics, but supportive of passage.⁴ Should the measure be enacted, it appears that a solar utilization policy for the Northwest may be one ramification. It is too early to say to what degree or in what direction BPA would travel in its promotion of renewable energy sources.

Federal Subsidies to Non-Solar Energy Sources. If achieving more favorable economics for solar utilization is the objective, then one alternative to raising the price of competing energy sources is to provide a direct federal subsidy to the solar user: to reward the "producer" of a valuable national commodity, energy, for an action that would normally be too risky and/or uneconomical to undertake has firm precedent. The mix of energy used today is the result of billions of dollars of market manipulation by the federal government in its effort to encourage the increased

production of coal, gas, oil, nuclear, and hydro power. A study prepared by Battelle-Northwest found that the total federal expenditures from 1916 through 1976 in the energy market--that is, the "incentives" given primarily to private industry in order that the American consumer might continue to have inexpensive and abundant fuel--approached \$130 billion.⁵ By fuel source subsidized, these expenditures were estimated as follows: oil, \$77 billion (\$40 billion in the form of tax reduction, \$30 billion in direct disbursement); natural gas, \$15 billion (\$11 billion in tax reduction, \$3.5 billion in disbursements); nuclear, \$15-\$17 billion (nearly all expended on RD&D programs, "nontraditional government services"); hydro, \$9-\$17 billion (100 percent expended in direct market activity, including production, transmission, and marketing); coal, \$7 billion (\$3 billion to the depletion allowance). Each fuel's percentage "take" of the total estimated cost of incentives is as follows: oil--60%; natural gas--12%; nuclear--13%; hydro--10%, and coal--5%.

In addition to the incentives just described at the production level, a substantial subsidy at the point of end use occurs through the business tax laws, affecting commercial, industrial, and multi-family rental units. A recent study by the Department of Energy points out that federal tax provisions allow commercial firms to treat the costs of conventional fuels as direct expenses, thus reducing the cost of these fuels by up to half. It concludes that "This is the single most important deterrent to the commercial use of solar water and space heating by business firms, and is not counter-balanced by depreciation allowances of solar equipment."⁶ Therefore, through federal entry into the conventional energy market, the relatively unsubsidized solar industry presently has to compete not only with average fuel costs that are artificially lowered but with

federal tax inducements to the business community to continue using depletable fuels.

Federal Assistance to Solar Development

The federal government's investment in the development of solar energy stands in sharp contrast to the well-developed but still heavily-subsidized conventional energy industries: 1974--\$15 million; 1975--\$43 million; 1976--\$115 million; 1977--\$294 million; 1978--\$390 million; for a total of \$857 million. Through 1978, all federal solar incentives have consisted of indirect assists to producers, primarily inducing production through RD&D, information transfer, and federal procurements activities. The end user has benefited from information transfer through such programs as the national hotline for solar heating and cooling information and the many conferences and workshops having federal sponsorship.

Neither the end user nor the producing industry has received such direct financial inducements as tax reductions or exemptions, however, items which historically comprised over 40 percent of the cost of federal incentives established to increase conventional energy production. In a developing industry like solar, the obvious advantage to this incentive is that it constitutes future federal revenue foregone rather than actual appropriation from existing budgets.

Federal Solar Budget. The budget proposed by the administration for FY 1979 is illustrative of the areas in which federal solar support has been centered.⁷ There are two program divisions in the Department of Energy (DOE) through which all federal solar programs are channeled: (1) Research and Technology Development and (2) Solar Applications. While such diverse federal agencies as Housing and Urban Development (HUD),

the National Atmospheric and Science Administration (NASA), the Department of Defense (DOD), the National Bureau of Standards (NBS), the General Services Administration (GSA), and Health, Education, and Welfare (HEW) all have solar program elements, each is accounted through the Department of Energy budgeting process. Therefore a central monitoring of all federal expenditures on solar is possible.

The new agencies created to deal exclusively with solar energy development (the Solar Energy Research Institute in Colorado and the four regional commercialization centers in Oregon, Minnesota, Massachusetts, and Georgia) are each allocated funds through the various DOE programs listed below. There is no specific Congressional or Departmental set-aside for implementation of their special agency functions.

Research and Technology Development Division. The 1979 solar budget proposed for this division by the Administration in February 1978 included the following items:

Solar Thermal Electric	\$ 69 million
Photovoltaic Energy Conversion	76 million
Wind Energy Conversion	39 million
Ocean Thermal	32 million
Biomass	27 million
Direct Thermal Applications	44 million
Technology Support	<u>14 million</u>
Subtotal	<u>\$ 301 million</u>
To which is added capital acquisition (solar thermal electric)	<u>34 million</u>
TOTAL	<u><u>\$ 335 million</u></u>

As the material prepared in this report deals primarily with solar heating and cooling applications, only the "direct thermal" and "technology support" expenditures will be discussed in more detail.

Among direct thermal applications, \$33 million is allocated to heating and cooling research. Programs begun in previous years include research on seasonal storage, cooling systems, control systems, solar design processes such as F-Chart and SOLCOST, new collector designs, thermal storage advances, and heat pumps. Many of these will continue, but an additional emphasis in 1979 will be placed upon passive systems and retrofit applications.

The remaining \$11 million is proposed for the areas of agriculture and industrial process heat. The objective of this research is to develop solar technology capable of supplying heat energy for food processing, grain drying, crop drying, livestock shelter heating, commercial greenhouse heating, and process heat producing steam in the range of 350 to 600 degrees F. Industrial demonstrations funded in the past have included solar heating for lumber drying, can washing, prune drying, soybean drying, fabric drying, textile dyeing, and concrete-block curing.

Into the technology support and utilization programs fall such activities as technology transfer and the study of barriers and incentives to solar development. Included in DOE "tech transfer" accomplishments has been the sponsoring of conferences and workshops dealing with various elements of solar development throughout the country; regional solar technology transfer programs administered through the national laboratories designed to meet the informational needs of "multiplier" groups such as architects, builders, lenders, educators, etc.; development of an installer's home study course now available through the Home Study Institute of Columbus, Ohio (a division of North American Heating and Air-conditioning Wholesalers Association); community college instructional materials developed by Colorado State University in the design, sizing,

installation, and operation of active solar systems; and distribution of solar science curriculum for grades K-12. Within the barriers and incentives workscope has been the development of analyses on legal and institutional roadblocks to the rapid commercialization of solar heating and cooling. Included are studies on solar access (sunrights), federal incentives to energy production, and an economic analysis quoted on page 20.

Also included in the technology support program is an environmental and resource assessment category which includes, among other activities, climatic monitoring and data dissemination services. One recently announced program of considerable interest is a pilot solar index which will present solar radiation data to the general public in 13 cities through radio stations and newspapers. An index scale of 1 to 100 will be used to indicate how much of the hot water heating load of a family of four (using 80 gallons per day in a single-family residence) solar equipment could have provided. Data will be computed from SOLCOST, the computer-based design method developed under the Direct Thermal Applications program. If the test is successful, distribution to other cities (which may bring it to the Northwest) is expected.⁸

Solar Applications Division. This division deals with solar technologies that are already at the commercialization stage and need only government assistance in the form of public confidence-raising and data-gathering demonstrations, federal procurements to decrease prices through larger production runs, institutional barrier removal through accelerated information transfer and problem analysis, consumer protection through standards development certification programs, etc. To achieve these objectives, the Administration's proposed expenditures for

FY 1979 assigned \$36 million to its heating and cooling demonstration program, nearing the end of a 5-year cycle begun in 1974; \$26 million to a federal buildings solar demonstration program; and \$3 million to solar commercialization, complementary to the technology transfer and barriers and incentives analysis functions, for a total solar applications appropriation of \$65 million.

The heating and cooling demonstration program has been developed in cycles, allowing industry to respond to each new grant series with the latest in technical efficiency and cost effectiveness. All grant projects will be instrumented and extensively monitored, with data analysis and dissemination to industry and the general public a major objective of the program. A wide variety of program elements have been accomplished to date: implementation of over 200 commercial projects and 500 residential projects involving over 9,000 housing units; development of a solar hot water initiative program in 11 states which will award \$400 grants to approximately 10,000 homeowners; implementation of a solar hot water initiative for 50 hotels/motels and 8 health care facility demonstrations; establishment of a National Solar Data Bank; and operation of a National Solar Heating and Cooling Information Center for the dissemination of solar information through a toll-free hotline, nationwide networking, technical advice, and mailing service.

As described in DOE's statement before the appropriations committee, the goals of the federal buildings program are (1) to increase hardware production capacity and lower production costs, (2) to add to the experience of local installers, (3) to introduce the federal government into the solar market as a major consumer, and (4) to provide maximum public visibility in areas where solar markets have a high probability of flourishing.

The program is expected to result in the installation of 2-3 million square feet of collectors over the life of the program and represent a significant fuel savings. DOE will choose agency proposals which provide the widest variety of building types, geographic locations, and solar applications to achieve program objectives. All federal agencies are included, with lead participation from those with large construction programs, such as DOE, GSA, VA, and NASA. Solar adaptations of approximately 150 buildings are planned for the years 1978 and 1979.

Additional Solar Budget Items Proposed. Feelings in Congressional energy committees following submission of the Administration's \$400 million budget ran strongly in favor of larger increases for federal solar expenditures. The pro-solar statements made by the President during his election campaign and in his National Energy Policy programs appeared to many legislators to have been compromised by inflation and concern for a balanced budget. Therefore, when the FY 79 budget was submitted to Congress for approval, both the House and Senate committees reviewing it marked it up by considerably more than \$100 million. Among the solar programs earmarked for the largest additional funding were wind, biomass, photovoltaics, and demonstrations (in particular, passive).

From the Solar Coalition, a loosely-organized group of solar advocates from the staffs of over 60 House members and several Senators, additional legislation was proposed to establish such solar market development activities as a low-interest solar loan bank; a major photovoltaics purchasing program for use in federal buildings and to power electric fleet vehicles; a small business loan program; authorization for a large-scale agricultural RD&D plan; establishing an Office of Small-Scale Technology in DOE; requiring the conversion to solar of 30 percent of

federal installations by the year 2000; and facilitating the transfer of alternate energy technologies to foreign countries, particularly the less-developed areas.⁹

Responding to this strong pro-solar sentiment, the President announced on Sun Day (May 3) that \$100 million would be shifted to solar development in the DOE budget for FY 79. Included in the appropriations were \$30 million for additional photovoltaic research, \$20 million for wind machine demonstration, \$10 million for fuels from biomass research, \$20 million for a low-head hydro power program, and \$5 million each in the areas of appropriate technology grants, dispersed energy systems demonstration, passive solar heating and cooling, and solar training and education.¹⁰

This "renewable" allocation was a part of a larger "energy supply initiatives" introduced by DOE to lessen U.S. dependency of foreign oil by 1985. In a tough anti-inflationary stance, the Office of Management and Budget rejected DOE's request for \$368 million in new FY 79 money to begin the supply initiatives program. In order to get its program moving, DOE cut expenditures in other program areas and postponed a portion of its initiatives program to FY 80. Solar programs were the lopsided winners in the resulting allocations for 1979, with only \$30 million considered for other fuels, specifically unconventional natural gas and high-Btu coal gas development projects.¹¹

Solar Market Studies. Bolstering the confidence of these solar supporters were several recently-published, government-sponsored studies. The Administration's Council on Environmental Quality (CEQ) presented the most optimistic outlook, estimating that with a strong national commitment to conservation measures, the U.S. could be supplied by solar

with 25 percent of its energy needs in the year 2000 and "significantly more than half" by 2020.¹² A congressional Office of Technology Assessment (OTA) assessment did not estimate percent of solar-supplied energy, but suggested in its look at decentralized "on-site" technologies such as photovoltaics and solar heating and cooling that solar energy can be meeting substantial portions of energy load within ten years.

Both the CEQ and OTA studies felt that solar was about to enter a flourishing new phase, but that without aggressive federal support its contribution to national energy supplies would fall far short of what now seems technically and economically achievable.¹³ Each analysis emphasized that existing federal energy policies controlling fuel prices and subsidizing non-solar sources have placed solar at a serious competitive market disadvantage. As a result, economic comparisons between solar and other energy technologies are inherently unfair unless replacement cost pricing for alternate fuels is used and some type of energy-production subsidies for solar are imposed.

Solar market penetration studies prepared for the Department of Energy by SRI International and Mitre Corporation also considered solar to be an important energy source in the years ahead. Although not so sanguine in the solar promise as CEQ, they nonetheless foresaw a future in which 6 percent to 9 percent of all U.S. energy supply could be derived from solar sources by the year 2000. The technologies which each study agreed would lead the solar supply effort during this time were solar heating and cooling, wind, and biomass. There was no agreement, however, over the potential contribution of photo-voltaics and central thermal station technology, with SRI favoring the cost potential of photovoltaics and Mitre assuming a more favorable

economics from the "power tower" concept. The Mitre study projected the industrial market to be the largest solar user of all, while SRI felt that institutional barriers, particularly tax disincentives, would minimize industrial interest in the foreseeable future.¹⁴

Solar and National Energy Policy. Throughout this section the evidence has been building that the public's market response to solar today is tempered not only by their perceptions of its technological capabilities but by national energy policies of the past. The future of solar utilization will continue to be shaped by what is done at the federal level, and debate over federal energy policy is presently underway in Congress and at the White House. Criticized as not having "an energy policy," the preceding discussion demonstrates that the U.S. has indeed had one for years: that is, to encourage the development of fossil fuels and power plants of all kinds so as to make energy available everywhere at a price which all Americans could easily afford.

It is in the context of policies which keep the lid on competing fuel prices that the annual budget appropriations for solar development should be placed. Whether a budget is \$400 or \$500 million will not define a "solar policy" guaranteed to make even the most modest of solar market penetration studies come true.

The President's National Energy Act (NEA) consists of five elements: (1) conservation, (2) coal conversion, (3) utility rate reform, (4) natural gas pricing, and (5) taxing policy. The items aimed directly at solar utilization consist of tax credits for those installing solar units, a federal procurements program, and prohibition of utility rates which discriminate against the solar user. Such items in themselves will bring the economics of solar utilization closer to a competitive position with

conventional fuels. The policies in the energy plan most likely to accelerate the adoption of solar technologies, however, do not speak to the issue of solar utilization at all, but propose to gradually lift the federal price regulations from conventional fuels. It is over these policies that the "Great Debate" has centered, and it is Congress whose feet are dragging.

Among the thorniest issues is the proposal to deregulate natural gas prices--which has been debated and rejected for decades. After a year and a half of seemingly intransigent deadlock, a compromise was reached in May of 1978, with agreement made to let prices rise slowly until they meet the market level in 1985. By August the fragile accord appeared to be unraveling once more. The fifth element--tax reform--contained another uphill battle: a proposal to place a crude oil equalization tax upon wellhead oil, designed to increase the price of domestic oil to the world market level (a surrogate for replacement cost). In the 95th Session of Congress, this issue appeared dead at the time of writing.

Passage of all elements of the NEA because they inherently encourage solar utilization is not rationale enough for a majority of Congress members, of course. Increasing the real price of America's fuel will induce major lifestyle and industrial changes that will have far-reaching impact, given our past and present fuel-inefficient ways of life and of doing business. Decisions to increase the price of oil and gas will place the burden of energy value realignment directly upon the low- and middle-income American. Measures to moderate this impact would be in order, but such implementation programs may prove difficult to reach Congressional agreement upon and potentially cumbersome to administer. The caution felt by many in Congress at beginning such a transition

may in the end halt passage of the National Energy Act. Not only would the market realignment of fuel prices be postponed or lost, but the direct subsidies to the solar user would be passed over as well.

Attempts to extract the conservation and solar tax credits from the overall NEA tax elements can be expected, if the Act fails to pass, to be amended to other tax bills. In the meantime, serious concern is being raised over the health of the heretofore vital solar heating and cooling industry. The number of collectors manufactured during the last half of 1977 dropped by 13 percent, the first decline ever recorded. Sales picked up slowly in 1978, at about half the growth rate that was experienced in preceding years. California sales have remained high due to that state's 55 percent tax credit. Elsewhere, however, consumers are waiting for passage of the solar tax credit.¹⁵

Solar Energy Program Policy. Whether or not solar energy finds a comfortable and equitable fit within the mix of national energy policies, the federal government must continue to administer a program of solar research, development, and demonstration that at present amounts to nearly half a billion dollars annually. Through the initiative of CEQ and other solar advocates, a Domestic Policy Review by Cabinet-level officials and White House representatives is presently being developed. The recommendations of this review will become the basis for the President's "National Solar Strategy," to be released in the fall of 1978 in time to affect the FY 80 budget.

Ten regional policy forums were scheduled throughout the country during the month of June. They were billed as an opportunity for those interested in solar's accelerated development to share their views in

testimony and panel discussions with framers of national energy policy. The six major policy areas to be considered were: (1) Solar Impacts (including goals for use of solar); (2) Federal Operations (role of federal power agencies); (3) Financing (including federal tax policy); (4) Regulations and Incentives (including state and local barriers to commercialization; evolution of new commercial and community organizations); (5) Research, Development, and Demonstration (allocation of people and money in current programs; balance between RD&D); and (6) International (potential benefits of cooperation in solar development; foreign policy implications for reducing world demand for non-renewable energy sources).

Within the solar community, considerable debate is occurring over the federal research mix of large, centralized solar technologies such as thermal electric, large wind machines, and solar satellite power stations and of decentralized, on-site technologies such as passive heating and cooling, photovoltaics, and small wind units. Behind the discussion is the deeper issue of status quo versus change in society's way of doing things. On the one hand, centralized solar technologies would fit into existing power grids as any other generating process has in the past, while decentralized sources would make the on-site user, whether residential, commercial, or industrial, more independent of central power requirements. Major institutional change is implied for the utility industry by the second approach.¹⁶

The heating and cooling industry itself illustrates the debate in microcosm. In the years just following the 1973 oil boycott, active solar systems were essentially the "only game in town." Use of mechanical systems to capture and convert the sun's energy so as to fit into existing

heating systems without further behavioral adaptation by either industry or the homeowner was the only solar option in most people's minds. Then came the realization that the use of this low-temperature solar heat would require painstaking attention to conservation construction details, for unnecessary losses from this "expensive," capital-intensive energy technology make the entire system cost-ineffective in most areas.

The passive design principle, using the building itself as a collector in a tightly conserving shell, is the next iteration of change being asked of the industry. Even homeowners may find themselves making adjustments in this phase. Finger-tip control is not the mode by which passive systems operate, for variations in temperature is a characteristic of the most energy-efficient operation of these systems. A conservation ethic in general (a lifestyle change or intensification) is the usual result of homeowner adoption of this type of heating system. Living with a passive system does not involve all sacrifice, however: a good passive structure has more thermal inertia than other structures of conventional design. Therefore, continuous radiant warmth from floors, walls, or other storage mass distinctly enhances the pleasure of living in a passive space, with comfort levels apparent even under cloudy conditions.¹⁷ The option remains, of course, for a passive homeowner to supplement the solar heat available with wood, oil, natural gas, or electric backup, if higher constant temperatures are felt to be necessary.

Incorporating passive systems into the community may require even further change in existing ways of doing things, with building codes, platting layouts, subdivision regulations, and utility interface each finding somewhat different regulations necessary than from the active solar unit. Among the benefits received from all these changes are decreased costs of system construction and maintenance and a heightened conservation ethic in general.

National Consensus Standards,
Certification, and Model Codes

Standards and Certification. Another debate within the solar heating and cooling community was institutionalized when the National Heating and Cooling Demonstration Act of 1974 called for the development of codes, standards, and criteria for solar energy system equipment. In a developing industry the premature establishment of over-rigid standards can stifle innovation that may lead to dramatic cost reductions and system improvements.¹⁸ Stunted growth in the industry and suboptimal solar utilization may result. Yet, there is also an urgent need to provide safe, reliable, and durable solar systems in order to develop and justify public confidence in solar applications. Accelerated promotion of solar heating through such federal efforts as tax credits and demonstration programs therefore requires acute sensitivity to the issue of consumer protection vs. industrial innovation.

Through Demonstration Act funding, intermediate standards have been developed for solar water and space heating systems (both active and passive) which supplement existing HUD/FHA Minimum Property Standards (MPS).¹⁹ Meeting these standards has been required of all HUD demonstration units. They are likely to be used to qualify systems or components for acceptance under proposed tax credit programs. Whereas they are prescriptive state-of-the-art, an "ongoing, iterative" updating process by industry and government is anticipated by DOE.²⁰

A longer-term program to develop definitive performance criteria to ensure the safety and reliability of solar systems is presently underway through the voluntary consensus standardization system, led by the American National Standards Institute (ANSI). As of June 1978, this industry-led effort, with the cooperation of DOE, the NBS, and the consensus standards

writing and industry organizations, had circulated drafts of the several elements in its standards-setting task; e.g., criteria on testing, materials, etc. However, the voluntary consensus process takes a considerable period of time to develop (8 to 10 years would not be unusual), and one should not expect to see adoption for several years. Yearly progress updates can be expected through the annual conferences on standards for solar energy use, the second of which will be held in New York City September 13-15, 1978.²¹

In the meantime, an interim program is being developed under DOE contract by the Solar Energy Research and Education Foundation (SEREF, research arm of the Solar Energy Industries Association) to certify, rate, and label solar collectors. Results of a collector testing program are expected to be published in a catalog of solar collector ratings available by the fall of 1978. In implementing this industry-based test program, DOE has agreed to subsidize the cost of testing for the first collector model from any manufacturer that has marketed 1,000 square feet of collector or more.²²

It is assumed that DOE participation in the industry's certification and labeling program is intended to assist in qualifying systems for eligibility in the solar tax credit program (if and when passed). In like vein, the Polytechnic Institute of New York has been testing collectors for approval on a state-by-state basis in the solar hot water initiative program. As of May 20, over 350 systems manufactured by 59 companies had been approved by the Institute, although the final decision on system acceptance is left to each of the 11 participating states.²³ As with the innovation vs. consumer protection issue, a policy concern is raised by requiring certification for federal tax credit eligibility. By doing so, the constructed-in-place solar system, whether by an owner-builder or by a general contractor, is economically penalized at the expense of

commercially manufactured systems.

Model Solar Codes. When standardization of practice deemed to be in the national interest becomes an issue in an industry as decentralized as the building sector, the usual solution is to develop a "model" practice which is suggested but not required. Implementation of the societally-valued act thereafter remains at the discretion of state and local officials. Such it is with a solar building code. Several model codes have been proposed which attempt to integrate solar elements into standard building practice. DOE is working in association with the National Council of States, the Council of American Building Officials, and several professional and trade associations on the establishment of model building code provisions for solar installations. Technical teams established by the four major national building code organizations drafted a first cut at the code and presented it for public comment on May 11 and 12. Further drafts and public meetings to participate in the review process will follow, with a full draft code expected by the end of 1978.²⁴ (For examination of state and local efforts to integrate solar designs into building codes, see pages 80 to 92.)

Once a model code is developed, adaptation to building practice would be administered and enforced at the local level by thousands of building officials representing wide variations in responsiveness. Years may elapse before widespread understanding of the new solar provisions is secured. The federal government could accelerate this process through development of training manuals, workshops, and follow-on activities for building officials and the building industry, administered through state or regional solar energy centers throughout the country. (New Mexico's experience in such a training process is discussed on page 91.)

Indirect Benefits to Society
From Solar Development

Increased Employment. Hearings held recently by the Energy Subcommittee of the Joint Economic Committee were the first to call federal attention to the issue of the employment impacts of national energy policy.²⁵ Testimony ranged from academics modeling projections of employment in various energy technologies through pragmatic labor unions speaking from first-hand experience and on to state and local officials describing attempts to implement energy conservation employment programs. The message throughout the two days of hearings was clear: As the U.S. moves away from an oil-based economy, it should abandon its bias for capital-intensive efficiency and go for energy sources like solar that offer independence from foreign sources, and less dependence on big business. It was also apparent that employment impacts had not been a factor in developing the National Energy Act, nor had DOE worked with the Department of Labor in making its decisions on program funding or policy direction.

In the hearing's opening statement, Senator Kennedy said,

We are told that more and more capital must go into energy production—even though energy already consumes one-third of our entire capital investment ... most of us have assumed there was an absolute relationship between energy and economic growth.... Today we cannot continue to accept uncritically this assumption. We cannot accept higher prices from highly priced technologies because we are told jobs are at stake.

He later summarized the hearings as having demonstrated that:

- (1) Because of subsidies to energy and capital, we have consistently disadvantaged labor and reduced the number of jobs available. We have made capital less expensive and labor more expensive, creating unemployment.

- (2) The thousand largest companies in this country—which use 80 percent of the investment tax credit and well over half of industrial energy—created only 75,000 new jobs in eight years. The other six million businesses created 9.5 million jobs.
- (3) Too little attention has been paid to the potential for creating jobs among our most disadvantaged citizens, particularly minorities, through conservation efforts in the cities or alternative energy systems.
- (4) Conservation is the best job-creator, outperforming all other energy measures by a margin of three-to-one, considering both direct and indirect employment.
- (5) Over the long run, conservation and alternative energy would place tens of billions of dollars in the hands of consumers, driving the economy through spending instead of trickle-down economics.

In testifying for the state of California, Wilson Clark discussed a study draft from the state's Employment Development Department. Some of its findings follow: the solar equivalent of a 1,900 MW nuclear plant would produce 241,055 man-years of work over 20 years' operation (compared to 36,268 for the nuclear plant); reaching the state's goal of 1.5 million solar units installed by 1985 would create 50,000 year-round jobs in the manufacture of collectors, maintenance, installations, and sales (more than exist in all of California's gas and electric utilities today); plans for reforestation and biomass projects would lead to 11,000 direct employment and 23,000 indirect jobs.

By increasing energy efficiency, promoting conservation, and supporting renewable energy sources, entirely new answers to unemployment may be found. The challenge before the nation is how best to accelerate the development of these realistic opportunities.²⁶

Following these hearings, a Congressional amendment to the Comprehensive Employment Training Act required that an annual report of the impact of energy technologies in jobs be made by DOE and HUD, categorized by the type and scale of energy technology used. The Congressional intent seems to be to quantify the comparative employment impact of these technologies, particularly the small-scale ones which are assumed to be very high. Also amended to the Act was a requirement that state and local governments provide employment and training where possible in the development and use of solar, conservation, and other alternative energy technologies.

To date there has been no analysis specific to the Pacific Northwest of the employment impacts from solar applications. However, a survey of Northwest energy firms and their projected employment growth from future energy-related activities is presently underway by Rockwell Hanford Operations. It includes but is not limited to future needs of individuals working in the solar field.²⁷

A study commissioned by the Bonneville Power Administration in 1976 compared the employment impacts between conservation measures in the residential and commercial sectors and central operating units producing an equivalent amount of power. (A "solar scenario" was not in its scope of study.) Their calculations were not as dramatic as that heard at the Kennedy hearings: they concluded that investment in conservation would create approximately 800 more jobs in the region than if thermal plants were relied upon to supplement energy to these two sectors.

The quality of skills necessary under a conservation strategy could be expected to shift the workforce mix to more readily accommodate lower-skilled and unemployed persons.²⁸

Exporting Solar Technology. Among the programs having strong support from the Congressional Solar Coalition are those to facilitate the export of U.S. solar technology, particularly small-scale applications directed at the lesser-developed countries (LDC's). Introduction of solar to these countries holds promise for a more rapid adoption than industrialized countries, reports Denis Hayes of the Worldwatch Institute, given their abundance of sunshine, a decentralized society, and a lack of a delivery structure for oil, natural gas, coal, and nuclear.²⁹ Bioconversion of plants and of waste, windmills, and solar heating and cooling all have great potential and present the U.S. with an excellent opportunity to become a leader in solar technology transfer. However, Japan, Israel, and Australia are all heating millions of homes and gallons of hot water at lower initial costs than those of U.S.-made collectors and therefore some redesigning and/or production costs decreases must occur. The expense of capital equipment and fuel for nuclear power plants make them less attractive to developing countries, for they would "strengthen rather than diminish the technological dependence of poor countries upon rich ones." Hayes concludes that, since there is a close relationship between investment funds and energy availability, the provision of "safe and sustainable indigenous sources" could be a key factor in the long-term economic development, as well as the increase in standard of living so desperately needed, of these countries.

In the view of Hayes and many other solar advocates, a U. S.

developmental assist through such activities as providing loans to help LDC's establish their own manufacturing plants is the kind of foreign policy that makes the most humanitarian as well as economic sense. Energy export to developing countries to date has been concentrated on nuclear power, through such means as negotiated agreements for cooperation on nuclear technology, provision of nuclear fuel from DOE uranium enrichment plants, and U.S. Export-Import Bank loans and loan guarantees for nations importing reactors from U.S. corporations. Proponents of solar export policy feel that a balancing is in order. Not only would the recipient country benefit, but also world stability and U.S. national defense in a broad sense, as the likelihood of nuclear proliferation was reduced.³⁰

Foreign Oil Purchases, Balance of Trade Deficit, and U.S. Inflation.

Massive American imports of any goods or services may place unwanted or unneeded dollars in the hands of foreigners or multinational corporations. If these dollars are not used in turn to import American-manufactured goods, they will be traded on the international market for currency of a country from which purchases are being made. Rapid trading brings concern to those still holding dollars about the currency's instability, and even more dollars are placed on the market.

Such a glut of American dollars brings their value down in relation to other currencies and increases the price of foreign goods to the U.S. consumer. Theoretically, cutbacks in U.S. imports will then follow as consumers purchase less of the more expensive foreign products. Analysts, however, say that increased import prices are frequently seen as opportunities for U.S. manufacturers to raise the price of their own goods. A Wall Street Journal

article estimates that the dollar's devaluation abroad added at least half of one percentage point to the U.S. inflation rate between September 1978 and March 1978.³¹ This would be an annual inflation rate of one percent directly attributable to the nation's trade deficit. In 1977 the U.S. Gross National Product (GNP) was approximately \$1,900 billion. Therefore, a one percent loss in the buying power of the dollar would equal a U.S. subsidy to foreign trading partners of \$19 billion.

Imported oil, costing \$42 billion in 1977, accounted for about half of all oil used in the United States and 30 percent of our total imports.³² Using the \$19 billion figure calculated as lost purchasing power from foreign trade deficits, foreign oil companies might therefore be viewed as receiving an indirect subsidy of nearly \$6 billion from the American public. Subsidies awarded to the solar industry and to consumers of such magnitude could make considerable inroads in displacing the foreign oil now used for stationary energy and, to a lesser degree, for transportation itself.³³

The area of international trade is, of course, not so straightforward as the analysis suggests. A \$6 million subsidy to solar energy production would be unlikely to yield \$6 million in increased purchasing power. The cause and effect of national and international money fluctuations are never direct. For example: The OPEC nations have established the U.S. dollar as the only currency in which OPEC oil is to be traded. Ironically, by doing so they have become a major prop of the demand for U.S. dollars abroad. They now contend that their fixed world oil prices are being seriously undermined by the devaluing dollar. By accepting U.S. currency without an inflation adjustment, the OPEC countries may in reality be subsidizing U.S. oil purchases.³⁴

The Carter Administration cites reductions in the oil trade deficit, and therefore in the rate of inflation, as a primary justification for early

passage of the National Energy Act. If present trends continue, the country's oil deficit in 1985 will total \$550 billion.³⁵ Critics charge, however, that many other factors are involved in inflation and the trade deficit - e.g., monetary policy itself (the creation of "new" paper money to cover an unbalanced budget); international money markets (the reliance on one nation's currency as the world standard); the health of the U.S. exporting industries and the nature of their export market (many are price inelastic, such as agricultural goods); fiscal policies of domestic expansion (designed to create jobs but frequently accompanied by inflation) and economic growth of the major U.S. trading partners (to help spur U.S. exports).³⁶ Therefore, they feel it improper to use oil imports as the scapegoat for problems in the balance of trade and for inflation.

Complex though these issues are, there can be no question that the U.S. balance of payments position will improve if the utilization of solar systems and design in America is able to displace some measure of foreign oil demand. It will be even more greatly enhanced if U.S. solar manufacturers were to develop a competitive edge in the world market and begin to export their goods in large quantity.

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III. STATE ACTIVITIES IN SOLAR ENERGY DEVELOPMENT

The diversity of interest and support in the development of solar applications among state governments is as wide as the country itself. Factors contributing to the intensity of state-level solar activity are: the energy awareness of citizens and their lobbying effectiveness at the state house; the initiative supplied by individual legislators; the funding available to the state energy offices, itself a function of both administrative and legislative priorities; the ability to channel non-state funds (i.e., federal) into alternate energy programs; and the extent to which the general public feels solar can make a contribution in their state.

The range of solar program involvement at the state level is impressive: tax incentives; building code adaptations; education; certification and testing; research and data dissemination; state purchasing and demonstrations; etc. In fact, every area of influence presently open to the federal government is available for state action as well. Most states, however, have not taken advantage of the full range of action open to them--some for lack of interest, others for lack of funds.

A few states have continuing sources of income available for solar programs from tax revenues on existing energy production. For example, the Montana legislature earmarked 1.875 percent of the coal severance tax (or .3625% of the price of coal at the mine)^{*} for renewables research, demonstration and education. The California Public Utilities

^{*}The Montana coal tax is 30% of the price of coal at the mine. 2½% of 75% of the 30% tax goes to the Montana Department of Natural Resources for work in renewable energies.

Commission has a \$.0015 surcharge upon electricity sales earmarked for support of the California Energy Research and Conservation Development Commission. Most states, however, depend upon their general budget appropriations for program funds, and it is at this juncture that state legislative priorities find sharp divergence.

Passage of some kind of solar incentive appears to be a popular political activity these days. As of February 1978 there were 25 states with property tax exemptions, 14 with income tax credit/deduction programs (of these, seven states had both types of incentives available), one state had repealed its property tax exemption and replaced it with an income tax credit, four states exempted solar purchases from sales tax, two gave refunds for sales tax paid, three instituted rapid amortization tax schedules for businesses installing solar devices, and three had authorized solar loan programs for certain state-operated institutions.¹

Of these state attempts to directly influence the commercialization of solar homes or systems, only the income tax credits are expected to be of major financial importance in the payback analysis a potential consumer may make when considering a solar investment. Most states give credit for 25 percent of the cost of the system or up to \$1,000 maximum. It must be remembered, however, that the state income tax rate is low relative to the federal tax, and that families of low and moderate income may not pay that amount in taxes for several years. Provisions for carryover are frequently

included to soften this effect.

Perhaps the action of most consequence that a state will take in the commercialization of solar energy is not a piece of specific solar legislation but an action emanating from its ongoing regulatory process. Decisions on utility rate setting made by a state's Public Utility Commission or a local publicly-owned utility are more likely to influence the economics of solar heat than any other single action.

Oregon.² The Oregon legislature has been among the most solar prolific of the Northwest states in terms of alternate energy incentive legislation. Included in their direct incentive programs are: a 25 percent income tax credit (\$1,000 maximum) for any system using solar radiation, wind, or geothermal resources for more than 10 percent of the total energy requirements in a primary or secondary residence; a property tax exemption for any solar energy system on any building (excluding heat pumps) effective till 1998; and a solar loan program enabling veterans to receive low-interest loans up to \$3,000 for installation of alternate energy devices. Other legislative action has enabled county governments to incorporate solar zoning considerations in their comprehensive plans and required Oregon State University to develop and distribute solar information through the office of a Solar Extension Agent.

In administering these programs, Oregon Department of Energy (ODOE) has developed one of the outstanding monitoring systems in the country. Design certification is required prior

to construction, as is cost verification upon completion. Among the items tracked through the income tax credit program and kept in ODCE records are: type of system (passive is clearly eligible), builder and designer, cost, location, and owner. A Solar Directory has been developed for the state and will be kept current via input from these state records.

Through the interim funds remaining from their Solar Planning Office West allocation (US-DOE funds awarded each state to plan for their participation in Western SUN), two information gathering programs are in progress: (1) A consumer protection study by the University of Oregon of other state activities in this area. Either a factsheet or proposed legislation is expected to result from this work. (2) A planning and data gathering effort on the potential for biomass utilization in Oregon.

An anemometer loan program is expected to be developed (possibly from monies from the resource development element of the energy conservation plan) for individuals anticipating use of the income tax credit but without access to wind instrumentation for their particular building site. ODOE has also sponsored conferences such as Solar 78 Northwest and workshops for community college science instructors on solar hot water collector construction. As is the case in other Northwest states, Oregon's energy conservation programs in general contain large portions of materials on the utility of passive solar design. U. S. DOE money was recently made available to Oregon for preliminary planning of an Energy Extension Plan

in 1979. These funds are being used to contact community groups throughout the state to determine how existing energy conservation and alternate energy community programs can best be integrated into a full-scale Energy Extension Service program.

Idaho.³ Idaho legislators passed an income tax deduction applicable to any Alternate Energy Device (including solar radiation, wind, geothermal, wood, or water-to-air heat pumps) installed in the residence of a taxpayer amounting to 40 percent of its cost in the first year and 20 percent in each of the next three years, with a \$5,000 maximum in any one taxable year. Department of Revenue administration of this tax credit is not conducive to monitoring, however. Both the AED tax deduction and a conservation credit are placed into a single line item deduction, and no certification is required. The issue of passive system eligibility has not yet been addressed by Department of Revenue regulations. A property tax exemption for solar systems was introduced but failed to pass in the 1978 legislature.

As agriculture is the most energy-intensive industry in Idaho, the state's conservation plan includes research and development on energy-efficient irrigation practices, which include investigations into the potential for using renewable resources in a pilot project next summer. A second R&D program dealing with other areas of farm practices (milking, hay production, tractor and vehicle operation, lighting, etc.) may include solar-oriented building design in its model-farm program.

In developing a building sector training program in energy conservation elements of the UBC, discussions on passive solar design have been included by the Idaho Energy Office. Educational seminars are being held involving inspectors, designers, and builders throughout the state, introducing them to new design and construction techniques as well as to the UBC conservation elements. In a related effort, a pilot program is being developed in the eastern Idaho communities of Idaho Falls, Ammon, and Rexburg for a comprehensive energy planning effort through their local governments. Solar aspects are expected to be included as applicable.

In July the Energy Office mailed a survey to all 85 financial institutions throughout the state requesting information on lending practices for solar-heated buildings. Its purpose is to identify: (1) areas in which the state can assist in providing information needed by loan officers, (2) other barriers to financing solar systems perceived by the Idaho banking community, and (3) a numerical inventory of solar structures presently financed by these institutions.

In other activities pursued by the Idaho Energy Office, including its general education and public relations programs, solar education is included as a matter of course. A newsletter produced by the office carries frequent mention of solar activities occurring throughout the state. The Energy Extension planning grant from U.S. DOE is likewise being used to integrate plans for a public information program in 1979 focused jointly on the use of conservation and renewable resources by Idaho residents and small businesses.

Washington.⁴ In Washington the legislature has enacted a seven-year property tax exemption, effective 1977 through 1981, of solar energy systems installed on any real property (excluding heat pumps). Initial implementing regulations specifically excluded "components of a building which utilized the energy of the sun in a passive way," but new regulations are being written by the Department of Revenue to include passive elements as eligible and are expected to be published by late summer 1978.

Among the solar programs administered by various Washington agencies is a study sponsored by the legislature in 1974 and presently underway at the University of Washington to develop a computer model of optimized passive/conservation design elements for institutional buildings. Its objective was to develop criteria that can be used by the Department of Social and Health Services in design bids for major construction projects (hospitals, etc.). A Department of General Administration directive to require lifecycle costing of all energy-using devices resulted in use by the Washington State Patrol of solar cells in radio transmitter stations in remote areas. The Department of Natural Resources is undertaking an analysis of biomass resources in the state and of the most cost effective ways by which their energy may be harnessed. Through a community college consortium, the State Board of Community Colleges has drafted a two-year energy management technician training program which would include a study element to provide at least a general background for its students of the solar

option. The Commission on Vocational Education has funded the Seattle Opportunities Industrialization Center to study the feasibility of incorporating a basic, six-month solar technician training course in its program for skills training of low-income, unemployed and untrained persons. Each of the above programs has been funded with state money through the general budget of the respective administering agencies.

The solar programs of the State Energy Office have been primarily funded through the Conservation Plan and Western SUN appropriations available from U.S. DOE. Among their conservation elements, solar energy applications will be heavily intermingled throughout their energy awareness program (expected to get underway in October), including references in publications, in their speakers' presentations, and as a substantial portion of the information available to callers using a toll-free conservation hotline operating out of the Olympia office. Through a heating plant conversion program, the conservation plan calls for a demonstration project to convert state-operated facilities presently using non-renewable fossil fuels to energy systems using pelletized and gasified biomass fuels from wood-waste. Three candidate installations have been chosen, facility managers trained, testing equipment installed, and tests begun.

Also through the conservation plan, WSEO is funding a local government demonstration program, three projects of which are directly related to solar demonstration and research: In Whitman County, design money has been awarded the Parks

Department for an energy-efficient earth-covered ranger residence and information program. In Longview, the city has been awarded feasibility study, design, and monitoring funds for a passive solar collector system on the Mint Valley Fire Station. The Energy Office and Department of Community Development of the City of Seattle will undertake a study of barriers discouraging use of solar technologies in existing land use controls and building regulations. Policy recommendations for inclusion in Seattle's current comprehensive plan revisions and zoning code modification efforts will be developed.

Washington's Energy Office contributed to such public information events as Solar 78 and Washington State Sun Day activities through the conservation plan funding available to them. Finally, the Office developed a two-week extensive training program with energy conservation as the focus for a dozen high school industrial arts teachers. This group will be used as training coordinators to teach 500 industrial arts teachers throughout the state, in a one-day In-Service Training session in October, how energy conservation and alternate energy technology can be incorporated into classroom activities. Included among the industrial arts are courses in wood arts (building technology), metal work, graphics (including drafting and photography), and "energy and power" units. A second phase of WSEO's work with this group will be to develop a projects booklet for use in experiments on alternate energy and conservation technologies at the high school and college levels.

Montana.⁵ In 1975 the Montana legislature established the Alternative Renewable Energy Sources Program to be funded by a percentage of the state's coal severance tax (1.875%). Since then the fund has provided nearly \$1 million annually in small grants for solar energy. Over this period it has financed 110 projects at sums ranging from \$600 to \$100,000, including educational programs and RD&D (research, development and demonstration) in wind, solar, biomass, geothermal, and small-scale hydro. Among its most visible and highly publicized programs is the New Western Energy Show, a traveling solar troupe developed by AERO (the Alternative Energy Resources Organization) which uses theatre, hardware displays, slide shows, workshops, portable informational exhibits, movies and videotapes to educate Montana residents on renewable energy opportunities open to them. A summer production for the past three years, in 1979 it will have a fully-staffed, year-round base in Helena from which to operate.

A recent reorganization of the executive branch integrated the Montana Energy Office staff and its functions into the Department of Natural Resources and Conservation (DNRC), which administers the renewable grants program. Out of the DNRC, therefore, is coming one of the Energy Office/AERO products, a greatly expanded Solar Handbook which explains for Montanans "the state of the art of: each major use of solar energy; climatological data; energy audits; energy conservation measures; lists of solar facilities and of individuals and groups in the state with solar expertise and experience; retrofit information; lists of local manufacturers, distributors, retailers, and

products; existing and proposed legislative incentives; a list of willing loan institutions; bibliographies, glossaries; and a copy of the state solar plan."⁶

Among other solar activities in which DNRC is involved are:

(1) Evaluation of the Renewable Energy Grants Program. A documentary slide show of the three-year program has been prepared. Five of the best-designed solar structures, including active, passive and hybrid systems, have been selected for performance monitoring over the next several years. Ten more are expected to be monitored in 1980.

(2) Administration of the Montana State Solar Plan, developed to establish priority projects for Western SUN support and now officially adopted by the legislature.

(3) Preparation of a government employee solar training program. There are three types of information sessions to be developed through this program: (a) an awareness/orientation session to bring solar concepts and opportunities to a wide range of public servants; (b) capacity-building, designed for those holding jobs of critical importance to solar technologies such as building inspectors, tax assessors, and consumer protection advocates; and (c) hands-on development, to allow government employees to gain practical experience with low-cost solar technologies.

(4) Channeling of Renewable Energy funds to the Human Resources and Development Council to organize training workshops in which solar air heating systems, domestic hot water units, greenhouses, and window box heaters are built.

(5) Contracting for the development by January 1979 of a comprehensive piece of legislation to address the institutional barriers that now exist to solar development. Expected to be proposed are revisions in the building codes and in subdivision regulations and new solar easement and solar access legislation.

(6) Supporting the Center For Innovations (CFI) at Butte with Renewal Energy Program funds. Montana supplies \$100,000 out of the total \$800,000 budget for this regional program to develop innovative inventors' concepts. Between 10 and 15 projects under development at CFI deal with some aspect of renewable energy. The support which CFI provides in seed money, technical assistance, marketing evaluation, and commercialization planning will eventually be repaid to CRI's revolving fund in order that future concepts can be developed.

The Montana legislature passed a property tax reduction bill that became effective in 1976 but was ineffective as written and never used. The law was subsequently repealed and replaced by one giving a personal income tax credit for non-fossil energy generation systems installed in a primary residence. The credit totals 10 percent of the first \$1,000 spent and 5 percent of the next \$3,000, with a four-year carryover. The law also provides for personal and corporate income tax deductions for investing for the purpose of conserving energy. The Department of Revenue is monitoring the applications for cost, type of system, and location, and its first report to the legislature is to be submitted in October 1978. The department did not feel, when questioned in March, that passive systems would

qualify directly for the credit, but that they would be covered under the conservation deduction clause.

Western SUN

The federal government has determined that commercialization of solar technology must be pursued through a combination of federal funding and state planning, if a solar contribution is to be made in reducing the nation's imported energy demand over the near term. In addition to the national Solar Energy Research Institute, therefore, which will pursue long-range technological research and will develop national solar policy materials, the Department of Energy is creating regional solar commercialization centers. In the West there are thirteen member states who will participate in this structure (called the Western Solar Utilizers' Network, or Western SUN), with the administrative office to be located in Portland, Oregon. Approximately \$15 million will be appropriated for each regional center from the general solar program budget and administered through DOE's Office of Conservation and Solar Applications.

Planning for Western SUN was accomplished by a steering committee of representatives from each of the 13 states. Funds were provided each state to develop an inventory of solar resources and to prioritize strategies through which solar could be best developed within their own states. From this list of individual state needs, agreement was reached upon project priorities to be funded through the regional center. Information programs head the list in a number of ways: requirements for networking, workshops, passive design programs, training,

homeowner's manuals, etc., are all high priority among the 40 projects recommended for the first year. Technologies to be emphasized are passive and hybrid space conditioning, water heating, wind and biomass energy conversion.

Operations were scheduled to begin June 1, but conflict over the management scheme proposed by the consortium of 13 states has delayed the program at least through September 1978. For further information and a status report, inquiries should be directed to your state energy office.

Regulations of Utilities

Because of the "natural monopoly" position of investor-owned utilities, they are regulated by state public utility commissions (PUC's). Federal jurisdiction in the past has been limited primarily to regulation of wholesale rates of interstate sales and of the siting of hydroelectric plants, although a more active role in encouraging conservation rulings through PUC's has recently developed. Municipal utilities, cooperatives, and public utility districts are usually exempted from jurisdictional regulation by state PUC's because they are already publicly controlled, and therefore presumed to be directly accountable to the public interest.

In 1977 investor-owned utilities generated 1,683 million megawatt hours of electricity throughout the U.S. Publicly-owned utilities generated 440 million megawatts. That same ownership mix is roughly reflected in each Northwest state except Washington. Investor-owned utilities generate approximately 85 percent of Idaho and Montana's power and 80 percent of Oregon's, but only 40 percent of that available in Washington.⁷

Rate Setting. From the standpoint of solar energy use, the crucial utility regulatory function is rate approval and the related issues of unreasonable rate and service discrimination. In general, state utility decisions have found preferential treatment of some classes (e.g., large industrial users) of customers reasonable if it produces indirect benefits to all customers or if there is a reasonable economic basis for distinguishing these customers from the rest.⁸ For solar users, the question of rate discrimination pivots upon backup utility service requirements. The solar energy user will turn to his/her utility for heating fuel only at infrequent intervals, usually after periods of cloudy or severe weather. If these infrequent demands occur when the utility's remaining customers are also requiring more electricity (during peak periods), then a separate reserve generating capacity will be necessary to supply the solar users. If their rate schedule is equal to that of non-solar customers, however, and their total utility demand lower, then the fixed cost of maintaining the reserve capacity required for solar backup service would be borne primarily by the non-solar customers.

Solar owners, of course, do not want a higher utility cost per btu of backup if their solar systems are capital-intensive themselves and therefore expensive, for they would then find pay-back periods prohibitive. The issue would be resolved if evidence were found that solar homeowners were not using peak power, therefore making extra generating capacity unnecessary.

Several studies have wrestled with the nature of the long-term "fit" between wide-scale solar energy adoption and electric utilities. In 1976, a study prepared by the Argonne National Laboratories for ERDA found that the major saving from a solar system was due to its storage capacity rather than its solar collectors.⁹ Therefore it suggested that the most cost effective means of using off-peak electric rates was to utilize a storage system without adding the expense of capital-intensive solar collectors. Only those solar systems that could thereafter compete with off-peak electricity prices would make economic sense in the short-run (this was estimated at \$3 per square foot). In the long-run, as seen in the European experience, the off-peak pricing advantage would tend to level the utility demand. At this point the intermittent nature of the solar user's demand would reassert the problem of capacity generation.

Another study prepared for NSF/RANN during that year studied weather data and utility records in six areas throughout the country to determine, through modeling of solar heating and cooling (SHAC) performance in these areas, whether the load curve of the electric utility in each area would be impacted during periods of peak demand from conventional users. Wide variations in the performance capacity of solar systems during peak periods were found. While

...there is little doubt that the height and direction of load curves may be significantly affected by SHAC, and consequently the costs of providing power ... no general statement can be made. This analysis must be performed on an individual utility basis [emphasis added], since variations in the ambient

weather conditions, load curves and generation mixes of utilities will be the prime determinants in the magnitude of the impact... (the impacts) are also a function of the size and design of storage and collector, and passive design of the solar building. Variations in these components will cause differential impact upon the utility.¹⁰

In 1977 a study of the impact of solar systems upon the Colorado Springs, Colorado public utility was funded by the Electric Power Research Institute (EPRI).¹¹ Its goal was to identify from among several types of heating and cooling systems, including variations of active solar, that system which would produce the minimal impact upon peak load supply requirements, coal consumption, and water consumption of the utility for different levels of growth rate. It then determined for each of the heating systems the average system cost ($\text{\$/kWh}$) to the utility (and in turn to the consumer) for heating with that technology.

The "preferred system" for the Colorado Springs utility was a solar-assisted heat pump with annual storage. Among the recommendations of the authors was that power rates should be approved by the Colorado PUC which would "encourage the use of the most economically attractive solar heating systems." They suggested the use of a cost-tracking (demand/energy) rate as...

the best device available to control the adverse economic affect on the utility and its customers that widespread use of the wrong kind of solar and electric heating systems will have. This rate also allows customer load management as an effective incentive.¹²

The results of this study are widely disseminated among utility companies, and throughout the U.S. utilities are debating whether the solar-assisted heat pump with annual storage could be the optimal system for their own area, based on the Colorado Springs analysis. EPRI itself has dedicated funding to a major \$2 million computer modeling and demonstration program during the next 3 to 5 years, which will use the same heat pump-and-solar-with-storage configuration on five experimental houses each in the cities of Albuquerque, New Mexico and Long Island, New York. Their objective again, as in Colorado Springs, is to evaluate "the impact the systems may have on the consumer's electric bills and the utility's cost to serve... and to develop test data on the best types of solar-electric systems for various regions of the country." A spokesperson for the utility states, "It is also possible that once utilities have the EPRI study results they may encourage their customers--through rates or public information programs--to install those systems found to be best for their mutual purposes."¹³

Conservation technology is one of the variables of the EPRI study. There is no experimentation on climate-adapted passive solar designs being developed through this program, however. One could expect the performance of these systems to differ across a range of climatic variables from that of active systems. Therefore conflict may develop if utilities design rate structures (or even information programs) to encourage a particular

solar system without adequate evaluation of the role of passive applications.

Individually, 150 investor-owned, federal, municipal, and cooperative utilities are themselves sponsoring solar research projects (a total of 458 in progress during 1977), estimated at \$15 million to \$20 million.¹⁴ Seventy-five percent of these were related to solar heating and cooling (SHAC) activities. Among these projects there are passive applications represented, as in the passive solar design of the Basic Electric Power Corporation office in Bismark, North Dakota; the passive features of a demonstration residence in Lawrence, Kansas; the Strickler house monitored by Puget Power and Light near Seattle, Washington with windmill backup; three passively conditioned solar residences in Pacific Gas and Electric's service area in northern California; etc. The electric heat pump with water storage is frequently found in combination with these features. The EPRI study would be well served by integrating its members' own experience with that which it is centrally funding.

There are many types of passive SHAC systems applicable on a regionally-specific basis throughout the U.S., however. Since none of the existing local projects monitor the passive-electric interface per se, a more structured attempt to formally integrate passive into EPRI's demonstration solar-electric interface would seem advisable. A second demonstration program would seem appropriate from this industry-based research effort if questions are not to be raised as to the thoroughness of its analysis. There is little question, however, of the

importance of this study in terms of its influence upon future electric utility acceptance of solar.

In the Northwest several attempts have been made to deal with the issue of solar-utility interface and the problems of load factor and backup capability. One of the chapters of the Interagency study discussed on pages 10 to 12 made projections of the impacts of "widespread solar development" on the three major sources of conventional heating energy--gas, oil, and electricity.¹⁵ Because of the storage capability of heating oil at the point of end use, no impact was anticipated on the oil industry's supply system by the conversion to solar heat.

A general definition of "widespread solar development" was: 50 percent conversion of the 1976 housing stock to solar water heating and 20 percent conversion to solar space heating, with solar supplying 80 percent and 50 percent, respectively, of the units' energy demands. "Load factor" was defined to be ...

the ratio of average load carried by an electric or gas utility to its peak load. A low (or "poor") load factor means that a utility has high peaks relative to its average load and this results in inherent inefficiencies.

This study calculated that a 2.1 percent decrease in load factor to the natural gas utilities would occur under the (simplified) conditions of "widespread solar development." This appeared to be of relatively small impact when compared to the 21 percent variation in monthly load which existed during 1975.

Gas companies in Washington, Oregon and Idaho are served

exclusively by Northwest Pipeline, which also transmits to parts of Montana, Wyoming, Utah, and Colorado. Northwest Pipeline, Washington Natural Gas, and Washington Water Power are approximately equal partners in two types of natural gas storage facilities: underground and liquefaction plants. Purchases from Canada during the low-demand summer months therefore can be utilized by these companies (one exclusively transmission and the other two investor-owned utilities) to provide a "peak-shaving" capability during high-demand winter months. Another means of storing natural gas available to a utility over the short-term is simply to increase the volume and pressure in the pipelines. This could be advantageous when dealing with nighttime demands and relatively short periods of heavy overcast. Because of this storage capability, the Interagency report concluded that solar conversions of Northwest natural gas customers would pose no particular problem to load management.

On the same 50/20 conversion rate for domestic hot water/space heating, the Interagency estimate for electric utility load factor decline was 1.8 percent. This, too, was felt to be relatively small and therefore manageable when compared to the 68 percent annual load factor or the 5 percent maximum variation between monthly load factors that existed in the Northwest Power Pool from July 1975 through June 1976.

Many simplifying assumptions were made in the Interagency's "order of magnitude" analysis: e.g., (1) All utilities will be equally affected in terms of load factor decreases. Actually, those with primarily residential base

loads will experience greater localized decreases. (2) Monthly averages in decreased demand due to solar were the smallest units of calculation. Actually, daily peak heating demand during December or January will exceed these averages and therefore decrease the load factor even further during those days. (3) Only rough assumptions were used in making the calculations, e.g., 50 percent conversion to solar water heating with 80 percent of the requisite energy supplied. Aware of these limitations, the study nonetheless concluded that widespread solar conversion would bring major energy savings while not substantially reducing supply utilities' overall load factors or their ability to provide adequate service to the public.

A study by George Hinman of WSU, discussed on page 18, described the basis upon which electric utilities can manage a decreased load factor attributable to intermittent sources, however quantified. In spite of agreements to sell and to exchange peak capacity in the Southwest in return for firm energy, he calculated that at least through 1990 an excess peaking capability remains in the Northwest because of its large hydroelectric component (approximately 80 percent of total electrical supply) and storage capacity. "The Northwest is short on energy not peak."

The Hinman study is a "position paper" designed to stimulate further inquiry at a more detailed level of analysis. Its conclusions do not penetrate the longer-term problem of what to do after the peaking capacity is equal to or less than

energy requirements. What it does do is suggest that there may be considerable lead time in which one can begin to encourage the use of alternate energy resources through financial subsidies of some sort (he suggests raising the overall price of hydropower by 1/2-1¢ per kWh) without penalizing the rate base of the utilities themselves, a situation contrary to that found in the Colorado Springs study.

A third study, commissioned by the U.S. Army Corps of Engineers, reported that combined wind and hydroelectric systems are ideally suited for increasing power generation in the Northwest. Written by researchers at the University of Idaho and Oregon State University, the report concludes that the region's hydro resources could supply peak-load leveling for windmills adding additional electricity to the power grid with minimal environmental impact.¹⁶

While such reports seem to paint a rosy picture for the interface of solar and electric utilities in the Northwest, further analysis may be required before firm commitments can be made to an incentives pricing policy and to supply and demand projections based on solar conversions. A spokesperson for the Washington Public Power Supply System, for instance, suggests that such factors as intertie agreements, small-capacity storage lakes behind individual dams, environmental considerations, fish run preservation, etc., limit the usefulness of the theoretical excess peaking capacity.¹⁷ She advocates the solar-assisted heat pump with annual storage as the preferred solar system for this region.

In the final analysis of the solar power and energy storage issue, it is important to distinguish between near term and long term implications. A recent article in Science magazine suggests that only when the solar penetration level reaches 15 or 20 percent will the overall stability of an electric network used as solar backup be adversely affected. Because the turnover in systems and equipment is too slow for rapid change to occur, reliance on solar energy with backup from conventional fuels (oil, natural gas, wood, electricity) appears to be well suited to the upcoming decades. The author suggests it is particularly ironic that some of the critics who say that solar energy cannot supply more than one or two percent of the country's energy generated by 2000 also cite storage as a critical problem. "The danger in focusing on the wrong time horizon is that solar energy may make less contribution than it could during the years immediately ahead."¹⁸

Elsewhere in the country, national attention has focused on utility decisions in Colorado and Columbia, Missouri to charge rates seen to be discriminating to solar users. In Colorado, the Public Utility Commission approved the demand/rate system proposed by the Public Service Company, a private utility. Under such a rate structure, a typical residence supplied with solar heat saving an estimated 70 percent in electrical heating would cut only 15 percent from its electric bill.¹⁹ After much public resistance was encountered, the PUC rescinded the order pending further study. In Missouri, the municipal utility imposed a \$200 service fee on all utility

customers with solar systems. The fee was to apply to retro-active application of a higher peaking rate for the solar customers, once determination of the proper rate was made.²⁰

The Missouri action prompted the federal government to intervene in its first-ever "solar-rate" case. Although without power to overturn such rates, the Economic Regulatory Commission sent a letter comment to the city council requesting that it rescind the action. While supporting their concern for recouping high-cost peak power demands from solar users, the ERC comment suggested two principles it felt should apply:

(1) Higher peak rates for solar installations should be accompanied by an offer of lower-than-average off-peak rates and (2) if any customer is to be penalized for aggravating a peaking problem, he should also be provided with a cost-justified financial incentive to avoid adding to the peak... Such incentives could provide the financial ability to design a solar system with enough thermal storage to result in a service cost per kilowatt hour no worse than an ordinary electric heating customer.²¹

The Columbia City council rescinded the service deposit pending further study.

Utility Participation in Solar Marketing. Beyond the issue of utility rate setting stands another major area of solar-utility interface: the role of utilities in promoting solar utilization through retail rental or sales, comparable with their marketing activities of insulation and other energy conserving devices. Supporters of utility involvement in the solar market point to these benefits from such action:²²

1. The first-cost barrier could be overcome by a utility leasing program since the utility has access to low-interest loans, good credit, and is accustomed to high first-cost (capital intensive) ventures.
2. Utility involvement may overcome problems of market fragmentation, providing manufacturers of solar equipment a more aggregated market in which to fabricate standard components.
3. The utility already has a sales/distribution/service network tying it to the housing industry, enabling it to enter the market more rapidly than individual solar entrepreneurs.
4. Utility entry in the solar market may lend confidence to the building industry and help to break down the traditional anti-innovation bias which presently exists.
5. Utilities need to expand into new energy technologies if they are to continue their service to the public in the light of diminishing fossil fuels.

Against these arguments, utility critics raise the issues of excessive profit-taking and monopolistic favoritism in equipment purchases, needless technological sophistication resulting in overly-expensive systems, a lack of innovation, and sluggish development of the solar market to ensure a competitive place for present fuels. Among the results of

these conditions are double payment by consumers (first through the rate process and then through tax subsidies allowed on utility investment) and the possibility that private manufacturers and distributors may be put out of business.²³

Alternatives to the commercialization of solar through private utilities are suggested:²⁴

1. To reduce the first-cost barrier, direct consumer incentives such as tax credits and deductions, rapid amortization of investment in solar and energy conservation materials, and property tax exemptions.
2. The use of municipal utilities, preferable for their public accountability and their non-profit structure.
3. The establishment by city governments of community co-ops to purchase large quantities of insulation and solar systems.
4. Reliance upon the industry manufacturing and distributing the solar units to institute leasing programs without middlemen.

In terms of private utility involvement, state PUC's will determine whether to allow their investment in solar capital as an approved element of the rate base and therefore eligible for inclusion in the general rate structure charged to

customers. This is likely to be viewed desirable from a utility's point of view because of the opportunities for cost sharing and risk spreading. If a PUC finding on this issue is negative, the utility could establish a wholly-owned but independent subsidiary operating in the unregulated private market in competition with other solar distributors.

A recent case brought before the California Public Utilities Commission by the Southern California Gas Company, requesting a rate hike to fund a five-year solar demonstration, focused national attention on this problem. The installation of 315 units was proposed at a total cost to gas customers of \$11 million, or more than \$34,000 per unit. The request was denied after much debate but the issue for California remains unresolved.²⁵

The only utility-related company in the Northwest to have been involved in a solar promotion program is the Washington Energy Company (formerly known by the name of one of its three subsidiaries, Washington Natural Gas Company). It has established a second subsidiary company, Thermal Efficiency, Inc., to market solar and other energy conservation products. It has been awarded an exclusive franchise for the sale of Solaron air systems in Washington, Oregon and Idaho and a non-exclusive franchise for Fafco low-temperature collectors. Thermal Efficiency is independent of the natural gas utility operation and therefore competes in the unregulated private

market.*

In Idaho a case involving utility insulation programs pending in the federal court may set a precedent for antitrust action in utility marketing of solar units as well. A number of independent contractors charge that a wholly-owned subsidiary of Intermountain Power Company uses the utility's funds and personnel improperly to provide unfair competition to the contractors who had previously handled most insulation contracts.²⁶ Should their suit be successful, treble damages may be awarded, which is usually considered a fairly effective weapon in restraining improper utility practices in restraint of trade.²⁷

Elsewhere in the Northwest, private utility companies have petitioned state utility commissions to approve conservation loan programs for their customers in Washington, Idaho, and Oregon. Making application are Portland General Electric, Pacific Power and Light, Puget Sound Power and Light, and Washington Water Power. Although their plans differ in some details, each offer no-interest loans to eligible customers to finance conservation measures such as insulation, weatherization materials, water heater blankets, etc. Repayment is not required until the property is sold. Justification for the proposals is based upon the lower cost of financing conservation measures to the utility than of financing new generating capacity. In the Puget Power service area, and estimated 450 million kWh could be

* From telephone conversation with T. Bratvold. See Acknowledgements.

saved if all residential customers participated (enough to serve 30,000 residential customers). Loans of \$63 million are anticipated, but future costs to the average household are not expected to exceed \$.60 per month. Without the conservation program, customer costs would be even greater.²⁸

Municipal utility involvement in conservation programs will vary according to each state's laws on the lending of state credit. In Washington, the prohibition of such activity by either a state agency or a creature of the state (a municipality) has been seen as a prohibition on municipal utilities' involvement in energy conservation lending or sales programs. A recent opinion by the state attorney general, however, suggests that the prohibition was intended to preclude special favors to individuals; therefore loan activities benefiting the general public, such as purchase of insulation materials and resale to customers at cost under installment contracts, would not be prohibited.²⁹

Following the AGO's decision, Seattle City Light asked the City Council for approval of a \$60,000 program to insulate approximately 100 homes. Homeowners would be charged 6% interest on a 36-month installment contract, with the utility hiring contractors and paying them for completed work. If the trial program is successful and a court case does not ensue, a City Light spokesperson indicated that a "significant increase" in spending in 1979 would be recommended.³⁰

Extending a utility's conservation programs to include solar water or space heating would require careful evaluation of the effects on capacity and energy generation of the solar system.

(See pages 61-70). Another problem which the utility must face is the need for assurance that the solar unit will be operational over its economic lifetime. The resolution of these issues may not come quickly. Neither, however, will rapid penetration of the water and space heating market by solar technologies, as discussed earlier. Given the value of the energy-generating capabilities and the renewable nature of solar heating systems, it would seem that utilities could proceed simultaneously on both the impact analysis, which is imperative, and on incentive programs of some kind for the utilization of solar systems in the near term.

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IV. LOCAL ACTIVITIES IN SOLAR ENERGY DEVELOPMENT

In this final section the critical issues of how best to implement a decentralized solar society are addressed. The federal and state governments may encourage or discourage; local governments must live with the consequences for years to come. Through their building codes they will bring the most impactful government influence to bear upon whether and how a solar system is built. Their zoning laws will either protect the right to unimpeded sunlight or will leave the future access problem to resolution by individual property owners. Their county assessors will face the dilemma of placing a value on property which may never have sold and which has an unknown future worth. Their elected officials will be asked to appropriate local funds from a limited budget for community projects that demonstrate solar effectiveness.

In all these actions it is the local governments who will be on the front lines, will be asked to respond to the solar homeowner or builder, will be expected to deal with the concrete, the glass, and the collector panels, and will be responsible for integrating the units into the community in a manner which best defines the widest public interest. This is the only level of government with which most solar owners, builders, designers, and enthusiasts will ever interact and influence. For this reason alone, it may be the most important of all.

Building Codes and Solar Development

Areas of Potential Conflict. Recently completed studies by three organizations which issue model building codes* conclude that there are no deterrents to the use of solar systems in any of the existing model codes.¹ The assumption is frequently made in the literature that because there are no specific provisions for solar heating and cooling systems in most codes, there is no barrier posed to these systems.² Nevertheless, the current level of activity related to this topic--including state-funded examinations of local codes and solar, the creation of several model solar codes, and adoption in two states of building codes which encourage passive design--indicates that the issue is more complex than the above generalizations suggest.

Several general issues dealing with building codes, while not unique to regulation of solar energy systems, should be considered. Model Code provisions for testing and approval of new materials and systems, because they vary from code to code and are enforced in different ways, create the potential for fragmenting solar markets and introducing uncertainty and delay into the permit-granting process. This tendency, which is exaggerated by the great variation in locally-adopted and locally-written codes, may result in unnecessarily expensive systems designed to meet the strictest standards in existence. In addition, compliance

* Building Officials Conference of America, International Conference of Building Officials, and Southern Building Code Congress.

with requirements for new materials and systems may pose greater difficulties for owner-built systems, particularly the more innovative designs, than for those which are commercially built and installed. Because a local building official has considerable discretion as to whether or not a homebuilt system will be approved, there could be a high level of risk involved in the permit-granting process and costs of compliance could become prohibitive.³

However, all solar systems--whether commercial or owner-built, passive or active, and more or less innovative--must comply with local building, plumbing, and/or mechanical codes. Because these codes currently lack references to nationally recognized standards or approved testing agencies to certify compliance for solar components and systems, building officials could impose costly and time-consuming tests for any solar applicant.⁴ Experience in the Northwest, however, suggests that this potential conflict can be partially alleviated by adoption of an honest and direct attitude on the builder's part and flexibility on the part of the building officials. As experience is gained with solar systems, local officials will be better able to evaluate system compliance and to determine what code modifications are necessary, rather than inhibiting experimentation during this early stage of solar development.

While code provisions concerning new systems are most frequently discussed as potential barriers to solar building, there are several other requirements which might create problems in specific solar applications. Active systems will most often be

affected by the plumbing and mechanical codes, while passive designs will fall more appropriately under the building code provisions. The following examples relate primarily to passive designs.⁵

Code provisions for fire escape access will likely affect construction of underground buildings and attached greenhouses. Structural aspects of the latter, such as type of allowable glazing, are also affected by currently enforced codes. Nevertheless, such difficulties are not insurmountable, and can be resolved through consideration of certain limitations and appropriate design adaptations. While limitations on roof overhangs and awnings vary by code, they could in some cases inhibit adequate design for shading, a critical summer temperature control in many passive systems.

Ventilating, heating and cooling, and lighting requirements in codes may also present barriers to solar design. For example, because solar systems are more effective with fewer air changes, unnecessarily high ventilation requirements may call for oversized and therefore less efficient heating or cooling systems. A related problem is based on the fact that most codes specify comfort in terms of air temperature and humidity, disregarding the mean radiant temperature of surfaces. In conventional heating systems, the air temperature is warmer than the radiant temperature of walls, floors, and ceilings, whereas with passive solar utilization the situation is frequently the reverse. 1.0 mean radiant temperature degree is equivalent to

1.4 air temperature degrees. Therefore passive systems, due to higher radiant temperature readings, are able to provide the same comfort level with lower air temperatures. If current code comfort provisions are employed to evaluate passive solar structures, overheated buildings could result.

Because local codes are so variable, it is important that a state or municipality study the impact of its mechanical, plumbing, and building code requirements on each of the different active and passive water and space heating system configurations. Following such a review, the time and cost involved in regulatory changes can be more easily justified. The California Building Officials (CALBO) are being funded by the California Energy Commission to examine their state building code and several local codes to determine their impact on solar installations.⁶ A manual is being written and workshops are planned to provide building officials with general information and specific tools to review and approve solar buildings under the current codes. The manual will not be released until there is agreement from building officials and solar industry representatives that it is workable. Recommendations based on this study will be made to the Energy Commission concerning the form and content of a uniform solar code for the state.

Preliminary findings based on a survey of building officials in Washington State⁷ indicate that those provisions which create the greatest potential problems for solar applications come

under the currently enforced mechanical and plumbing codes, and in the building code ventilation specifications. At the time of the survey, no responding jurisdiction had modified its codes to make specific allowances for solar installations. Building officials expressed a general preference that the national code organizations develop nationally accepted standards which could then be administered by local jurisdictions. Because of the limited number of installations to date, building officials in Washington are at a preliminary stage in evaluating solar systems in reference to the codes. The survey findings reflect a lack of awareness of passive systems, in particular.

Proposed Solutions-General. According to the Environmental Law Institute (ELI), the best long-term approach to provide for testing and approval of solar systems would be the incorporation of nationally recognized standards and testing and certification procedures in all local and state building codes.⁸ Such an approach would put solar heating and cooling systems on the same footing as competitive conventional systems. In the short-term, adoption of evolving national standards could be made mandatory or left voluntary. While the latter approach may not necessarily yield nationwide uniformity, ELI concludes that it is the most reasonable and politically acceptable choice. In order to encourage prompt and widespread adoption of the interim standards, the model code writing organizations could draft legislation which would provide for states to promulgate standards based on current

federal standards, and to adopt industry consensus standards as they develop.⁹ ELI further recommends that solar standards be integrated into current specification-oriented codes because the limited funds of local building departments, as well as their general lack of experience with solar, would make performance-based codes difficult to administer.

It is not within the scope of this section to argue the merits of national versus state, or performance versus prescriptive standards and testing criteria for new solar systems. Other code provisions which may deter solar development, such as those described above, vary considerably between and within states. Local diversity in climate, level of involvement and reliance on solar energy, and relevant legislative change to date all suggest that at least certain aspects of building code revision can be handled more appropriately on a decentralized basis. A suggested statute drafted by the American Bar Foundation requires, among other things, that states and localities assess the impact of their building codes on solar installations, alter those provisions that are found to be barriers, and allow citizens to petition the appropriate state or local agency for exemptions from current code provisions if their solar systems are certified in one of several ways.¹⁰ A more radical suggestion is to provide separate compliance classifications for owner-builders and commercial builders, and apply only minimal code requirements to the former group.¹¹

Proposed and Implemented Solutions-Specific. In the section on "National Consensus Standards, Certification, and Model Codes" (see p. 36), it was mentioned that several model solar codes have been proposed, and that one is currently being developed by the U.S. Department of Energy in association with a number of national code organizations. One of the code writing organizations (BOCA) has already issued a brief document to its members providing interpretations of existing codes as they apply to solar. In addition, a committee of solar-related trade and professional organizations is developing a set of test questions for building officials responsible for inspecting solar installations. The test questions will be distributed to local governments for incorporation into their codes.¹²

One model code has been published: the Uniform Solar Energy Code, 1976 edition, written by the International Association of Plumbing and Mechanical Officials (IAPMO). While this code does not deal with passive designs and has certain other errors, omissions, and biases,¹³ it has been adopted in several places, including Los Angeles County and a few other California municipalities. The Building Division in Kitsap County, Washington is considering adoption of the IAPMO code, but will first explore potential conflicts between its provisions and existing thermal efficiency standards, and consider alternative approaches which will allow for greater solar design flexibility.*

*From telephone conversation with R. Perkerewicz. See Acknowledgements.

As part of a state-wide revision of comprehensive land-use plans, a number of counties in Oregon are recommending code revisions to incorporate solar and energy conservation considerations. The City of Portland is developing a City Energy Policy which will include standards for wind systems to be administered by the Building Bureau. In Idaho, where the energy conservation standard ASHRAE 90-75 is an option for local adoption, the State Energy Office plans to provide training seminars during the fall of 1978 to engineers, architects, and building officials. Training will address compliance of alternative technologies, including solar, with the ASHRAE standard.* In the city of Cerritos, California, an ordinance was enacted in 1977 which gives the Planning Commission flexibility to approve solar installation permits while being mindful of aesthetic considerations. San Diego County, California has recommended amendments to its building and plumbing codes which would require incorporation of passive elements in buildings, provision for solar retrofitting in all new buildings, and development of a solar energy code which would allow flexibility for passive innovation.¹⁴

In addition to this national and local level activity, several states have passed legislation dealing with solar and the codes. Florida, for example, amended its building code in 1975 to require that all new single family residential construction incorporate readily accessible plumbing to facilitate solar hot water system retrofits in the future.

*From telephone conversation with J. Brinch. See Acknowledgements.

The state has interpreted this law by requiring a T-pipe fitting on the inlet water pipe of the domestic water heating unit. A 1976 California law authorizes cities and counties to require that new buildings subject to the state housing law be constructed to permit future installation of solar heating and nocturnal cooling devices, by requiring, for example, a certain roof pitch and orientation.¹⁵

Building Codes and Passive Design-The New Mexico and Davis Experiences. The energy conservation standard, ASHRAE 90-75, provides an interesting example of nearly complete nationwide adoption of a model standard, and raises a few critical issues concerning conservation and solar codes. There is considerable discussion about the extent to which this primarily prescriptive standard can actually reduce energy consumption, and about the impact it may have on certain types of solar design. While some writers contend that Sections Ten and Eleven of ASHRAE 90-75 provide adequate give and take to qualify solar and other innovative design solutions,¹⁶ others argue that innovative uses of economical solar systems, such as passive designs, will be made difficult or prohibitively expensive under this standard.¹⁷ The criticisms are based largely on the use in ASHRAE 90-75 of historically accepted methods of calculating heat flow through the building envelope using "steady state U values."¹⁸ Pioneering energy conservation

codes which have been implemented in the state of New Mexico and the city of Davis, California serve as examples of approaches through which building code provisions can significantly reduce residential energy consumption and encourage solar design. While the New Mexico approach improves a designer/builder's chance of achieving an energy conserving design, the Davis code precisely details passive design procedures.

While the concept of a steady state U value is helpful in sizing heating and cooling equipment for worst possible conditions, it does not reflect actual daily heat flow through a wall, nor does it account for radiant heat flow through windows (i.e., solar gain) or heat storage capacities of masonry floors and walls. In response to this inadequacy in ASHRAE 90-75, the New Mexico Energy Institute developed the concept of "effective U values" which would reflect more accurately the average thermal response of various building components in different climatic areas of New Mexico.¹⁹ In addition to wall type, effective U values reflect structure/wall orientation, wall color, climate, and other considerations essential to passive solar design.

New Mexico's new energy conservation building code, implemented in November 1977, incorporates this concept in one of three alternative paths by which a builder may demonstrate compliance. The first two paths, the component criteria method and the systems analysis method, are based respectively on the prescriptive and performance options for compliance outlined in

ASHRAE 90-75. The third path, the acceptable practices method, allows the use of effective U values as an alternative method of thermal analysis to indicate code compliance. These values have been calculated and are available for a number of wall and window types in eleven different New Mexico climatic zones. Solar-heated buildings are also given an energy credit which should make compliance with energy consumption standards easier than for non-solar buildings.

Another instructive aspect of the New Mexico experience is the state-funded program developed to aid in the new code's implementation. An applications manual was written to serve several purposes, including use as an on-the-job reference document and as a design manual. Workshops were held throughout the state, involving a high degree of building official participation in exercises of code enforcement.²⁰ While building officials have been trained to interpret and apply the new code, the various building heat load calculations required for code compliance under any of the alternative paths may create a roadblock to solar owner-builders and low-income or uneducated builders. The outcome for these individuals will be determined by the quantity and quality of assistance provided by the state and the Construction Industries Commission (a state agency responsible for building code enforcement).

In October 1975, the city of Davis, California adopted the nation's first comprehensive energy conservation building code for residential buildings designed to meet the needs of the local microclimate. As a result of years of research at

the University of California, Davis and an extensive study of actual building performance in the city, it was found that the state building code, by its failure to adequately address such factors as net heat gain through glazing and glazing orientation, did not deal adequately with the Davis climate.²¹ By providing two alternative paths of compliance, the code seeks to meet certain goals including maximum design flexibility and workability, that it be easily understood by homeowners and officials, allow for use of standard building practice in complying, and avoid raising construction costs significantly. Path I, which provides a prescriptive standard, has been used in almost all buildings. Path II sets a minimum performance standard and encourages innovative solutions in adapting buildings to the local climate.

Major provisions of Path I set standards for wall and roof insulation (at R-11 and R-19, respectively); allowable glazing regulated as a percentage of floor area (summer shading is required for most glazing); and use of light roof colors to reflect summer sunlight. A number of exceptions to these standards are made to encourage use of passive solar design elements. For example, less insulation is required for brick or concrete walls if the insulation is outside of the wall, and an increase in allowable glazing is earned when a house plan includes double pane glass or south-facing windows backed by thermal mass. Path II is usually needed only if the permit applicant wants to:

- ...meet the thermal performance standards at the minimum, use special construction techniques, receive credit for special shading systems, and/or receive credit for winter solar heat gains on other than south facing glass.²²

The building code and related education measures have significantly reduced energy use and established a viable solar industry in Davis. Furthermore, a majority of builders who initially opposed the new code are now convinced that it works and strongly support it.²³

Solar Access

The value of technical, economic, and other solutions currently being sought in the field of solar energy is contingent on whether or not unimpaired access to solar energy can be guaranteed, within reason, to any active or passive solar collector. It is generally accepted that property owners in the United States have no legal right to receive solar energy which flows across adjoining land owned by another party.²⁴ While most legal experts agree that some degree of solar access should be guaranteed, few studies have actually been made to determine the frequency and severity of shading problems. The limited empirical evidence that does exist, including opinion surveys of lenders and architects and aerial photographs taken of several communities, suggests that the problem may be less extensive than sometimes feared, particularly in most types of conventional single-family residential development.²⁵ Further research to clarify this situation is important because perceived problems can retard acceptance of a new technology, as well as bring about hasty or inappropriate legislative solutions.

Measures to assure solar access can be taken in the private sector and at different levels of government--local, state, and federal. Although a direct federal role is unlikely,²⁶ financial and technical assistance from the federal government could be conditioned on state and local adoption of legislation providing for solar access. Federal backing of this type, which could include a focus on several approaches and provision of model ordinances, would eliminate some cost and time in the local search for solutions. A detailed discussion of the federal role or of proposed federal legislation is inappropriate at this point, as enactment and implementation of the various proposed solutions will usually fall under state and local jurisdiction.

While this discussion cannot go into great detail on alternative solutions which have been recommended to guarantee solar access, an attempt is made to portray the broad scope and complexity of the issues involved. The extent and nature of the solar access problem and, therefore, of the most appropriate solutions vary with type and use of structure, density and zoning characteristics, architectural and system design features, and topography and other site characteristics.²⁷ In general, guaranteeing solar access for passive systems is apt to be more difficult than for rooftop collectors because large areas of south-facing walls are involved in solar energy collection. Decisions about defining passive components and determining what is considered a reasonable degree of solar access protection will be critical.

Advantages and Disadvantages of Proposed Solutions

Private land use controls. An easement is basically the right to use another's property for a narrowly defined purpose. A solar homeowner, for example, could "use" another's land by enjoying the unhindered flow of sunlight passing over it. Because such an arrangement is a "negative" easement, it is usually created expressly. For the solar homeowner this means that the two landowners involved must negotiate for and legally establish their arrangement; there is no right to receive light transversing adjacent property simply because one has received it without interruption for many years.²⁸ In general, the landowner receiving the benefit pays the other a flat fee, although easements can also be leased. If no termination provisions are specified in the contract, in most cases an easement will bind all subsequent owners of either lot.

Two major advantages of using express easements to assure solar access are that individuals can obtain them through their own efforts and thus avoid governmental red tape, and such private agreements offer solar homeowners greater protection and a guarantee of permanence which is not found in relatively easily changed zoning laws. Express easements would be used most appropriately for retrofits in established neighborhoods, while in new residential areas other land use controls should be considered. While easements can effectively assure solar access in low density districts, their usefulness in urban areas is questionable, since purchase of an easement would severely limit vertical development which accounts for much of urban land value.

The already high cost of an easement for light in a densely populated area could become prohibitive in situations where a solar landowner was required to negotiate more than one contract to prevent several nearby structures from shading the collectors. Nevertheless, easements to protect solar access could be useful in downtown areas where zoning or eminent domain proceedings might be impractical.²⁹ The following are several general disadvantages of using easements to guarantee solar access: since they are voluntary, courts cannot force their creation; once created, their enforcement could involve long and costly court proceedings; all purchase and enforcement costs fall on the would-be solar homeowner.³⁰

Covenants, or private restrictions on the use or improvement of property, are included in each deed when individual lots are sold, and they are generally enforceable against future purchasers. Restrictive covenants with solar access provisions are of most potential use in new developments, such as subdivisions, malls, or industrial parks, and state law could require their inclusion in the deeds of such properties.³¹ Major advantages of using restrictive covenants to protect solar access in new developments are minimal cost and simplicity--i.e., a developer's lawyer has only to add a clause or two to the property deeds, and individual property owners are not required to draw up complicated legal documents. However a restriction is worded--as a solar easement or by specifying generous setback and strict height requirements for trees and structures--it is critical that it be written in clear, precise language to ensure its effective implementation. The major dis-

advantage of this approach is its limited use in established neighborhoods and for some commercial and industrial structures. Additionally, as with any private agreement, enforcement involves time and expense of court proceedings.³²

Although "solar easements" can be negotiated and enforced under current law in most states (as easements for light), it is frequently recommended that special facilitating legislation be passed to guarantee express solar easements the legal status of regular easements. Such a law could provide that states create a simplified form and recording procedure, and thus eliminate the expense of involving lawyers for each homeowner's transaction. This general approach is expanded and more specifically defined under a suggested statute of the American Bar Foundation (ABF) which would authorize private solar skyspace easements.³³ According to this statute, the definition of solar skyspace easement includes an easement, covenant, condition, or other property interests which protects the solar skyspace of an actual, proposed, or designated solar collector.³⁴ The solar skyspace, that area between the sun and the collector which must remain unobstructed to permit efficient operation of the solar system, may be interpreted in a broader sense to include direct, diffuse, and reflected sunlight where passive systems are used. The statute requires that the solar skyspace be described in three dimensions and/or in terms of the times of day during which a collector cannot be shaded, generally from three hours before to three hours after noon, mean solar time.³⁵

As previously described in the case of easements for light, private transactions will continue to serve a necessary function in guaranteeing solar access as they provide for voluntary procedures and freedom from unanticipated changes in governmental policy. Appropriate applications of this approach are consistent with those described for easements for light, although under the expanded ABF concept, solar skyspace easements would offer solar homeowners legal protection in new as well as developed areas. While local governmental power to regulate land use is generally limited to public purposes, and therefore not available to individuals for procuring private easements, according to another ABF suggested statute municipalities would be given the power to acquire solar easements by negotiation or condemnation.³⁶ The statute defends this taking of private property by eminent domain by arguing that promotion of efficient use of solar energy is in the public interest. The statute would essentially provide for the publicly administered transfer of privately-owned solar easements. The expense to the local government of acquiring a solar easement would be assessed in whole or in part against the benefited landowner(s).³⁷

Public land use controls. Although local zoning and planning officials generally have the authority to consider protection of solar access and to modify land use regulations accordingly, state enabling legislation explicitly giving local governments the right to create and implement such protective provisions would have several benefits. For example, the public and lawmakers would be made more aware of solar energy generally and the access issue specifically, and local governments would be given the authority

to implement more innovative solutions which might become necessary in the future. Enabling legislation would be imperative if the state were to require local governments to consider solar access.

If a state passes enabling legislation, encouragement of solar energy must be found to be in the public interest, and therefore a valid exercise of police power. While the current trend may be toward accommodating broader public interests which are affected by private land use practices,³⁸ such as solar energy utilization, the balancing of public and private interests is a difficult and complex topic. Although they will not be discussed here, several complicated legal issues are relevant. Of particular importance are the distinctions between regulation of land use (through zoning, for example), compensable taking by eminent domain, and a new concept which has been advanced to bridge the gap between these two extremes, the accommodation power or compensable regulation.³⁹

Local governments interested in protecting solar access could include a solar element in their comprehensive land use plans to insure coordination of solar with other energy uses. Such an element could provide for methods of protecting solar skyspace and locations of such protected areas.⁴⁰ Inclusion of provisions like these should initiate extensive review of zoning, subdivision, and other land use regulations and should bring about subsequent removal of regulatory roadblocks to guaranteed solar access.

Whether a municipality has a comprehensive plan or not, existing local controls on construction and land use could be

modified to protect solar access. By careful consideration of the solar access issue before developments are planned, buildings completed, and vegetation planted, many conflicts could be avoided without resort to new legal devices. Existing ordinances should be reviewed to determine their impact on solar development and protection of access. Those inhibiting solar use could then be revised to include appropriate height restrictions on structures and vegetation; more flexible setback and side-yard requirements; and provisions for optimal lot and structure orientation and, wherever possible, for east-west street configurations. An alternative to uniform height and setback restrictions is the use of envelope or bulk plane zoning. With this approach a three dimensional tent-shaped area is described over each building delineating allowable heights for structures and vegetation in order to minimize shading to adjacent property.⁴¹

Regardless of the zoning technique utilized, particular emphasis should be placed on vegetation since existing land use regulations seldom apply to its control. For this and other reasons (such as the variety of aesthetic and environmental functions vegetation serves), restrictions on species, height, and placement of trees have the potential to become one of the most controversial issues in solar access protection. According to some experts, the best and only really essential solar access land use regulation is a shade control law that would affect only trees and shrubs.⁴²

The type of zone in which a solar system is located will determine, at least in part, the extent of the shading problem. For example, in very dense central-city areas it may not be

feasible to protect solar access for passive designs, whereas many rooftop collectors may have no shading problem. In office-residence districts, the variability in structures' heights may make solar access difficult. On the other hand, areas zoned for industrial parks and the like (garden-factory districts) should present few problems for solar systems since structures are usually low and widely separated.

This variety of situations makes it difficult to generalize about the content of a good solar access zoning law, or about the most appropriate applications of zoning to guarantee protection to solar owners. New subdivisions, low-rise commercial districts, rural and suburban areas, and shopping centers appear to be most readily adaptable to solar access protection through zoning ordinances. Special problems may arise where different zones, such as residential and commercial, border each other. Creation of a buffer zone or green strip in such a situation would entail questions as to who should bear the costs involved--the government, commercial or residential property owners, or a combination.⁴³ While zoning could provide solar access in old as well as new residential neighborhoods, the practicality of this approach in established areas is somewhat debatable.⁴⁴

Most proposals for mandatory solar zoning are limited to single-family residential areas. While some give all homeowners sun rights, others use a first come, first served approach. An ABF statute recommends that two types of solar energy use districts be created which could be superimposed on existing

land use districts: mandatory and affirmative districts, where the latter would encourage but not require solar development.⁴⁵ Under this statute local governments would be authorized to purchase or condemn solar skyspace easements for cost-effective collectors which are located to minimize impact on neighboring land and structures.

The mandatory solar zoning approach is frequently criticized because of its potential conflicts with other energy-conserving zoning techniques. For example, goals of the latter often include compact, contiguous development to minimize heat loss, transportation, and other energy-related costs. While it is often assumed that solar zoning necessarily requires low density development, with proper land use control solar access considerations could be adequately protected in single-family dwellings at densities of 8 dwelling units/acre,⁴⁶ as well as in multi-family residences. Another area of potential conflict is in mixed use neighborhoods which may be designed for energy conservation purposes, but which make protection of solar access more difficult due to irregularity in building height.

Local regulation of large-scale development, whether it is applied to commercial, industrial, or residential projects, is an effective way to guarantee solar access because the necessary provisions are executed before property is fully developed. For example, an initial residential site plan or subdivision parcel map could indicate maximum southern exposure of homes based on appropriate lot arrangement and dimensions, street layout and orientation, and block design. Trees and major

vegetation are usually included as part of a developer's site plan; their shadow patterns could also be analyzed and predicted before the plan is submitted to local officials for approval. Proper arrangement of open space, parking facilities, and taller structures can also minimize shadowing of solar homes. Appropriately oriented cluster, row, and town house units need not impair solar access, and can actually assist efficient functioning of solar systems by reducing building heat loss. Approaches such as these require flexible siting and zoning practices, and a high degree of cooperation between municipal planners and private developers. The Planned Unit Development (PUD) can provide such an arrangement.⁴⁷

Several other techniques have been proposed to maximize solar access, particularly in high density areas. For instance, a developer who makes design allowances for solar access to neighboring buildings could be granted higher density rights through "incentive" or "bonus" zoning. Another approach involves the concept of transferable development rights (TDR) in which a municipality would allow development rights to be severed and sold separately from the land to which these rights apply. For example, in a commercial or industrial district initially zoned for development to a specified height, expansion could be constrained in certain areas in order to assure solar access to a nearby solar building or complex. The limitation could be imposed by a solar easement acquired by the municipality through condemnation or zoning. Whether an easement is created or another

approach is used, those property owners who are restricted from using all or part of their lands' development rights could sell those rights to owners of property zoned for more dense development, and thus receive a cash equivalent for their loss. The feasibility of the TDR approach depends largely on the existence of adequate markets for the development rights. While the concept is much discussed, it has had little practical application and there appear to be a number of legal, economic, and political complications in its implementation.⁴⁸

Another approach which has been suggested is to use the building permit process to control and protect solar access. Would-be solar property owners would be reviewed on a case-by-case basis, and issuance of a permit would guarantee solar access protection. Both zoning and building officials would be involved in the implementation process, depending on whether an area was zoned for low or high density development.⁴⁹ A related approach would hinge the granting of a development permit on several criteria, including prior creation of a solar easement.⁵⁰

While problems of specific zoning techniques have been mentioned throughout the preceding discussion, the following are a few of the disadvantages inherent in protecting solar access through zoning regulation in general:

1. Although enabling legislation for zoning and subdivision control exists in every state, many localities do not exercise this authority. Consequently, while the authority to plan for solar access may be adequate, it is not a sufficient solution in and of itself.

2. Considerable time and expense to municipalities could be involved in reevaluating existing zoning plans and implementing modified plans to provide for solar access. The extent of such difficulties will vary with a locality's physical characteristics and political climate. As experience is gained with solar access regulation, such difficulties could be alleviated by drawing on other communities' experiences and by utilizing model legislation and guidelines.
3. The changeability of zoning laws was mentioned previously. The ease with which zoning boards grant variances and special exceptions further undermines the permanence and reliability of this approach.

The following alternatives to protect solar access are less widely and easily applicable than those discussed above, and will therefore be mentioned only briefly:

1. It is unlikely that existing nuisance laws would alleviate the solar access problem since courts would seldom determine that a nuisance exists merely because a structure interferes with the flow of light to adjoining property. Unless a municipality simply declares shading a solar collector to be a public nuisance, the complexity and local variability of nuisance law, in addition to the cost, delay, and insecurity involved in lawsuits, make this approach generally unappealing to solar system owners.⁵¹

2. The often discussed Doctrine of Ancient Lights from English common law entitles property owners to receive a limited amount of indirect sunlight for illumination purposes if that light has been flowing through their windows without interruption for a given number of years. While some early American courts enforced the doctrine, it has since been unanimously repudiated as being inconsistent with the needs of a developing country. If the doctrine were revived for solar access protection, it would clearly require major modification.⁵²
3. Model legislation has been drafted to provide for allocation of sunlight under the prior appropriation system currently used for water allocation in the western U.S. A number of difficulties with this approach stem from basic differences in the nature and actual use of sunlight and water, difficulty of applying it to passive solar systems, and the emphasis in water law on priority in time (i.e., first person to develop wins) at the expense of fairness.⁵³

Approaches Taken to Date by State and Local Governments.

While it is valuable to understand the general advantages and disadvantages of alternative approaches to solar access protection, more practical knowledge is gained through an examination of existing and proposed state and local legislations.

Because such a limited number of solar buildings have been constructed

since these laws went into effect, there is little experience from which to draw conclusions. Problems of implementing solar access legislation would likely be a useful focus for future study, particularly in the treatment of passive systems.

At least six states have passed solar access legislation and many more will be considering a variety of bills in the 1979 session.⁵⁴ The most frequently passed law provides state recognition of procedures for creating private solar easements in order to give them equal legal standing with express easements for light. Laws passed in Colorado (1975), Kansas (1977), and North Dakota (1977) require that the easement be expressed in terms of vertical and horizontal angles extending over the property of the servient landowner. While the language differs in a 1977 Maryland law, provision is indirectly made for solar easements.

New Mexico (1977) is the only state which has passed legislation creating solar property rights analogous to prior appropriation water rights, although a similar bill was introduced in Washington in 1977. The 1979 legislative session in Washington will consider a solar easement bill and possibly solar zoning legislation. The state of Idaho has passed a solar easement law (1978), and a bill on solar rights was introduced but not passed during the same legislative session.

A 1975 Oregon law provides that solar access be included as a consideration on which any comprehensive plan, zoning, subdivision, or other ordinance affecting land use shall be based. It further allows county planning commissions to recommend specific ordinances to county governing bodies to insure solar access protection. A proposed amendment to this law would provide for solar access consideration in cities as well.

All Oregon counties are currently revising their comprehensive plans; and a number are incorporating policy statements about solar access protection. While there is a high level of interest in solar and energy conservation, no counties have yet enacted solar-related ordinances.* The Oregon Department of Land Conservation and Development and the State Department of Energy are distributing information to aid counties in their planning efforts. A citizen's residential task force of Portland's Energy Policy Project is considering recommendations on solar access, which will be made public in draft form in October 1978.*

Outside of the Northwest, Kiowa, Colorado (a small town southeast of Denver) has passed a zoning ordinance allowing a property owner to have a structure declared a public nuisance if it interferes with his or her collector. In New Mexico the cities of Albuquerque and Los Alamos have passed solar access ordinances. Albuquerque's ordinance applies to multi-family dwellings commercial and manufacturing zones; it uses bulk plane zoning to set height restrictions. An amendment to the city zoning code, which is currently under review, would protect solar access in all new low density residential areas and, to a limited extent, in established neighborhoods. The regulation is intended to protect passive designs to a reasonable degree.** The Los Alamos ordinance protects a solar collector from shading by a neighbor's vegetation or accessory structure which is planted or constructed after the solar system is installed.

*From telephone conversation with B. Mackie and M. Hemphill.

**From telephone conversation with D. Peterson. See Acknowledgements.

The city of Davis, California has developed a set of planning policies, some of which address solar access protection: provision for lot orientation to maximize southern exposure of residences, flexible setback requirements for structures, and more flexible setback and height requirements for fences. Davis has also incorporated shading evaluation in the environmental impact reporting process set up under state (CEQA) regulations.⁵⁵ San Diego County, California is actively examining the solar access issue and considering inclusion of several provisions in the energy element of their comprehensive land use plan. These provisions will most likely include zoning variance procedures for single lots, possible use of envelope zoning in subdivisions, and use of the PUD approach to give additional density bonuses to developers using solar.*

Conclusion and Recommendations. The range of available alternatives should allow jurisdictions to provide solar owners with adequate legal protection in a manner appropriate to the local situation. Given this variety of alternatives, an important goal may be to concentrate on a few solutions which would then be developed carefully and thoroughly. Otherwise, local governments could become overwhelmed with financial and administrative burdens. Whether or not federal guidelines could provide such a focus is beyond the scope of this section. Whatever approaches are chosen, such decisions should only be made after existing regulations are examined and the extent of the problem, and the need for a solution, are realistically assessed.

*From telephone conversation with D. Bules. See Acknowledgements.

Use of restrictive covenants and appropriate zoning techniques in new development, in conjunction with provision for solar easements and various zoning modifications in established neighborhoods, is stressed generally as the most effective means to assure solar access to the majority of solar users, while minimizing the need for modification to our present legal system.⁵⁶ Whatever combination of solutions is adopted, an essential balance should be sought in taking enough legislative and administrative action to insure solar access, while not taking such extreme action that solar systems become cost prohibitive. Legal protection of solar skyspace will not be practical in all circumstances. Provision for solar access must be integrated into the overall goals of land-use planning; its effect on development patterns and the total energy budget should always be considered. The following points ideally should be included in any solar access legislation to increase its efficacy: give clear and specific descriptions of property owners' rights; include passive as well as active systems; protect only those systems that are reasonably sized, located, and suitable to the locale; be flexible enough to adapt to new solar technologies; and provide for all types of property zones.⁵⁷

Several important issues merit further study by those lawyers, planners, builders, and architects seeking solutions in the area of solar access. These include provision for solar access protection in existing medium and high density areas and determination of the extent of shading problems in specific locations. Two major studies funded by the U.S. Department of

Housing and Urban Development (HUD) are due to be completed by fall or early winter, 1978. The first, contracted to the Environmental Law Institute, involves a legal analysis of proposed and existing approaches for securing solar access in developed areas. The two most promising solutions being explored appear to be: (1) a solar building permit approach to be implemented by local zoning and building officials; and (2) the solar envelope or bulk plane zoning approach. Prototype legislation will be included in the final report. Another HUD contract is being carried out by the American Society of Planning Officials to study solar access in new residential developments. Two guidebooks are being developed; one for local officials on planning and regulatory problems in providing solar access through traditional land use planning practices, and the second describing for local developers appropriate site planning techniques for 15 climatic regions in the U.S.

Land Use Planning Not Directly
Related to Solar Access

Since provision for unshaded collectors and maximum southern exposure is so central to the efficient functioning of solar heating systems, the majority of solar land use planning is geared toward the protection of solar access, and has already been discussed. There are, however, several additional aspects of public and private land use control which could either deter or encourage solar energy use. These include aesthetic considerations, control of accessory uses on land, and limitations on size and placement of a collector.

Architectural design and aesthetics in residential developments are frequently controlled by architectural review boards, homeowners associations, and restrictive covenants. A solar homeowner is therefore put in a vulnerable position, unless the terms of the covenant are amended and/or the powers of the review boards are modified, either voluntarily or by government regulation. On the other hand it is unlikely--although not impossible--that a collector would be successfully declared a public or private nuisance simply because it was unattractive, or because it reflected light on to a neighbor's property.⁵⁸

Zoning ordinances in most states cannot be based solely on aesthetics, although aesthetic considerations are often joined with some other more acceptable public purpose, such as maintenance of property value. If some measure of public control is desired to require reasonably attractive solar designs, care should be taken that the aesthetic considerations can be accommodated without excessive cost to the solar homeowner. Local governments could adopt guidelines clearly describing the status of any existing aesthetic regulations that might apply to solar systems, and indicate with drawings those designs which are and are not acceptable. While such an approach would be helpful for most solar homeowners, it could discriminate against homebuilt systems, particularly those made from recycled materials. In retrofit situations, screens could be used to shield unsightly collectors, while in new structures solar systems can be integrated more easily into the overall design. The potential problem

of regulatory discrimination against solar systems should dissipate over time, since once a few designs have been accepted the government cannot rationally discriminate against others with similar plans.⁵⁹

A number of approaches to land use regulation can affect solar energy use on grounds other than aesthetics. One frequently discussed option is to include a solar energy element in a municipality's comprehensive plan which could accomplish any or all of the following: validate regulatory activities to encourage solar; integrate solar development with energy conservation and other energy uses; increase community awareness and public support for solar; and describe generally the types of structures and locations in which individual or joint solar systems would be encouraged or required, and under what conditions.⁶⁰ Because most zoning ordinances were drafted before solar energy use was viewed as an appropriate consideration, review of the impact of these regulations on solar utilization is in order. For example, regulation of accessory uses on a land parcel can be unpredictable, and the status of solar units in this regard is equally unclear. Local governments may need to be vested with new powers to adopt zoning ordinances to regulate types of energy sources and location of their components. Subdivision regulations, through control of aesthetics, public utility services, and location and use of structures, could either encourage or discourage solar development if explicit provisions favoring solar are not adopted.

Consideration of vegetation, topography, and climate in residential site planning can provide, in addition to protection of solar access, that buildings be located to reduce energy requirements and thus make the use of solar systems more cost effective.

Property Tax Exemptions for Solar Systems

In those states where property tax exemptions for solar have been passed, it is up to the county assessors to carry out the difficult task of actually valuing these systems or designs. Valuation is currently the major problem in implementing the tax exemption program⁶¹ due to the relatively recent appearance of solar buildings on the housing or commercial market, and the dependence of a solar system's value on long-term energy and economic returns in the context of escalating fuel costs. Assessors in most states use market value as the reference for estimating a residence's worth. However, since there is little or no resale experience with solar homes, fair market comparisons are not possible. Assessors' knowledge of solar energy varies by individual, but most have limited or no experience on which to make an "educated guess" as to the worth of a system. Property tax exemption laws in several states specify that solar systems be given no value and assessments be made therefore as if the home were conventionally heated. However, in most states valuing is left completely to the assessor's discretion, and no state has prepared guidelines to give assessors a reasonable measure by which to evaluate specific applications. Experience to date indicates that in most cases assessors are recording replacement cost values for the solar systems with which they deal.

An alternative valuing mechanism proposed by the Ecotope Group in Seattle, Washington would involve developing an assessor's manual based on average solar system efficiencies and an adaptation of rate of return analysis.⁶² The approach, which provides for the valuation of a solar system in terms of productivity rather than cost, won enthusiastic support during a presentation to Washington county assessors and the state Department of Revenue in March 1978. This method could be used until market data for solar homes becomes available, and perhaps could provide an alternative mechanism to market evaluation in the long-term.

Out of 25 states which have enacted solar property tax exemption laws, five states (Connecticut, Georgia, Virginia, New Hampshire, Vermont) leave the decision of whether or not to actually pass and implement the exemption up to local jurisdictions. Experience in several states suggests steps which local governments could take to more effectively carry out such a program, and points out a few drawbacks of the local approach. In Connecticut, where over half the towns have passed an ordinance exempting solar from property tax assessment, the Connecticut Citizen's Action Group has distributed written and other information publicizing and describing the law and encouraging that action be taken.⁶³ In Georgia, very few counties had passed exemptions until six months ago when the state distributed pamphlets describing this option. Although more than ten percent of the counties in Georgia have now taken action, several reasons given by the state's energy office for local reluctance to pass exemptions include: lack of manpower to

administer a program; low consumer demand for solar; minimal property taxes. In Maryland, where state law provides for a locally-enacted property tax credit for solar, very few counties have acted. They are apparently waiting for more state and federal pro-solar action; and they feel they cannot justify subsidizing solar without doing the same for other energy sources.*

Community Development, Demonstration,
and Public Affairs Programs

The purpose of this section is not to present an exhaustive survey of local solar activities, but rather to describe representative projects in order to portray the diversity of such ongoing activity.⁶⁴ At one extreme are those communities which are trying to achieve energy-independence using a variety of renewable resources including solar. One such example is the creation of a new town, Cerro Cordo, 20 miles south of Eugene, Oregon. Winona, Minnesota plans to be energy self-sufficient by the year 2000. The goal in Palm Springs, California is for a completely solar-energized future. Other city-based projects include a program for buying and leasing solar hot water heaters in Ocala, Florida; a broad-based effort in Los Angeles, California to encourage the development of a solar industry through numerous installations, designation of "solar ombudsmen" as troubleshooters in various city agencies, and a number of demonstration projects on city-owned buildings; creation of a neighborhood solar utility

*From telephone conversation with A. Kruglak. See Acknowledgements.

in Palo Alto, California to establish a district solar heating system for domestic hot water for an entire block; solar heated swimming pool demonstrations in Shelby, Montana and Santa Clara, California; a program in Cleveland, Ohio where one of NASA's research centers is supplying local news media with daily insolation data; and a city-run test facility for solar and other alternative energy devices in Wichita, Kansas.

Numerous construction and education activities have been undertaken to provide low-income families with solar heating. The majority of these are funded by the federal Community Services Administration and implemented through county-level community action programs (CAPs) throughout the country. Solar programs organized through the local CAPs are becoming frequent and diverse; a brief sampling includes: solar interest surveys, construction of freestanding and attached solar greenhouses, passive space heating retrofits, installation of hot water heaters, and education programs such as developing manuals and holding workshops on the range of technologies mentioned above. Human Resources Development Councils, the Montana version of the CAPs, are actively involved in solar and other appropriate technology programs in at least ten communities. In the state of Washington, the Okanogan, Grant, and Kittitas County CAPs are among those which have undertaken projects on various solar applications.* In Oregon solar projects have been implemented by the Lane County and Benton-Linn CAPs, and a solar technician program is being developed by a CAP in the Willamette Valley.

*These include: publication of a solar greenhouse construction manual in Okanogan County, a weatherization/appropriate technology technician training program in Grant County, and solar water heater and passive retrofits in Kittitas County.

There are also a variety of projects for low-income families which are not run by the CAPs. A public housing project in San Bernadino, California was retrofited with a central solar space and water heating system. By involving a number of local people in its construction, unemployed individuals were trained in solar-related jobs. Other examples include solar crop drying and space heating projects for farms in Cedar County, Nebraska; a regional council program in Alamosa, Colorado for families who built simple solar space heating units from recycled materials; and installation of a solar hot water system in a cooperatively-owned apartment building in New York City with funding, in part, from the city's sweat equity loan program.⁶⁵

Several final examples round out the scope of solar activity initiated and/or sponsored by local, municipal, and county governments. Mohave County, Arizona is one of few counties to have created a Solar Energy Commission and special solar office, both of which are involved in legislative and educational programs. The county's major solar effort is the construction of a new corrections facility which has a hybrid space heating and active water heating system. Prisoners are assisting in the construction, and will thus receive solar job training.⁶⁶ At the opposite end of the country, about two-thirds of the towns in Vermont have

appointed energy coordinators (an option provided by state law) whose responsibilities include exploring alternative solar uses and assisting homeowners with solar purchases. There are also a variety of activities being organized throughout the country by private citizens, churches, and community groups such as local solar energy associations, but a description of these is beyond the scope of this section.

REFERENCES TO SECTION IV

1. S. Oddo, "Standards and Codes," Solar Age, May 1978, p. 18. BOCA issues the Basic Building Code (BBC), primarily used in the Midwest and Northeast U.S.; ICBO issues the Uniform Building Code (UBC), primarily used in the Mountain and Pacific states; and SBCC issues the Southern Building Code (SBC), used throughout the South. Approximately 60% to 70% of jurisdictions enforcing building codes use model codes, or revised versions thereof.
2. Environmental Law Institute (ELI), Legal Barriers to Solar Heating and Cooling of Buildings, Washington, D.C., ELI, March 1977 (for U.S. ERDA), p. 50.
3. Kern et al., The Owner Builder and the Code, Oakhurst, California, Owner-Builder Publications, Chapter 12, for detail on difficulties for owner-builders seeking appeal to, or change in, local building codes. This book deals with owner-builders in general, not solar builders specifically.
4. See, for example, Sections 106 and 107 of the Uniform Building Code which apply to new systems and methods of construction.
5. ELI, op. cit., Chapter 2, for detailed examination of provisions in the Basic, Uniform, and Standard codes (plumbing, mechanical, and building) and their potential barriers to solar, particularly active systems.
6. P. Niland, "Hand in Hand: The Credit and the Codes," Solar Age, June 1978, p. 31.
7. This survey was conducted during Fall 1977 by Battelle-HARC, Seattle, Washington, for the U.S. DOE-funded solar technology transfer program. See Appendix B.
8. ELI, op. cit., pp. 63-67.
9. A number of states, including Connecticut, Florida, Minnesota, and California have passed legislation requiring that solar standards be written. See National Conference of State Legislatures, "Energy Report to the States," Vol. 4, No. 8, April 4, 1978, p. 31.
10. ELI, op. cit., pp. 65-66.
11. Kern et al., op. cit., p. 136.

12. Committee members include: the Northamerican Heating and Airconditioning Wholesalers Association (NHAW), the Sheet Metal and Air Conditioning Contractors National Association (SMSACNA), the National Environmental Systems Contractors Association (NESCA), the Mechanical Contractors Association of American (MCAA), and the National Training Fund (NTF). (U.S. DOE, "Solar Energy R&D Report," June 4, 1978.)
13. ELI, op. cit., pp. 68-73.
14. San Diego Integrated Planning Office, San Diego County General Plan--1990, Part XI, Energy Element, November 1977, p. XI-11, Action Programs US-1.4, 1.5, 1.7; see also "Solar Ordinance Feasibility Analysis for San Diego County," prepared in response to Action Programs S-1.4, 1.15 (p. XI-17), Energy Element, San Diego General Plans-1990.
15. NCSL, "Energy Report to the States," April 28, 1978, pp. 27-28. Several states including Minnesota and Nevada have implemented energy conservation codes which give energy credits for solar systems.
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17. G. Kah and L. Palmiter, "New Building Energy Conservation Standards and Solar Energy Utilization: Opportunities and Conflicts," presented at 2d Helioscience Institute Conference, Palm Springs, April 10, 1978. Paper contains a number of references to analyses of ASHRAE 90-75. See also L. W. Bickle and W. J. van der Meer, "Effective U-Factors: An Average Heat Transfer Rate," Conference on Technology for Energy Conservation, Albuquerque, NM, January 24-27, 1978, pp. 21-29.
18. The idea of a steady state U value assumes that the U value is a constant material property that does not change with time." B. Stickney, "New Energy Conservation Code," NMSEA Bulletin, November 1977, p. 6.
19. An effective U value is defined as "the average...heat transfer rate per unit area during a specified time

period, divided by the average temperature difference during the same time interval." Ibid., p. 6. See also Bickle and van der Meer, op. cit.

20. J. Dritt and T. Shisman, "The Energy Conservation Building Code: Implementation in New Mexico," Conference on Technology for Energy Conservation, Albuquerque, NM, January 24-27, 1978, pp. 16-20.
21. Living Systems and Davis Community Development Department, Energy Conservation Building Code Workbook, July 1976; see Ordinance No. 784, p. 3.
22. Ibid., p. I-1.
23. M. Hunt and D. Bainbridge, "The Davis Experience, "Solar Age, May 1978, pp. 20-23.
24. Alan S. Miller et al., Solar Access and Land Use: State of the Law, 1977, Washington, D.C., Environmental Law Institute, 1977, p. 3; William A. Thomas et al., Overcoming Legal Uncertainties About Use of Solar Energy Systems, Chicago, American Bar Foundation, 1978, p. 24.
25. Miller et al., op. cit., p. 3.
26. Ibid., p. 25.
27. See "Selected References: Solar Energy and Land Use," Environmental Comment, May 1978, pp. 14-15.
28. A negative easement is one in which the servient landowner (or seller or grantor) is restrained from doing something on his or her land that would be allowed if the easement did not exist. The dominant landowner (or purchaser or grantee) of the easement for light could therefore seek a court order to remove the neighbor's structures or trees which exceed the height restriction stated in the easement. In an affirmative easement the purchaser has a right to actually enter the land of the seller to a specified extent. Affirmative easements can be acquired by prescription, i.e., created by uninterrupted use for a number of years.
29. R. Maullin and K. Sheehy, "Solar Rights in California," Environmental Comment, May 1978, p. 7.
30. For detail on light easements to protect solar access, see Miller et al., op. cit., pp. 8-11; and Thomas et al., op. cit., pp. 26-27.
31. A recent survey of some existing solar developments found

a fairly widespread use of restrictive covenants to assure solar access. Typically the covenant provisions state that no solar collector shall be shaded by a structure or vegetation between certain hours on a certain date. See M. Jaffee, "Protecting Solar Access," Environmental Comment, May 1978, p. 13.

32. For detail on covenants and solar access, see Miller et al., op. cit., pp. 11-12.
33. Thomas et al., op. cit., p. 44.
34. Ibid., p. 37.
35. New York State Legislature Commission on Energy Systems, Proceedings of A Forum on Solar Access, New York, NY, July 28, 1977, testimony of R. Stein, pp. 6-17, for further technical description of solar access.
36. Thomas et al., op. cit., pp. 48, 63, and 64.
37. This approach has been criticized as being so expensive that it would be useful only in very limited circumstances (Miller et al., op. cit., p. 16). The overall cost would seem to depend on the situation: the amount and location of condemned airspace, the number of solar owners being benefited and therefore reimbursing public funds, etc. Presumably such power would be exercised only in situations where the result would be a significant public benefit rather than a windfall to a select few with solar collectors. See also Maullin and Sheehy, op. cit., p. 7, for possibility of state reimbursement for local expenses incurred in this type of arrangement.
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40. Thomas et al., op. cit., p. 48.
41. For detail on solar envelope zoning and zoning to maximize solar access generally, see Ralph Knowles, "Solar Ethics--Urban Form," Proceedings of the Second National Passive Solar Conference (AS-ISES), Philadelphia, PA, March 16-18, 1978.
42. Miller et al., op. cit., p. 22. For detail see, G. B. Hayes, "Trying to See Both the Forest and the Trees," Environmental Comment, May 1978, p. 11; and New York

State Legislative Commission, op. cit., testimony of G. B. Hayes, pp. 23-24. Preliminary findings of a study by the American Society of Planning Officials also indicate that vegetation control is the most important issue in guaranteeing solar access (personal communication, Duncan Early, ASPO, May 1978).

43. D. Engel, "Developing Solar Land-Use Plans," IDEA, The Journal of Law and Technology, Vol. 19, No. 1, 1977, p. 50.
44. Miller et al., op. cit., pp. 19-22 on solar zoning in general.
45. Thomas et al., op. cit., p. 50.
46. Jaffee, op. cit., p. 14. See also, New York State Legislative Commission, op. cit., testimony of R. Stein, pp. 18-21.
47. Jaffee, op. cit., pp. 12-14 and Miller et al., op. cit., p. 24, for detail on site planning for solar access.
48. Miller et al., op. cit., pp. 9-10 and Thomas et al., op. cit., pp. 69-72 for detail on TDR.
49. For description of potential enforcement problems and legislation proposed in Massachusetts and Rhode Island in 1977, see New York State Legislative Commission, op. cit., pp. 25-26.
50. Thomas et al., op. cit., p. 51.
51. Miller et al., op. cit., pp. 6-8.
52. Ibid., pp. 5-6 and Thomas et al., op. cit., pp. 20-26.
53. Miller et al., op. cit., pp. 17-19.
54. NCSL, "Energy Report to the States," April 18, 1978, pp. 28-29; Miller et al., op. cit., p. 17; New York State Legislative Commission, op. cit., pp. 28-30, 73. The entire New York State solar access forum provides an interesting discussion of the relative merits of different solutions on a level of detail which can be relevant and useful for local lawmakers and planners. Implementation, enforcement, and other key issues are addressed as the forum is geared around actual solar access legislation proposed in the 1977 New York State Legislature.

55. Living Systems, Davis Energy Conservation Report: Practical Use of the Sun, 1977, p. 35. See also, City of Davis, Revised EIR No. 3-77, Energy Conservation Planning Measures, November 1977, pp. 20-28 for text and impact assessment of a solar rights ordinance which was not adopted. The EIR also contains the other solar planning ordiannces.
56. Miller et al., op. cit., pp. 25-26 and U.S. DOE and U.S. EPA, op. cit., p. I-7.
57. Miller et al., op. cit., p. 14 and New York State Legislative Commission, p. 26-27.
58. Miller et al., op. cit., p. 8 and Thomas et al., op. cit., p. 61.
59. Miller et al., op. cit., pp. 12-14 for detail on zoning for aesthetics.
60. Thomas et al., op. cit., p. 37 for ABF statute including several of these points.
61. This and other findings discussed are based on a survey done during Spring 1978 by Battelle-HARC, Seattle for the U.S. DOE-funded Solar Technology Transfer Program. See Appendix A. Survey also includes analysis of difficulties of defining and valuing passive systems in tax incentive legislation regulations.
62. The concept was developed by Dave Baylon (Ecotope Group, Seattle) for the U.S. DOE-funded Battelle Solar Technology Transfer Program. See Appendix A.
63. Citizen's Energy Project of the Center for Science in the Public Interest, People and Energy, Vol. 3, No. 5, p. 5.
64. For detail see two excellent periodicals: People and Energy (CSPI, Washington, D.C.), and AERO Sun-Times (Alternative Energy Resources Organization, Billings, Montana); see also K. Bossong, Local-State Energy Efforts, Report Series No. 13, Washington, D.C., CSPI, Citizen's Energy Project, 1977.
65. No Heat, No Rent, An Urban Solar and Energy Conservation Manual, New York, Energy Task Force, 1977.
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APPENDIX A

VALUING SOLAR SYSTEMS

Material developed in response to questions raised by lenders, appraisers, and assessors at workshops presented by the Regional Solar Technology Transfer Program staff and consultants.

SURVEY OF STATE SOLAR INCENTIVE LEGISLATION

by

Jill A. Goodnight

This paper describes the limited recognition given passive solar energy in solar incentive legislation and suggests areas in which changes may occur.

INTRODUCTION

The survey of state solar incentive legislation discussed below was conducted under the sponsorship of the U.S. Department of Energy's Regional Solar Technology Transfer Program. It was an outgrowth of the introductory solar program developed by Battelle-Northwest and the Ecotope Group of Seattle for lenders, appraisers, county assessors, state departments of revenue, and all others concerned with the valuation of the solar increment in a facility.

Initial telephone contact was made with the appropriate revenue department division in each state during early January, requesting preliminary information and copies of legislation and regulations if available. A follow-up call was placed during the weeks of February 27 and March 6, 1978. Normally, just one contact was made per administering division. A second call was placed if standards were to be established and the department of revenue was unfamiliar with their development. This brought contact with several state energy offices.

Among the data items sought were the following: 1) type of incentive; 2) effective dates; 3) eligibility criteria, including reference to passive designs; 4) valuing criteria; 5) monitoring capability and type of data collected; 6) number of applications processed; 7) groups contributing technical input to criteria development; 8) estimated incentive value per taxpayer; 9) problems in administering the program; 10) other financial incentives available to solar consumers in the state.

[It must be recognized that specific data compiled in this preliminary report is tentative, for it has not been reviewed by those interviewed.]

OVERVIEW OF STATE INCENTIVE PROGRAMS

A recent summary survey of state solar legislation¹ shows the following numbers and categories of state consumer incentive programs: 25 states with property tax exemptions, 14 income tax credit/deduction states (of these, 7 have both programs), one state repealed its property tax exemption and replaced it with an income tax credit, 4 states

exempt solar purchases from the sales tax, 2 give refunds for sales tax paid, 3 have a rapid amortization option, and 3 have authorized solar loan programs for certain state-regulated institutions.

States are limited in the kinds of incentive programs open to them by their existing tax structure. States without an income or sales tax cannot adopt credit or exemption programs in those areas. Among those options remaining, differential impacts upon the consumer, state revenue receipts, and the administering agency may cause one incentive to be preferred over another by state lawmakers.

In the sections which follow, the major elements of the solar property tax exemption and the income tax credit/deduction programs will be described. The treatment given to passive solar design in each state's administration of its legislation is the unifying factor of comparison.

INCOME TAX INCENTIVE PROGRAMS

As seen in Figure 1, characteristics given to solar income tax incentive programs by both lawmakers and administrators vary considerably. A fairly even division exists between states seeking to encourage solar installations in all structures and those primarily concerned with the residential taxpayer. The duration of the incentive is also a major variable.² Seven states have legislated incentives with no time limit, while in four others 1984 will bring termination. The remaining states have set their "sunset" legislation to expire at different times between 1980 and 1987.

The solar income tax credit program is likely to be the most effective financial incentive throughout the country for consumer installation of solar systems. It is a direct mechanism for lowering first costs. Its importance in governmental energy conservation programs cannot be underestimated. But its success in encouraging passive solar construction is yet to be determined. Lawmakers and rulemakers alike are unaware of passive's potential. This situation has led to an implied assumption in over half of the states surveyed that mechanical systems are the only legitimate solar conversion units eligible for credit.

FIG. 1. CHARACTERISTICS OF SOLAR INCOME TAX INCENTIVE PROGRAMS

Incentive Description

Solar tax credit for residence of taxpayer only--OK, AZ, OR, MT, NM
 Solar tax credit for any building or use--NC, HI, ND, CA, KS
 Solar tax deduction for residence--AR, ID, CO
 Solar corporate tax deduction--MA, CO
 Insulation/energy conservation tax credit--AR, ID, NC, AZ, OR, KS, CA
 Insulation/energy conservation tax deduction--MT

Incentive Value

Credit 10% of 1st \$1000, 5% of next \$3000--MT
 Credit 10% of total cost, no maximum--HI, ND
 Credit lesser of 25% of cost or \$1000--NC, OR, NM
 Credit lesser of 25% of cost or \$1000 (residence), 25% or \$3000 (business)--KS
 Credit lesser of 25% of cost or \$2000--OK
 Credit declines 5% yearly from 35%, \$1000 maximum--AZ
 Credit lesser of 55% of cost or \$3000 (res.), greater of \$3000 or 25% (non-SFR)--CA
 Full cost deducted--AR, ID, CO, MA

Presence of Central Monitoring, Record Keeping

Yes, at least cost, system type, and location--CA, OR, NM, MT
 Yes, extent of data unknown--NC, KS, MA
 Yes, only cost claim on tax form to date--CO, AR, ND
 No, will have in 1979--ID
 No record keeping anticipated--HI, AZ
 Undetermined--OK

Role of Passive Systems in Eligibility Criteria

Law ambiguous, adopted or proposed regs include passive--CA, OR, MA, AZ
 Law ambiguous, no regs written, passive a possibility--CO
 Law ambiguous, no regs written, passive unlikely/unknown--MT, HI, AR, OK, ND
 Law ambiguous, regs omit mention of passive--ID
 Solar H/C Demo Act (HUD) standards required, regs include passive--NM
 Solar H/C Demo Act (HUD) standards required, no regs developed--NC
 Law describes active system--KS

The determination of what constitutes passive solar requirements, during the cooling and heating components as opposed to regular construction is seasons, respectively. Also included are minimum admittedly difficult. Particularly troublesome for insulation standards for new construction. Thermal rulemakers are eligibility requirements for thermal mass is eligible for credit but not required in a mass found in load-bearing walls and floors, allowable glazing amounts for southern walls and exposures in direct gain systems, allowable insulation amounts for improvement of a passive system's overall performance, and percent of costs eligible in attached greenhouse designs.

The earliest and still-definitive criteria developed for passive systems are found in the regulations of New Mexico, developed after the HUD criteria were found to be too vague for administrative purposes. Beyond ruling on specific items to be eligible, the regulations include a simple and useful formula for determining allowable window area. Similar regulations have been adopted by the majority of states which specify passive as eligible.

Unique among the states is California's development of passive design criteria, as opposed to the line-item eligibility approach of New Mexico. Chief among their criteria are shading and exposure

PROPERTY TAX INCENTIVE PROGRAMS

As opposed to a true incentive program, these inducements for solar construction should more accurately be termed "removal of disincentives." A conventional heating system does not increase a structure's assessed value. The energy production characteristics of a solar system may do so, however, and could thus require a larger property tax payment. This could add a substantial amount to the annual O&M costs of the solar system. Therefore, a property tax exemption is needed so as not to penalize homeowners for investing in energy saving devices. The precise savings resulting from such an exemption will vary depending upon the assessment ratio in a given state and the local property tax rate. On a solar system valued at \$5,000, with assessing done at full market value and a tax rate of \$50 per \$1000, taxes of \$250 would be exempted.

FIG. 2. CHARACTERISTICS OF SOLAR PROPERTY TAX INCENTIVE PROGRAMS

Incentive Description

Statewide property tax exemption, usually all property--ND, WA, IN, IL, NY, MA, RI, MD, ME, OR, AZ, MI, NC, HI, NJ
 Allow municipalities to exempt if they wish--CT, GA, VT, NH, VA
 Exemption has \$2000 limit--SD
 Reduced 30% assessment to 15% for solar; then repealed--MT
 Property tax allowance; state repays counties for exempted revenue--NV
 Assess at 5% of actual value--CO
 Reimburse 35% of entire property tax for solar systems providing 70% of H/C needs on an average annual basis--KS
 Allows municipalities to provide tax credit for solar--MD

Value Approach

Discretion of assessor; law specifies difference in assessed value with and without solar addition--IL, NY, CT, NV, NJ, SD
 Discretion of assessor; no guidelines or standard format--WA, MD, CO, GA, VT, ME
 Cost itemization--MI, KS
 Assign no solar value at all; assess as with conventional heating system--ND, MA, RI, AZ, NC
 Difference between assessed value with and without solar; value must be not less than normal cost of purchase and installation of solar system--VA
 Valuing procedure determined by each locality--NH
 Difference between true cash value with and without solar; discretion of assessor--OR
 Statutory standard to assess at replacement cost--HI
 Difference between assessed value with and without; recommends \$2/ft²--IN

Presence of Central Monitoring, Record Keeping

Yes, available information varies--IL, NY, NV, VA, ME, MI, KS, IN
 No--ND, WA, CT, MT, RI, NH, CO, GA, NJ, VT, AZ, SD, HI, MD
 Will ask assessors to submit solar application data--MA, OR
 Statewide access to market sales data to gather solar resale values--NC

Role of Passive Systems in Eligibility Criteria

Law ambiguous, passive elements included in proposed or adopted regs--NY, NJ, CT
 Law ambiguous, no regs written, passive would be considered--OR, CO, IL
 Law ambiguous, no regs written or necessarily expected, contact thinks passive ineligible--HI, MI, ME, GA, IN, NC, MA, MT
 Law requires HUD standards, proposed or written regs include passive--RI, VA, WA
 No definition in law, no regs written--SD, AZ, ND, MD, VT, NV
 Law describes active systems--KS, NH

Defining eligible systems is as difficult in property tax states as it was earlier described for income tax credit purposes. Only two of the 25 states surveyed have laws which seem clearly to exclude passive elements. Nonetheless, in at least 14 states the question of passive systems either has not been considered or it is felt that such systems are an over-improvement of standard construction and likely will be ruled ineligible.

Compounding the difficulty of defining eligibility is the complex problem of placing a value on any solar system, regardless of type. In all but two states contacted, the reference for estimating residential worth is market value. However, with solar homes there is little or no resale experience; therefore market comparisons are not possible.

Responsibility for assigning value to property is

dispersed among county assessors throughout the states. Their knowledge of solar energy varies by individual, but most have limited or no experience upon which to make an "educated guess" as to the worth of a system. No guidelines in any state have been prepared to give assessors a reasonable measure by which to evaluate specific applications. Their official response to the exemption program appears to be, in most cases, to record replacement cost value. Their unofficial response is to register a high degree of frustration at the absence of standard references by which to make comparisons.

POLICY ISSUES INVOLVED IN INCENTIVE LEGISLATION

A review of the survey responses finds that solar incentive legislation and its administration can vary in the following basic areas:

1) Eligibility of passive systems--This issue remains undecided in most states, although it is not specifically precluded by law. Not infrequently one finds rulemakers and regulators unaware of the existence of passive designs, and certainly uninformed of their legitimate role as effective solar energy systems.

2) Selection of incentive--This decision has a differential impact upon consumers and administrators alike. The income tax credit and property tax exemption fall at opposite ends of the scale, with relative ease of administration and immediacy of consumer benefits accrued, characteristic of the income tax program. The property tax incentive, on the other hand, is characterized by its dispersed administration, problems arising from its judgmental value approach, the ongoing nature of most state programs, and its small fiscal benefit to the taxpayer. Consequently, this program has brought a great deal of "bang" for very little "bucks", in a curious reversal of the traditional meaning of the phrase.

3) Monitoring--When an entirely new technology is introduced with the assistance of government incentive programs, there is usually a concern to follow up on the impact both to the state and to the recipient. Information such as type of solar system, location, cost, performance data, manufacturer, designer, and installer would all be useful in the coming years in developing a consumer protection profile for different types of solar systems. Income or property tax claim forms could require any or all of this information prior to approving a tax incentive application. Central collection and analysis, such as the Oregon Department of Energy is undertaking, can relieve the assessor or the department of revenue from extraordinary record keeping. If adequate records are maintained locally, solar property tax exemption files can be used by assessors to register true market value in future solar sales transactions. There are trade-offs in gathering such data which must be considered, however: the administrative paper shuffle can be expensive to the state; consumers may object to filing elaborate application forms and forego the incentive altogether; industry may find legal objections to such close scrutiny. This is the rationale behind Arizona's failure to monitor, and the reason for California's solar census being administered on a voluntary basis.

4) Rate of Commercialization--A state can attempt to "steam-roll" the installation of solar systems by offering very large tax incentives over a limited period of time. In doing so it hopes to achieve the objective of rapid penetration of the heating or H/C market. Simultaneously, however, it runs the risk of encouraging low-quality systems that offer poorly constructed components or improperly sized or installed units or designs. California has such an incentive program and has attempted to resolve the quality issue by requiring warranties on both active and passive design

components and developing a certification program for active units. The administrative price of such a program is high, as standards must be written and certification and approval programs developed.

No other state has set such a fast turn-around or placed such a high value on its incentive. The majority of other income tax programs have established a \$1,000 maximum and provide no termination date. They do not require the extensive warranty and certification approvals of California, nor do they expect to develop performance standards for either active or passive systems. They proceed on the assumption that with a modest boost to the homeowner's pocketbook, the market will self-regulate quickly enough, as poorly-performing systems lose value in resale transactions. The administrative advantages to the state of this streamlined approach are considerable.

5) Performance Requirements--Only a few states have attempted to tie their incentive programs to some measure of system effectiveness. As previously described, in California the effort has involved the development of extensive standards and testing programs. It is at present the only state whose passive regulations involve minimum design criteria. In Indiana the legislature required the Tax Commission to issue property tax regulations based upon, among other things, the amount of energy a solar system produces. The Commission presently feels that legal challenges from individual manufacturers may arise if they carry out the legislature's intent. In Kansas a substantial property tax refund will be given to any taxpayer whose active solar system carries 70% or more of an average annual heating or cooling load. In draft form at present, their calculations are expected to combine ASHRAE heat loss calculations, a design temperature change of 73°, the size of collectors versus square foot of floor area and storage space, etc., in determining average energy output. In Oregon a requirement that eligible solar systems provide 10% of a home's energy needs eliminates the "casual" passive design and has led to the development of minimum active collector area requirements based upon local climate zones and square feet of structure. Certainly, many factors affect the amount of energy a given system will produce. The experience of these few states who are developing eligibility criteria based on reasonable expectations of performance will be of major interest to all persons concerned with establishing, state by state, a nation of quality solar designs and installations.

6) Effectiveness of Financial Incentives--Homeowners install solar systems for many reasons, cost effectiveness and payback periods being only one consideration. Certainly, a \$5,000 investment in an attached greenhouse would be all the more inviting if \$1,000 were returned within the year. But if it were not, would the decision to construct be altered in any way? Conversely, for those who perceive solar energy still fraught with uncertainty and risk, or just do not like houseplants, would

a \$1,000 inducement convince them to go solar? A recent study by the George Washington University suggests that aversion to risk-taking is a major impediment to widespread solar utilization.³ If so, then passive solar systems with their lower first costs and their considerably lower anticipated O&M budgets should place them in a more advantageous position relative to the general risk-averse consumer than are active solar systems.

IMPACT OF THE STATE INCENTIVE SURVEY

The contacts made with departments of revenue throughout the country produced some personally gratifying results, but highlight the great need for spokespersons for passive solar energy in each state. From among many conversations, these highlights emerge:

1) The inquiries about the treatment which passive systems received in law and/or regulations brought the concept of passive solar energy to many administrators for the first time. In several states, what was considered a clear-cut definition of solar energy on which to base eligibility criteria took more complex dimensions. Our questions seemed to pique a genuine interest in learning more about how passive systems might be applied in their incentive program, and frequent requests were made for a list of states who had already included passive eligibility criteria in their regulations.

2) An initial inquiry and subsequent conversation brought Battelle into brief services as a clearinghouse for passive information. Several days after a lengthy discussion with one Midwest state about the implications for passive in their solar legislation, I received a call from a neighboring state. This second person had heard from my first contact about the study that was underway and wanted to learn more about passive solar energy. His state was in the process of developing solar legislation and was actively seeking all available information where it could be found!

3) Making more than just telephone contacts in the Northwest area, the Technology Transfer Program sponsored 4-5 hour presentations on solar energy heating and cooling applications, their economic underpinnings, and a discussion of state property tax incentives before county assessors in the states of Washington and Idaho. A heavy emphasis in the presentation, prepared by the Ecotope Group of Seattle, was on passive applications.

Out of the first meeting, held in Boise and attended by Idaho county assessors and staff from the Idaho Department of Revenue, came a very clear message that valuation was the major problem of the property tax incentive program. The idea for an assessor's manual based on average solar system efficiencies and rate of return analysis was then developed by Dave Baylon of Ecotope. On March 9, the concept was presented to Washington county assessors and Department of Revenue staff for its first critique. It won overwhelming support for

its apparent ability to present reasonable estimates of value in terms of productivity rather than cost until market data can be provided and the traditional value approach re-established.

The proposed valuation tool developed in response to the lack of assessing guidelines was not the only thing presented to the Washington assessors that day. They also received a well-prepared and thoroughly documented slide show on the ability of passive solar systems to perform well in the Northwest climate. As a result of this information session, the Department of Revenue will revise its ruling that passive elements are ineligible for the solar property tax exemption.

SUMMARY

Among states that are newly administering a solar incentive program, there is a noticeable lack of information or even awareness of passive solar systems. However, the impression received from many of our contacts was that as a new program, solar regulations would continue to be revised until all regulations had had time to be "debugged" of earlier mistakes or omissions. If true, then it is now time to bring passive solar cases to the attention of state incentive administrators.

At the same time, documentation of passive performance characteristics and of the manner by which other states have determined eligibility standards for south-facing glass and greenhouses, etc., should be presented. Crossing statelines to learn from other's experience is particularly useful at this point in time, for there are several good models that can be referenced.

From the issues developed above, the following recommendation is made:

An information network is greatly needed to develop and maintain communications relating to solar incentives. Whatever the format established, it should be able to regularly operate in the following areas: a) between state governments, in order that problems and solutions might be shared; b) within each state, preferably through the mechanism of a solar energy association which can serve both as a bridge and a translator between consumers, legislators, builders, etc.; c) within the administrative system itself, in order that data on projects approved through the incentive program be compiled in one central place.

From the discussions of an earlier section, the following problem areas also suggest that immediate attention is warranted: a) development of a uniform valuing mechanism that may be used by assessors until market data becomes available; b) use of performance criteria in determining eligibility should be explored for its potential usefulness in other states.

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Seattle, WA 98105

Footnotes

1. "State Solar Legislation*--*as of January 1978," pamphlet prepared by the National Solar Heating and Cooling Information Center, available at no charge by calling their toll-free number, (800) 523-2929.
2. As listed in the worksheets prepared for this report and available from the author.
3. Solar Energy Incentives Analysis: Psycho-Economic Factors Affecting the Decision Making of Consumers and the Technology Delivery System. Prepared for the U.S. Department of Energy, Division of Solar Energy, Washington DC 20545, by the George Washington University. Document No. HCP/M 2534-01. January 1978.

Solar incentive legislation involving the property and income tax has been passed in 30 states as of January 1978. Of those 30, the following states have developed regulations to implement this legislation which specifically include passive solar systems:

NEW MEXICO (Income tax credit)

Contact: Clinton R. Chandler
Depart. of Taxation & Revenue, Technical Serv. Bureau.
P.O. Box 630
Santa Fe, NM 87503 (505) 827-3221

CALIFORNIA (Income tax credit)

Contact: Mike DeAngelis
Energy Resources Conservation & Development
Commission
1111 Howe Avenue
Sacramento, CA 95825 (916) 920-6011

OREGON (Income tax credit and Property tax exemption)

Contact: Al Kiphut
Oregon Department of Energy
111 Labor & Industries Building
Salem, OR 97310 (503) 378-8446

VIRGINIA (Property tax exemption)

Contact: John Spears
Virginia State Board of Housing
6 North 6th Street, Suite 202
Richmond, VA 23219 (804) 786-7891

NEW YORK (Property tax exemption)

Contact: Wendy Wild
New York State Energy Office
Empire State Plaza
Agency Building #2
Albany, NY 12223 (518) 474-1785

INCOME TAX INCENTIVES WORKSHEET

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Description	Value	Monitoring	Eligibility
ARIZONA			
<ul style="list-style-type: none"> Personal income tax credit for cost of solar system installed in permanent residence. Includes swimming pool heaters. Effective with 1977 tax returns, through 1984. 	<ul style="list-style-type: none"> 35% of cost in 1978; declines 5% each year until expires in 1984. \$1000 maximum remains constant. 	<ul style="list-style-type: none"> No. Tax form requires cost information. Proposed regs require claims to be accompanied by description of function. Tracking only through random audit. 	<ul style="list-style-type: none"> [Law not received 3-10-78] Proposed regulations include passive elements similar to New Mexico. Also allow tax credit for residential insulation at 25% of cost or \$100 maximum.
ARKANSAS			
<ul style="list-style-type: none"> Income tax deduction in year of installation for any residence owned by individual homeowner for energy-saving equipment. Effective with 1977 tax returns and indefinitely thereafter. 	<ul style="list-style-type: none"> Entire cost of purchase and installation. 	<ul style="list-style-type: none"> Tax form does not require system description, only amount deducted. 	<ul style="list-style-type: none"> "Improved insulation, storm doors or windows, motor-driven power vents and solar heating and cooling equipment." Regs define solar H/C equipment as "solar H/C equipment" and exclude deduction for new construction. Passive not mentioned or ruled upon.
CALIFORNIA			
<ul style="list-style-type: none"> Income tax credit for new or retrofit solar systems, including single and multi-family residential H/C, hot water, and swimming pools; commercial and industrial H/C or hot water; other commercial or industrial solar applications; solar electric. Effective with 1977 tax returns, through December 1980. 	<ul style="list-style-type: none"> Single family residence = 55% of cost or \$3,000 maximum; all other buildings with a system cost greater than \$6,000 = the greater of 25% of cost or \$3,000. If federal tax credit is awarded, supplemental CA tax credit will be given only to reach CA maximum allowable. 	<ul style="list-style-type: none"> Yes. Cost of system and brief description required on application form by Franchise Tax Board. Energy Commission will distribute extensive voluntary survey requesting info. from all applicants re: system description, characteristics of use and users, identification of designer and builder. 	<ul style="list-style-type: none"> "Equipment which uses solar energy to heat or cool or produce electricity and which has a useful life of at least three years." Interim Regulations (to be reviewed 3-78) include extensive section on passive applications. Minimum passive system must meet requirements given below for solar glazing, solarium, or thermal pond. <u>Solar glazing:</u> direct radiation exposure for 4 hrs on Dec. 21, walls facing within 45° of true south; U-value of 0.65 for all glazing in heating areas; shading coefficient of 0.70; glazing shaded from 6am to 6pm on Aug. 21 in cooling areas; 100% of glazing eligible for retrofits; formula based on designated solar surface glazing minus wall areas of non-designated solar surfaces gives eligibility for new construction. <u>Solariums:</u> glazing must equal half of floor area; direct radiation exposure for 4 hrs on Dec. 21; provisions for air circulation into building, venting, or full shading are required; 100% of cost eligible for circulation equipment; 50% of all other. <u>Thermal ponds:</u> must have operable insulated covers, transparent surface cover to prevent evaporation, and shading, as applicable to its climate. Other passive components which are eligible under stated conditions are: <u>thermal mass</u> in exterior and interior residential walls; <u>glazing controls</u> including movable insulation, summer shading devices, films and special coatings; energy conservation measures which exceed the legal standards prescribed at time of construction.

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Description	Value	Monitoring	Eligibility
CALIFORNIA (Continued)			
			<ul style="list-style-type: none"> Criteria for eligibility of passive components for buildings other than low-rise residential are yet to be drafted, but will be forthcoming.
COLORADO			
<ul style="list-style-type: none"> Income tax deduction for alternative energy device (AED) installed in any building owned and placed in service by taxpayer. Effective with 1977 tax returns and indefinitely thereafter. 	<ul style="list-style-type: none"> Full cost of installation, construction, reconstruction, remodeling, or acquisition of an AED. 	<ul style="list-style-type: none"> No application form as yet. Total cost only item requested on tax form. 	<ul style="list-style-type: none"> "AED means any system or mechanism...using solar radiation, wind, or geothermal resources." No regs written until see what kinds of problems arise after first year returns are processed. Had not known of passive design and therefore was not considering it as eligible. Wants more passive information; also, to see how other states are handling definition and value problem.
HAWAII			
<ul style="list-style-type: none"> Personal and corporate income tax credit for solar energy device purchased and placed in use. Effective with 1975 tax returns, through 1981. 	<ul style="list-style-type: none"> 10% of total cost of the device. No maximum. 	<ul style="list-style-type: none"> No. Inspected for eligibility of invoice claims. Then filed with rest of tax returns. 	<ul style="list-style-type: none"> "Any new identifiable facility, equipment, apparatus, or the like which makes use of solar energy for heating, cooling, or reducing the use of other types of energy dependent upon fossil fuel for its generation." No regs adopted; case-by-case basis. Do not allow items to reduce air-conditioning loads such as shutters on windows; therefore passive elements unlikely to be eligible.
IDAHO			
<ul style="list-style-type: none"> Income tax deduction for construction, reconstruction, remodel, installation, or acquisition of alternative energy device to serve residence of taxpayer. Income tax deduction for insulation of <u>existing</u> residence. Effective with 1976 tax returns and indefinitely thereafter. 	<ul style="list-style-type: none"> AED: 40% of cost in first year, 20% of cost in next 3 yrs. \$5000 maximum in any one taxable year. Insulation: Actual cost of installation; no maximum. 	<ul style="list-style-type: none"> None of 1977 and 1978 tax returns. 1977 returns will provide box for energy conservation and AED deduction, but will indicate only combined amount deducted (no description). 	<ul style="list-style-type: none"> "Insulation means any material commonly used in the building industry and actually installed for the purpose of retarding the passage of heat energy into or out of a building, including but not limited to fiberglass insulation, weather stripping, double pane windows, and storm doors and windows." Does not apply to residences constructed after Jan. 1, 1976. "AED means any system or mechanism...using solar radiation, wind, geothermal, or wood...primarily to provide heating, to provide cooling, to produce electrical power, or any combination thereof." Regs do not mention passive and no ruling has been made; issue hasn't yet come up.

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Description	Value	Monitoring	Eligibility
KANSAS			
<ul style="list-style-type: none"> Personal income tax credit for solar or wind energy system supplying taxpayer's principal dwelling. Income tax credit for solar system supplying a trade or business or used in the production of income. Effective with 1976 tax returns, through June 1983. 	<ul style="list-style-type: none"> Residence: lesser of 25% of cost, including installation, or \$1000; 4-yr carryover. Business: lesser of 25% or \$3,000. 	<ul style="list-style-type: none"> ? Research Division follows up on cost to state, but uncertain as to what other data, if any, is compiled. 	<ul style="list-style-type: none"> "A system of apparatus and equipment capable of collecting and converting incident solar radiation into heat, mechanical or electrical energy and transferring these forms of energy by a separate apparatus to storage or to point of use..." Ruling on a case-by-case basis: No regulations have been developed. But would not allow passive under terms of this legislation. However, up to \$500 insulation tax credit is available for retrofit insulation (as it is generally defined in the marketplace) that meets or exceeds R=13 and R=19 standards.
MASSACHUSETTS			
<ul style="list-style-type: none"> Corporate income tax deduction for cost of solar or wind systems in year of installation (rapid amortization). Effective with 1976 tax return and indefinitely thereafter. 	<ul style="list-style-type: none"> Cost of eligible components. 	<ul style="list-style-type: none"> Yes. Bureau of Building Construction will keep file upon issuing certificate (no applications to date). 	<ul style="list-style-type: none"> "Solar or wind powered climate control unit and any solar or wind powered water heating unit or any other type unit or system powered thereby for which the manufacturer's british thermal unit impact statement has been submitted to the director of the bureau of building construction and which have been certified by said director as complying with applicable regulations and standards issued by him..." Proposed regulations being drafted; will include passive elements similar to New Mexico regulations.
MONTANA			
<ul style="list-style-type: none"> Personal income tax credit for nonfossil energy generation systems installed in primary residence. Personal and corporate income tax deductions for investing for the purpose of conserving energy. Effective with 1977 tax return, through December 1982. 	<ul style="list-style-type: none"> 10% of first \$1000 spent and 5% of the next \$3000. If federal tax credit received, amount from state will be halved. Four-year carry-over. 	<ul style="list-style-type: none"> Research Department, Department of Revenue will collect information on cost, type, and location from application forms. 	<ul style="list-style-type: none"> [Law not received 3-10-78] "A system for the utilization of solar heat and wind"--definition of eligible solar systems in regs.; ruling on case-by-case basis. Passive not likely to be included directly. Separate energy conservation deduction makes eligible all elements "recognized to substantially reduce the waste or dissipation of energy, or reduce the amount of energy required for proper utilization of the building."

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Description	Value	Monitoring	Eligibility
NEW MEXICO			
<ul style="list-style-type: none"> Personal income tax credit for New Mexico residents for solar H/C of principal residence.* Refunded to taxpayer if exceeds tax liability. Effective with 1975 tax returns and indefinitely thereafter. Personal income tax credit for certified solar energy system for irrigation pumping purposes. Effective with 1977 tax returns and indefinitely thereafter. 	<ul style="list-style-type: none"> Residential H/C: 25% of cost of equipment only; or \$1000 maximum. Irrigation credit: amount not to exceed \$25,000 for cost of equipment. 	<ul style="list-style-type: none"> Yes. Number approved, cost, system type. Will audit to verify installation. Yes. Certified through Energy Resources Board. 	<ul style="list-style-type: none"> "Any heating, cooling, or H/C equipment which meets the definitive performance criteria prescribed [in the] Solar H/C Demo Act of 1974, or amendments thereto..." Used federal regs until so many unanswered questions were raised that wrote own, issued August 1977. Eligible passive elements must serve primary function of solar heating: e.g., masonry walls and floors ineligible; 100% of cost of <u>drumwalls</u> and <u>trombe walls</u> eligible if non-loadbearing (50% if load-bearing); 50% of <u>thermal contact ceilings</u>; 100% of <u>movable insulation</u> on south-facing glass; other insulation and draperies ineligible; cost of <u>glazing material</u> equal to $x - y = z$ where <ul style="list-style-type: none"> x = % of south-facing window-to-wall area y = % of E,W,&N-facing window-to-wall areas z = % of eligible solar tax credit Skylights and roof glazing eligible only when insulated and used for direct solar heat gain during day; an <u>attached greenhouse</u> is eligible only if air is circulated through residence by a permanently installed air movement system and insulating devices are used.
*Amendment includes swimming pools and other recreational purposes.			
NORTH CAROLINA			
<ul style="list-style-type: none"> Personal and corporate income tax credit for solar system installed in any building. Effective with 1977 tax return and indefinitely thereafter. 	<ul style="list-style-type: none"> 25% of cost of system or \$1000 maximum. 	<ul style="list-style-type: none"> Research Division of Department of Revenue will have data in fall on cost claims. 	<ul style="list-style-type: none"> "Any hot water, heating, cooling, or H/C equipment which meets the definitive performance criteria...of the Solar H/C Demonstration Act of 1974...or any other performance criteria approved by the Secretary of Revenue..." No regs issued yet, but may have to develop soon. No inquiries about passive--haven't considered their eligibility. Energy conservation credit given for 25% of cost of insulation on existing building (\$100 maximum).
NORTH DAKOTA			
<ul style="list-style-type: none"> Any taxpayer may claim tax credit for cost of solar or wind energy device installed in a building. Effective with 1977 tax returns and indefinitely thereafter. 	<ul style="list-style-type: none"> 5% of actual cost of purchase and installation per year for 2 years. 	<ul style="list-style-type: none"> Yes. Will be programmed for automatic reject in order to process manually. Will look at revenue effect and type of installation. (Unclear whether 1977 returns are being monitored as described.) 	<ul style="list-style-type: none"> "A system or mechanism...designed to provide heating or cooling or to produce electrical or mechanical power, or any combination of these, or to store any of these, by a method which converts the natural energy of the sun or wind." Have developed no guidelines; legal department is considering them; unknown whether corporation counsel will include passive.

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Description	Value	Monitoring	Eligibility
OKLAHOMA*			
<ul style="list-style-type: none"> Income tax credit for principal private residence of cost of solar energy device. Five-year carryover provision. Effective 1978-1987. 	<ul style="list-style-type: none"> 25% of cost or \$2000 maximum. 	<ul style="list-style-type: none"> Undetermined. Requires itemized accounting of cost and allows field inspection and cost certification, but no extra funds appropriated for additional staff time. 	<ul style="list-style-type: none"> "System or series of mechanisms primarily designed to provide heating or cooling, electrical or mechanical power, or any combination thereof, by means of collecting, transferring, or storing solar generated energy." Regs not written and won't be till later in 1978. Unsure whether passive will be considered.

*Bill proposed in legislature to expand definition to AED and provide larger credit (March 1978). Used Idaho law as model, substituting "credit" for "deduction" and keeping same definitions and percentage costs allowable.

OREGON			
<ul style="list-style-type: none"> Personal income tax credit for AED installed in primary or secondary residence. Effective with 1977 tax returns, through 1984. Weatherization tax credit for primary residences (available to landlords as well as homeowners). Effective 1977-1984. 	<ul style="list-style-type: none"> 25% of cost or \$1000 maximum. Five-year carryover. Will be credited even if federal claim has been received. 25% of cost of installation and materials, or \$125 maximum. 	<ul style="list-style-type: none"> Yes. Oregon DOE will certify design prior to construction, then note actual cost upon completion before signaling Revenue to give credit. Items tracked: type of system, builder and design, cost, location, owner. 	<ul style="list-style-type: none"> "Any system, mechanism, or series of mechanisms which uses solar radiation, wind, or geothermal resources...for space heating, water heating, cooling, electrical energy, or combination thereof for a dwelling which source meets or exceeds 10% of the total energy requirements for the dwelling." Regs are at printers and not yet available--but include a passive section which has eligibility criteria similar to other states, e.g., New Mexico. Do not define in terms of passive design performance standards. Requires application by owner/taxpayer and certification prior to construction.

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PROPERTY TAX INCENTIVES WORKSHEET

Description	Value Approach	Central Monitoring	Eligibility
ARIZONA			
<ul style="list-style-type: none"> Property tax exemption on new or existing housing from increase which may occur from a solar addition. Effective 1974 with review in 1984. 	<ul style="list-style-type: none"> Treat as if no solar were there. Do not identify value added. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> [Law not received 3-10-78] No regs written.
COLORADO			
<ul style="list-style-type: none"> Value solar devices on any building improvement at 5% of actual value; effective year of application and each year thereafter without resubmitting application. Effective 1976 and indefinitely thereafter. 	<ul style="list-style-type: none"> Solar device is assessed separately. Discretion of assessor (state form is used for owner to apply to local assessor). 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "All hardware necessary to effect the installation of a solar heating or cooling system...shall not include walls or roofs unless...specifically designed...to provide additional heating or cooling that would not ordinarily be contained in a structure..." No regs written. First passive application currently being considered.
CONNECTICUT			
<ul style="list-style-type: none"> Allows local governments to exempt any building new or retrofit for 15 years. Effective 1977-1991. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar. Discretion of assessor (no guidelines). 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "Equipment...which provides for the collection, transfer, storage, and use of incident solar energy." Must meet state standards for systems sold in state. Systems meeting standards set by HUD Minimum Property Standards are eligible under DPEP standards.
GEORGIA			
<ul style="list-style-type: none"> Allows local authority to exempt from all ad valorem taxation full value of solar system. Effective 1976-1986. 	<ul style="list-style-type: none"> Discretion of local assessor. 	<ul style="list-style-type: none"> Property Tax Division will keep track of which localities implement exemption, but not individual cases. 	<ul style="list-style-type: none"> "All equipment used directly and exclusively for the conversion of solar energy for heating or cooling, but shall not include walls, roofs, or equipment...ordinarily...contained in a similar structure not designed or modified to use solar energy for heating or cooling." No regs written (unclear on passive).

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Description	Value Approach	Central Monitoring	Eligibility
HAWAII			
<ul style="list-style-type: none"> Permanent property tax exemption for alternate energy improvements to any property. Effective dates, 1976-1981. 	<ul style="list-style-type: none"> Statutory standard: replacement costs. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "Any construction or addition, alteration, modification, improvement, or repair work undertaken which results in the production of energy from a source other than fossil fuels or nuclear...or in an increased level of efficiency in the utilization of energy produced by fossil fuels." No guidelines written--do not allow "tacked on" solar systems; feel passive would not qualify.
ILLINOIS			
<ul style="list-style-type: none"> Permanent exemption of solar system for any property. Effective 1975 and indefinitely thereafter. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar; primarily using cost. 	<ul style="list-style-type: none"> Yes--claim form now being revised; statistics kept at Dept. of Local Gov't Affairs. 	<ul style="list-style-type: none"> Law allows "passive elements" but does not allow structural, insulating, protective shading, aesthetic, or other non-solar energy utilization purposes, "as defined in the regs of the Division." Standards to be written by Division of Energy not yet begun.
INDIANA			
<ul style="list-style-type: none"> Permanent exemption of solar system on any property; includes mobile homes. Effective 1978 and indefinitely thereafter. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar. Law requires Tax Commission to write regs based on cost, portions unique to production of solar energy, and amount of usable energy system produces. Instead, using \$2/ft as suggested guideline for assessors. 	<ul style="list-style-type: none"> Duplicate filed with Tax Commission. 	<ul style="list-style-type: none"> "Solar energy heating or cooling system." Regs not written; will request legislature to reconsider efficiency requirement if pressure is applied to use efficiency criteria.
KANSAS			
<ul style="list-style-type: none"> Solar system providing 70% of energy to heat or cool any building on an average annual basis will be reimbursed 35% of full building tax for 5 yrs. Effective 1977 and indefinitely thereafter. 	<ul style="list-style-type: none"> Cost itemization. 	<ul style="list-style-type: none"> Yes--Research Management Division in Department of Revenue follows up projected impact of legislation with actual cost to state. 	<ul style="list-style-type: none"> "System capable of collecting and converting incident radiation and transferring by separate apparatus to storage or point of use." Will make rulings in fall 78, but passive not expected to qualify.

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Description	Value Approach	Central Monitoring	Eligibility
MAINE			
<ul style="list-style-type: none"> Five-year exemption for solar water or space heating equipment on all property. Effective 1977-1982. 	<ul style="list-style-type: none"> Discretion of assessor. Probably cost. 	<ul style="list-style-type: none"> Yes--Revenue asking local municipalities to include solar assessments in their annual reports. 	<ul style="list-style-type: none"> "Solar energy equipment...all necessary for collection, transfer, and storage of solar energy. Shall be used directly and exclusively for conversion of solar energy for purposes of water heating and space heating and cooling and does not include walls, roof, or equipment ordinarily contained in similar structure not designed or modified to use solar energy." No regs written unless local assessors run into trouble.
MARYLAND			
<ul style="list-style-type: none"> Two separate laws provide: 			
<ul style="list-style-type: none"> (1) Property tax credit for residence and non-residence can be passed by locals. <p>Effective 1976 and indefinitely thereafter.</p>	<ul style="list-style-type: none"> (1) Local assessors 	<ul style="list-style-type: none"> (1) Energy office may try to act as information clearinghouse. 	<ul style="list-style-type: none"> (1) "Solar energy heating or cooling units..." <p>Regs left to locals.</p>
<ul style="list-style-type: none"> (2) Property tax exemption on solar system on residence and non-residence, new and existing. <p>Effective 1975 and indefinitely thereafter.</p>	<ul style="list-style-type: none"> (2) Local assessors 	<ul style="list-style-type: none"> (2) No. 	<ul style="list-style-type: none"> (2) "Solar energy heating or cooling units..." <p>No regs.</p>
MASSACHUSETTS			
<ul style="list-style-type: none"> Any property using solar or wind system exempted for 10 yrs from value added. Effective 1976 and indefinitely thereafter. 	<ul style="list-style-type: none"> Ignore solar increment; but ask owners for solar cost. 	<ul style="list-style-type: none"> Asking local assessors to record solar on assessment cards and compile resale values. 	<ul style="list-style-type: none"> No regs anticipated; if problems arise, may develop later.

Description	Value Approach	Central Monitoring	Eligibility
MICHIGAN			
<ul style="list-style-type: none"> Certified solar, wind, or water energy conversion device is permanently exempt from real and personal property tax. Effective 1975-1985. 	<ul style="list-style-type: none"> Cost of materials and labor. 	<ul style="list-style-type: none"> Yes. Annual report to legislature required, including number, type, and value of certificates. Not yet submitted. 	<ul style="list-style-type: none"> "Mechanism designed primarily to collect, transfer, or store for future use solar energy for purposes of heating or cooling, or electricity supply but not those parts that would be required regardless of the energy source being utilized." No regs written--don't want to lock out new systems. Passive would not likely be eligible.
MONTANA*			
<ul style="list-style-type: none"> Property tax exemption for capital investment in a recognized non-fossil form of energy generation. Property tax reduction for investment for an energy conservation purpose. Effective 1976. 	<ul style="list-style-type: none"> ? Not used (one application). Property tax reduction for energy conservation measures from 30% assessment value to 15%. For energy generation investment, exempted first \$100,000 and taxed remainder at 7%. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "The Department [of Revenue] shall approve an application which demonstrably promotes energy conservation or utilizes a recognized nonfossil form of energy generation... may deny an application which it finds to be impractical or ineffective." No regs written before repeal.
*Repealed and replaced by income tax credit.			
NEVADA			
<ul style="list-style-type: none"> Property tax allowance up to \$2,000 on residences--counties repaid by state; reappropriate funds each year. Effective 1978 and indefinitely thereafter. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar. Discretion of assessors. 	<ul style="list-style-type: none"> Yes--unsure of specific items; form not developed. 	<ul style="list-style-type: none"> "...any system...designed...to heat or cool the building by using: solar...energy..." Eligibility criteria not yet written; begin in mid-March for summer adoption; no decision on passive.
NEW HAMPSHIRE			
<ul style="list-style-type: none"> Allows towns and cities to decide at town meetings to exempt solar H/C from property tax. Each town determines amount of exemption. Effective 1975 and indefinitely thereafter. 	<ul style="list-style-type: none"> Shall be determined by each locality. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "...system which utilizes solar energy to heat or cool the interior of a building or to heat water...which includes one or more collectors and a storage container." No regs written. No passive allowable.

Description	Value Approach	Central Monitoring	Eligibility
NEW JERSEY			
<ul style="list-style-type: none"> Permanent property tax exemption for certified solar H/C system on any property. Certifying during 1978; effective with 1979 tax statements, through 1982. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar. Discretion of assessor--whatever info is available; probably would not be full cost. Proposed regs--glazing at 100%, insulated skylights-50%, etc. 	<ul style="list-style-type: none"> Maybe. Department of Revenue's application forms not yet written but will include cost. Local building officials will certify application. Assessor will get duplicate copy of certificate. 	<ul style="list-style-type: none"> "Any system which uses solar energy to provide all or a portion of H/C needs of a building through, but not limited to, such means as nocturnal heat radiation, evaporation cooling towers, flat plate or focusing collectors, photovoltaic cells, or windmills." Proposed regs include passive elements similar to New Mexico income tax credit regulations.
NEW YORK			
<ul style="list-style-type: none"> 15-year exemption for solar or wind system on any property. Effective 1978-1988. 	<ul style="list-style-type: none"> Difference between assessed value with and without solar. Discretion of assessor. Not likely to use full cost. With passive components, determine typical construction costs and only exempt solar increment. 	<ul style="list-style-type: none"> Yes--Energy Office will report annually on types of systems and average values. 	<ul style="list-style-type: none"> "...solar equipment means...hardware...necessary to the process by which solar radiation...is converted into another form....Solar system means...equipment designed to provide H/C...by the collection and storage of solar energy...does not include pipes, controls, insulation, or other equipment which are part of the normal H/C system of a building..." Guidelines include selected passive systems, specifically, drumwall, moveable insulating panels, thermosyphon masonry wall, water wall; perhaps attached greenhouse. Exclude energy efficient construction components not in themselves constituting a system such as size and placement of windows or roof overhang.
NORTH CAROLINA			
<ul style="list-style-type: none"> Buildings with solar H/C system to be appraised as if equipped only with conventional system. Effective 1978-1985. 	<ul style="list-style-type: none"> Assign no additional value. 	<ul style="list-style-type: none"> No. Computerized statewide property sales file may record solar sales, however, for market data in future. 	<ul style="list-style-type: none"> "All equipment used directly and exclusively for conversion of solar energy for heating and cooling. Does not include land or structural elements of building such as walls and roofs nor other equipment ordinarily contained in the structure." No regs written.
NORTH DAKOTA			
<ul style="list-style-type: none"> Exempt systems which utilize solar energy for H/C of new or existing structures from property taxation for 5 yrs. Effective 1975 and indefinitely thereafter. 	<ul style="list-style-type: none"> Do not value solar portion. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "Installations, machinery, and equipment of systems which utilize solar energy for...heating or cooling..." No regs written.

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Description	Value Approach	Central Monitoring	Eligibility
OREGON			
<ul style="list-style-type: none"> Property exemption for any solar energy system on any building. Excludes heat pumps. Effective 1975-1998. 	<ul style="list-style-type: none"> Difference between true cash value with and as if it were not equipped with solar. Discretion of assessor. Probably based on cost till better market data is available. 	<ul style="list-style-type: none"> Yes--Revenue will ask assessors to submit specially assessed property records; may also track resale values. 	<ul style="list-style-type: none"> "Any system or mechanism which uses solar radiation or wind as a source for heating or cooling in dwelling that exceeds 10% of total energy requirements for dwelling." No regs for purposes of property tax exemption. May have trouble dealing with passive as more are built. Haven't had questions thus far.
RHODE ISLAND			
<ul style="list-style-type: none"> Exempt solar device from property tax assessment on existing or new, residential or nonresidential building. Effective 1977-1997. 	<ul style="list-style-type: none"> Solar device shall be assessed at no more than value of conventional H/C system. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "...any H/C system which meets performance criteria established by the secretary of HUD pursuant to the provisions of the Solar Heating/Cooling Demonstration Act of 1974." No state regs written.
SOUTH DAKOTA*			
<ul style="list-style-type: none"> Property tax deduction up to \$2,000 for residential solar device. Effective 1975 and indefinitely thereafter. 	<ul style="list-style-type: none"> Difference in assessed value with and without solar. Cost until market data is established. 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "Solar heating or cooling devices..." No regs written.
<p>*Superceded by recently passed new law which may change entries. Copy not received 3-10-78.</p>			
VERMONT			
<ul style="list-style-type: none"> Allows towns, at town meeting, to exempt alternative energy sources from real and personal property taxation on premises for private, domestic, and agricultural purposes. Exemption shall continue in given town until voted otherwise. Effective 1976. 	<ul style="list-style-type: none"> Discretion of local assessor. 	<ul style="list-style-type: none"> State Energy Office keeping track of towns passing exemption, but not specific cases. 	<ul style="list-style-type: none"> "Alternative energy sources include any plant, structure, or facility used for the generation of electricity or production of energy...shall include...facilities for the collection of solar energy." No regs written; bill is pending to write more explicit definitions (unclear on passive).

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Description	Value Approach	Central Monitoring	Eligibility
VIRGINIA			
<ul style="list-style-type: none"> Allows local governments to exempt or partially exempt solar device from property tax valuation on any property, real or personal property, equipment, facility, device, for not less than 5 years from passage. Effective 1978 and indefinitely thereafter (?). 	<ul style="list-style-type: none"> Difference between assessed value with and without solar--value of solar devices must not be less than normal cost of purchasing and installing such equipment. Local assessor determines value--probably cost of equipment and labor. 	<ul style="list-style-type: none"> All applications go through State Office of Housing. 	<ul style="list-style-type: none"> "...for the purpose of providing for the collection and use of incident solar energy for water heating, space H/C or other application which would otherwise require a conventional source of energy..." State Board of Housing provides regs to certify solar equipment--HUD intermediate property standards used as definition. Regs include some passive elements.
WASHINGTON			
<ul style="list-style-type: none"> Seven-year property tax exemption of solar energy systems installed on any real property. Effective 1977-1981. 	<ul style="list-style-type: none"> Discretion of assessor. Must be appraised on the "added value to the property...and may or may not represent the cost of the improvement." 	<ul style="list-style-type: none"> No. 	<ul style="list-style-type: none"> "Equipment which meets the minimum standards, if any, promulgated by the USD-HUD, and which provides for the collection and use of incident solar energy for water heating, space heating or cooling, or any other application which would require a conventional source of energy ...and which perform primarily with solar energy." Initial regulations specifically excluded "components of a building which utilize the energy of the sun in a passive way." New regulations will be written to include passive elements.

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A RATE OF RETURN VALUATION METHOD

David Baylon
Ecotope Group
Seattle, WA

Solar energy-based technologies represent an important anomaly in the energy field. They have an energy-producing capability with well-established parameters for producing energy to do heating, cooling and generating electricity and to provide a broad range of process heat to meet various kinds of energy demands. At the same time, it is a consumer technology which would be purchased by individuals and business to enhance their own lifestyle or/and economic well being.

In this sense, solar-based technologies are at a distinct institutional disadvantage when compared to other energy-producing options. These options are evaluated on their economic potential at the margin, their marginal cost. This cost will be averaged with other sources such that the consumer will see an average cost which in the present economy is substantially below the marginal cost of the commodity. While the economic advisability of this pricing technique is very suspect, the effect is to make solar-based technologies compete with energy prices which are substantially below the marginal cost of production.

Since the investment in solar energy remains a consumer decision, the institutional advantages and subsidies afforded other energy-producing technologies are unavailable. This includes lower interest rates and rebates, research subsidies and regulated utility monopolies. Taken as a whole, this makes investment in power plants and frontier oil much more attractive than investment in solar technologies or conservation which promise greater amounts of energy at lower cost.

It is in this context that the states have attempted through various incentive programs to induce consumers into investing in solar energy systems for their homes. These programs are rather embryonic, but they represent a form in which various institutions can develop methods of evaluating and developing expertise to account for on-site energy "producing" technologies. The most popular of these programs (and least effective) is the property tax "incentives" or exemption. There are 25 states with various sorts of property tax exemption for solar energy devices installed on homes or other buildings (Goodnight, 1978). These programs place the development of evaluation criteria in the hands of the state revenue departments or local assessors. In general, three alternatives have been chosen for implementing these programs:

- 1) The solar "device" ignored in the evaluation of the building.
- 2) The solar device is assessed at its cost and this is then deducted from the total assessed valuation.
- 3) The solar device is assessed but the value is not added to the value of the building.

These methods have several deficiencies:

1) The definition of a "solar system" is in many cases inadequate to include passive systems and certainly evaluating a system composed substantially of well-designed windows or solariums presents difficulties in describing divisions between the solar system and the building itself. For this reason, many states have excluded passive solar systems from consideration, even though in many cases they are the most cost effective and energy effective alternative.

2) The energy-producing capability of the system is ignored if the system is assessed by its capital cost. This is very suspect in that it assumes efficiency to be a function of first cost and that assumption is not warranted. This

technique also obscures the value of solar systems as energy producers and promulgates regulations which allow assessment based on first cost -- criteria that good solar design should ignore.

3) These techniques do not provide a forum for assessors and indeed other financial institutions to develop expertise in evaluating solar systems. It is possible for the assessors to never understand a solar system as anything but an interesting amenity which may or may not receive recognition in the market place at some point in the distant future. In fact, the basis for establishing future market value is not examined in the context of these regulations and it would be unlikely for future evaluations of market value to have adequate information to make a coherent assessment even when market data is available.

It is clear that some evaluation criteria and procedure is necessary in this context to aid assessors and revenue departments to understand solar systems and describe the long term value of a solar system for energy production. To do this, a system should be devised which would:

- 1) estimate the energy output of the system;
- 2) evaluate the worth of that energy; and
- 3) provide the assessor with tools to evaluate a wide variety of systems on consistent and fair criteria.

"RATE OF RETURN" VALUATION METHOD: A "rate of return" procedure can be designed to meet these criteria. The rate of return will be defined as the return on the initial capital invested in a solar system in dollars saved on present and future energy bills. In algebraic form,

$$M^N = \frac{S}{I} \quad \text{where: } M = \text{rate of return} \quad S = \text{total net savings over life of investment} \\ I = \text{investment and interest costs}$$

To account for life cycle procedures, this formula can be expanded:

$$M^N = \frac{S \left(\left(\frac{1+e}{1+r} \right)^N - 1 \right) \{1 - (1+i)^{-N}\} \{N(1+r)\}}{CC \cdot i \cdot \ln \left(\frac{1+e}{1+r} \right) \{1 - (1+r)^{-N}\}}$$

where: S = the energy produced by the solar system
CC = the capital cost of the system
i = the interest rate of apportional costs on the invested capital
e = fuel cost escalation
r = rate of return

Solving for CC cost:

$$CC = \frac{S \left(\left(\frac{1+e}{1+r} \right)^N - 1 \right) \{1 - (1+i)^{-N}\} \{N(1+r)\}}{M^N \cdot i \cdot \ln \left(\frac{1+e}{1+r} \right) \{1 - (1+r)^{-N}\}}$$

This equation can be standardized to a square foot of solar aperture in a given climate and a solar collection efficiency for a given system such that:

$$S_{(ft^2)} = SG \cdot \bar{e} \cdot t \cdot FC$$

where: SG = the total solar gain incident on the collection surface during the heating season
t = the transmission coefficient of the glazing material
e = the average efficiency of the solar system over the year
FC = heat costs in \$/million BTU (or equivalent)

These three parameters can then be described in a simplified manual which describes solar gain for a given locality during a heating season, transmission of various glazing systems and combinations, and average system efficiencies given basic parameters (e.g. storage system, distribution system, collection surface, passive or active components, etc.)

The evaluation of the solar resource (SG) can be localized, although the method allows approximation. The solar resource in Spokane, as shown in Table 1, is about 16% greater than Seattle. This difference is reflected consistently throughout the analysis. However, given that the assumptions about fuel escalation, inflation and rate of return have a substantial effect on the outcome,

minor variation in solar climate can be neglected. Since these parameters are visions about the future, the need for lengthy refinement in either the solar data or the system efficiency is questionable.

Table 1.							
Value per Square Foot of Collector Surface							
assumptions: inflation rate = 6% fuel cost = \$4.60/MMBTU				fuel escalation = 15% interest rate = 9%			
rate of return	.6	.55	.5	.45	.4	.35	
Seattle	1.08	5.80	5.32	4.84	4.35	3.87	3.39
	1.05	13.57	12.3	11.26	10.14	9.01	7.88
Spokane	1.08	9.48	8.69	7.90	7.11	6.32	5.53
	1.05	22.06	20.23	18.39	16.55	14.71	12.87

Table 2.	
Estimate System Efficiencies	
Active system, low temperature (90°F)	.60
Active system, high temperature (140°F)	.50
Passive system, Trombe wall	.40
Passive hybrid, greenhouse	.55

Equation 3 becomes standardized to the value per square foot when the saving (S) is standardized to the incident insolation per square foot. By adjusting assumptions, a value can be computed with respect to the marginal cost of energy capacity supplanted by the solar investment or to reflect consumer investment alternatives.

Table 1 is derived from the given assumptions. The rate of return is varied to reflect alternative views of the energy or capacity of the solar installation. The efficiency refers to the system efficiency in collecting, storing and delivering solar heat to the user. In general, these efficiencies are highest when the collection temperature is kept in low ranges with respect to ambient temperature. Thus, a collection system which depended on 90°F collection temperature would be more effective than one designed for 140°F temperatures (see Table 2). This distinction can be made easily with a questionnaire or by reviewing the design specifications. The production of a guide would be essential to enable an assessor or appraiser to evaluate the system with respect to system configuration and efficiency. In this sense, the production of a manual can be substantially simplified to the explanation of system efficiencies and the publication of approximate solar regions within a given locale.

It should be noted that this procedure could be adapted to evaluate an energy saving technology such as insulation, double glazing, heat pumps, etc. While this method might tend to underestimate the capital costs of a system, it can provide an index of the value of the capacity to produce energy. This is somewhat independent of the actual energy produced and will allow the society as a whole to forego investment in other energy-producing capacity at the margin.

Given this promise, the rate of return valuation method can give a solution to the quagmire of incentive programs and guidelines, and allow appraisal based on system performance rather than uninformed guess or system cost.

David Baylon
Ecotope Group
30 May 1978

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APPENDIX B

RESPONSE OF BUILDING OFFICIALS
TO PROBLEMS OF INTEGRATING SOLAR SYSTEMS
INTO EXISTING CODES

(Material distributed to building
officials in Washington State,
with accompanying questionnaire
and analysis of responses.)

Human Affairs Research Centers
4000 N.E. 41st Street
P.O. Box 5395
Seattle, Washington 98105
Telephone: (206) 525-3130
CABLE: HARCSEA

Battelle-Northwest and the U.S. Department of Energy are developing an information program for solar applications in the Pacific Northwest. Among the issues to be considered are technical, economic, and regulatory constraints that may affect widespread adoption of solar heating systems in our region. As a building inspector, we would like to share with you some technical and economic information we are compiling and, in turn, to ask your assessment of the ease or difficulty with which solar heating systems may be incorporated into the building code which you administer.

Even in cloudy Western Washington, a growing number of solar hot water and/or heating systems are being incorporated into buildings. These structures have to date consisted of a typical "active" system, gathering solar radiation with rooftop collectors and mechanically distributing the heat energy via an air or water transfer fluid and ducting or piping system either immediately into the structure or into storage. Most systems are designed to carry from 50-75 percent of the year-round heating load. Although most solar systems have been used in residential applications, a growing number of commercial applications are being made.

Operating experience is limited for many of the Northwest installations, and track records for durability and maintenance costs are therefore not firmly established. That active solar systems can be effective in a cloudy climate has been demonstrated in a Coos Bay, Oregon home that over the past 10 years has annually received over 70% of its heat from the sun.

Cost considerations may prove to be the major detraction to widespread adoption of "active" solar heating systems for Washington residents. At 2 cents per kilowatt hour with an estimated annual increase of 8 percent for conventional electric heat, the payback period of a typical solar system priced at \$20 per square foot of collector installed is over 15 years in Washington State. At \$10 per square foot installed, the payback period would be 8-10 years in areas

such as Friday Harbor, Spokane, Pullman, or Richland.* In Seattle the lower solar radiation level would place it beyond the 15-year payback period. Typical systems adding \$5,000 - \$10,000 to the cost of a home may not be judged cost effective by many homeowners under these conditions. For other owners however, the assumption that energy prices will rise beyond the 8% annual rate, plus the attractiveness of using a "renewable energy source" that cannot be cut off, will be sufficient reason to install an active solar system. Therefore, the installation of active solar systems throughout the state can be expected to continue, though the market may be relatively small compared with solar sales in other states.

Of great interest to Northwest solar designers is the rediscovery of "passive" solar systems. This concept incorporates solar energy collection by the building materials themselves (absorbed by walls and floors, etc., transmitted through cover glazing, windows, skylights, etc.) and the natural distribution of solar heat. In a passive system no mechanical systems are required to transfer solar heat to the living space and storage units. As with the active systems, an average passive design may carry from 50-75% of the annual heating load. Six basic passive heating types, which are frequently mixed to increase design possibilities, are described in the attached ERDA press release.

The excitement which is being generated in the Northwest over passive solar systems stems from four main factors:

(1) Although there are fewer working examples to supply cost and operating information, the supplemental cost of passive elements appear to be much lower than active components. (On Camano Island a direct-gain system built at no additional cost carried most of the heating load during the winter of 1976-1977, according to the owner. In Richland a Trombe-wall system designed to carry 60% of the heating load will be built for approximately \$3 per square foot installed.)

(2) The passive design systems continue to work in over-cast daylight hours when active systems shut off. In most active systems, a threshold temperature must be attained either for immediate use or for use via the storage system. If weather conditions do not allow this, a conventional heating unit will take over and the solar energy collected in storage will be bypassed.

* These figures are taken from a preliminary draft of a study on the economics of solar heating prepared by G.L. Liffick of ERDA-Richland and H.L. Parry of Battelle-Northwest.

(3) The building materials of a passive system are familiar to the construction trade in terms of durability and of characteristics essential to the transmission, absorption, and radiation of solar energy into occupied space. No special installation skills are required, so the risks of a new technology are reduced in terms of improper installation. The body of knowledge on system efficiencies in heat gain/heat loss terms is growing as more structures are monitored for actual operating experience.

(4) The vertical slope of south-wall or south-window systems becomes more effective for winter heating the farther north one builds, given the lower altitude of the sun at its zenith. The combination of (2) and (4) therefore brings to the "cloudy" Pacific Northwest winter season a design advantage that makes the use of solar energy in buildings more regionally competitive than heretofore supposed.

As a building official, the elements most likely to cause concern in your decision to approve or deny a solar heating application are the lack of long-term operating experience and the absence of a nationwide testing and approval mechanism for active components. Some recent developments in the latter area are as follows:

Although industry consensus standards may take several years to develop, an interim testing standard has been developed by the National Bureau of Standards and is presently used to list solar products qualifying for federal grant and lending programs. Minimum Property Standards (MPS) have been developed for FHA approval of solar heating and domestic hot water systems. Several state governments in implementing solar incentive legislation have adopted the HUD-MPS criteria as the basis of their own certification programs. Most recently, the Solar Energy Industries Association contracted with the U.S. Department of Energy to develop the nation's first solar collector rating, certification, and labeling program to measure thermal performance, reliability, and durability.

National certification has involved the mechanical components of "active" systems. ASHRAE 90-75 conservation standards have been adapted by several state governments to incorporate "passive" solar gain calculations into analysis of a building's energy load. New Mexico and California, for example, have developed "passive" system certification criteria for purposes of compliance with energy codes and incentive programs. In conclusion, certification procedures and performance data, although by no means complete, are being developed for both collector components and system designs.

Apart from the issue of standards and certification, however, several other provisions of building codes have been identified as possible areas of conflict for solar systems. These include:

(1) Roof overhangs and awnings limited to a percent of side yard may inhibit proper shade control design, a critical element in passive systems for summer temperature control.

(2) Unnecessarily high ventilation requirements may make solar systems, which are more effective with fewer air changes, less competitive.

(3) Building codes may regulate height restrictions for accessory roof structures, but most do not. Zoning restrictions, however, may present problems for retrofit solar applications where buildings are already constructed to maximum height.

(4) Most codes specify comfort in terms of air temperature and humidity, disregarding the mean radiant temperature of surfaces. In conventional heating systems, the air temperature is warmer than the radiant temperature of walls, floors, ceilings, etc., whereas with passive solar utilization the situation is frequently the reverse. 1.0 mean radiant temperature degree is equivalent to 1.4 air temperature degrees. Therefore passive systems, due to higher radiant temperature readings, are able to provide the same comfort level with lower air temperatures. If current code comfort provisions are employed to evaluate passive solar structures, the present inadequacies could well result in overheated buildings which are uncomfortable to the occupants.

Now that this background information has been presented, we would like to hear of your own experience with solar heating or domestic hot water applications. The attached questionnaire is intended both to inventory the number of solar structures around the state and to determine from you, a building official, whether problems presently exist or are likely to arise in adapting solar heating systems to the building code in your area. An analysis of the statewide response will be returned to you so that your own experience and reactions to solar energy may be compared with other experiences around the state.

Thank you for your considerable patience in reading this material. I hope it has proved of use and of interest to you, and I look forward to receiving your comments.

Sincerely,

Jill A. Goodnight
Research Specialist
Science and Government Study Center

JAG/sm
Enclosures

The questionnaire which follows will be compiled in complete anonymity. The only "identifying" information that will be generally released is the location of solar projects around the State. If you feel uncomfortable or inconvenienced by any question, please disregard it and proceed to the next. Thank you in advance for your assistance.

Jurisdiction represented _____

SOLAR HEATING QUESTIONNAIRE

1. Which building code version is enforced in your jurisdiction?
1973 UBC _____ 1976 UBC _____
1977 Supp. Chapter 53 (Energy Conservation) _____
2. Have any modifications to your building code been made to apply specifically to solar installation? Please describe.

3. How many building permits are processed through your office each year (please estimate)?
New construction _____
Remodel over \$5,000 _____
4. How many solar applications have been processed by your office for the following purposes:
Swimming pool _____ Heating _____
Domestic hot water _____ Heating/cooling _____
5. Of these, were any denied? _____
If so, please describe the major non-conformance areas involved. _____

6. What regulations, criteria, etc. do you have for approving new components, techniques, or construction materials not covered under the code? (Please discuss in terms of heating/hot water systems.) _____

7. Under present code provisions, if a solar heating system were certain to provide at least 25% of the daily heat load, would a backup system of 75% capacity be acceptable? Could a 100% solar system be approved without a backup heat source at all? _____

8. Solar heating systems will be both ineffective and uneconomic if energy conservation measures are not designed into the structure. Has your jurisdiction adopted an energy conservation code? _____
- If so, please describe. If not, has it been considered? _____
- _____
- _____
- _____
9. On considering solar applications, which reference material or solar consultants have you used to determine the adequacy of the system? _____
- _____
- _____
- _____
10. Would you or someone in your department be interested in attending a workshop on solar applications and their relationship to building codes? _____
- What areas in particular would you wish discussed? _____
- _____
- _____
- _____
- Are there persons within your own department or with whom you are familiar that would make good resource persons for such a workshop? _____
- _____
- _____
- _____
11. Please describe those code provisions which you enforce that you see as creating potential problems for solar approval over the next several years. _____
- _____
- _____
- _____
12. Would a solar standards and certification program administered at the State level be useful to your office in processing a solar application? _____
- _____
- Would you recommend that the State become involved in such a standards and certification program? _____
- _____

Information from

ERDA

Washington, D.C. 20545

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FOR IMMEDIATE RELEASE
(Friday, September 30, 1977)

**"PASSIVE" SOLAR HEATING USES
THE SUN'S ENERGY "NATURALLY"**

Solar energy has been around as long as the sun, but solar heating for homes and other buildings has become a popular subject in just the last few years. And already many people have come to think of solar energy in terms of the pipes, pumps, tanks, and flat-plate collectors that equip most solar-heated buildings.

But a more simple "built-in" approach to solar heating has been demonstrated to be as economical and effective as systems that use collectors mounted on rooftops.

This approach is called "passive" solar heating. In a passive system, the house itself collects and stores the sun's radiant energy in the form of heat. The heat is distributed throughout the building by natural processes. "Active" heating systems, on the other hand, use special collectors to capture the sun's energy in heated air or liquid, which is distributed by fans, pumps, or other mechanical devices.

How can a building be its own solar collector? It has to be designed that way. Architects, designers, and engineers throughout the country have come up with some innovative designs, featuring greenhouses, roof ponds, and massive thermal storage walls. All are meant to provide a comfortable living environment with minimal consumption of energy.

The basic ideas behind passive solar heating were in fact developed hundreds and even thousands of years ago. The Pueblo Indians of the American Southwest designed dwellings with thick adobe walls which absorbed solar heat during the day, and radiated heat into the living space during the cold desert night. Indians in what is now Arizona built cliff dwellings in 1100 A.D., using the cliff as a natural overhang to block the summer sun.

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With this very early use of solar energy in the Southwest, it's not surprising that the passive solar energy movement is quite active in New Mexico. It is also popular in New England, where cold winters, high fuel bills, and "Yankee" self-reliance make solar heating look attractive.

New Mexico residents benefit from a state income tax credit that applies to both passive and active solar systems. There are about 150 passive solar homes in New Mexico, according to Dr. J. Douglas Balcomb of the Los Alamos (N.M.) Scientific Laboratory, a facility of the Energy Research and Development Administration (ERDA). The homes in New Mexico represent about ten percent of the total number of passive solar homes in the U.S., said Balcomb, even though the state has only two percent of the Nation's population.

Analysis of passive systems at Los Alamos is the core of an expanding program to learn more about passive heating and cooling systems and how they can save energy and money. The program is funded by ERDA's Division of Solar Energy, Research and Development Branch. ERDA spent about \$300,000 in Fiscal Year 77 on passive solar research and development, mostly for work at Los Alamos. In Fiscal Year 78, plans are to spend about \$1.4 million, with contracts to be awarded to small businesses, universities, government laboratories, and individuals throughout the country. Some of the projects will involve design, construction, and instrumentation of buildings with innovative passive heating and cooling systems. Data from these buildings will provide a "quantitative basis" for designing passive systems for other buildings.

"The architectural, engineering, and building community needs an accurate way to predict the amount of energy that can be supplied by a passive heating and cooling system, said ERDA program manager Michael W. Maybaum. "They also need simple but accurate tools and techniques for designing such systems. We hope to make these available in the next year."

As part of this effort to develop a "quantitative basis for design," a series of 14 "test modules" has been set up at the Los Alamos laboratory. Each module is a tiny one-room building using a different passive solar concept. By taking careful measurements over many months, the Los Alamos group has developed a computer modeling technique to predict the performance of passive solar heating concepts in different climates and under different conditions.

(MORE)

The results look encouraging. According to a Los Alamos study published in July, a passive system could provide practically all the heat needed in a Los Angeles residence -- 99.9 percent -- and 60 percent in New York, 57 percent in Boston, 52 percent in Seattle, and 42 percent in Madison, Wisconsin.

The test modules illustrate the four main passive solar concepts. The simplest is the "direct gain" approach, in which a building's south wall is a large expanse of double-pane glass. The low-altitude winter sun illuminates the south wall most of the day, but the high-altitude summer sun is prevented from reaching the wall by an overhang.

During the winter, the glass wall lets the sunshine in, and solar heat is stored in the building's massive masonry or concrete floor and north-facing wall. This design makes the whole building a live-in solar collector. Stored heat radiates throughout the living space on cold days and nights.

Insulation is used in all passive solar designs, not only on the inside, but in some cases on the outside of walls and roofs as well. Moveable insulating shutters are used at night to cover the south wall in order to prevent heat loss. Some buildings use a unique "beadwall" system, which fills the air space between the two panes of glass with tiny styrofoam beads. During the day the beads are vacuum-pumped out and stored until needed.

Another basic approach to passive solar heating is the thermal storage wall -- a thick south-facing concrete wall covered with glass, with an air space between the glass and the wall to prevent heat loss. Sunshine enters through the glass and is immediately stored in the wall. The stored heat radiates throughout the building at night.

A thermal storage wall is usually made of concrete, up to two feet thick. But it doesn't have to be concrete. A home in Albuquerque uses a row of 55-gallon water-filled drums as a thermal storage "wall." At night the outside of this "drumwall" is covered with insulating shutters. During the day, the shutters are kept flat on the ground to reflect additional sunlight onto the wall.

Another variation of the thermal storage wall concept is the Trombe wall, first used in the Felix Trombe house

(MORE)

in Odeillo, France. It is a thick concrete or masonry wall with vents at the top and bottom of the room. Cold air from the room enters the bottom vents, and rises through the space between the wall and its glass glazing. As it becomes warmer, the air rises to the top of the space, where it re-enters the room through the top vents. This way a natural "thermocirculation" pattern is established, using convection to continually replenish the supply of warm air in the building.

A greenhouse added to the outside of a thermal storage wall can collect additional heat. Solar energy not only provides all the heat needed by the greenhouse but provides substantial heat for the house itself as well.

The last major design concept is the roof pond, which can be an open pond or can consist of water-filled plastic bags on the roof. California scientist Harold Hay designed a roof pond system, which he calls "Skytherm," for his house in Atascadero and for other homes as well. The flat roof is covered with large plastic bags of water which absorb solar heat and radiate it through a metal ceiling to the rest of the house. On cold nights, moveable insulation panels cover the pond to prevent heat loss. In hot weather, the pond is covered during the day, and is opened at night so it can radiate heat from the house to the night sky.

Will these unusual home designs become commonplace in the future? Much of passive solar heating's potential success depends on cost. Passive solar systems are still more expensive than conventional heating systems, and ERDA scientists say that more research is needed to compare the cost-effectiveness of passive and active systems. However, passive systems generally last the life of the building, and require little upkeep, according to ERDA's Maybaum. "If we consider the life-cycle cost of passive and active systems," he said, "passive appears even more economically viable."

Right now, passive systems are used mainly in custom-built homes, which represent only five to eight percent of the nation's total housing volume. But one of the ERDA projects to be conducted in 1977-78 will test the feasibility of "retrofitting" an older masonry home with a Trombe wall passive solar system. And ERDA's Los Alamos scientists have just begun testing a prototype modular home that might prove the feasibility of making passive solar systems available in manufactured housing.

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The potential success of all solar energy systems will depend on many factors, including the future cost of gas, oil, and electricity. Basically, passive solar heating will catch on if builders can sell it, according to Baltimore architect Peter Powell. "We're already seeing a surge of demand for energy conservation features in homes," Powell said, "and this demand may eventually extend to passive solar if we can show how well it works."

For more information about solar heating and cooling, write to the National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, Maryland 20852.

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PASSIVE SOLAR HEATING CONCEPTS

(Shaded Areas Are Main Solar Heat Storage Areas.)

DIRECT GAIN

THERMAL STORAGE WALL

TROMBE WALL

SOLAR GREENHOUSE

ROOF POND

DIRECT GAIN WITH CLERESTORY WINDOWS

SOLAR HEATING QUESTIONNAIRE ANALYSIS

Responses to a "Solar Heating Questionnaire" mailed by Battelle's Science and Government Study Center to building department officials throughout the state of Washington totaled 64, representing a response rate of approximately 45%. The Solar Heating Questionnaire was designed to monitor activity, interest, and various legal "encouragements" and impediments to development of solar energy that presently exist in jurisdictions throughout the state. Respondents were questioned whether energy conservation ordinances/codes were in effect in their jurisdictions and whether currently-enforced code regulations existed which might create potential problems for solar approval in their areas in the years ahead. They were also asked their opinion of the practicality of solar energy without a backup system and whether they wanted a solar standards and certification program to be administered and/or enforced at the state level. Finally, recipients of the questionnaire were asked whether they would be interested in attending a workshop on solar energy specifically oriented to solar applications and their relationship to building codes; and if so, which areas in particular they would like to see discussed.

In terms of geographical distribution, the largest number of responses came from cities and counties in Northwest Washington, where the majority of Washington residents live.

Relative to the number of existing jurisdictions, however, the response rate could be considered good for all parts of the state.

For evaluation purposes, responses were separated into four subcategories following the major city/county classification. These subcategories were based on the number of new construction permits processed annually by the responding office: specifically, under 100 permits per year, 100-500, 500-100, and over 1,000.

Responses indicate that more jurisdictions responding to the questionnaire presently enforce the 1973 UBC than the 1976 UBC (36 vs. 27), although numerous offices mentioned they were considering an update. A few jurisdictions (four) indicate they have adopted the 1977 Energy Conservation Supplement to the code. No jurisdiction has amended building codes to specifically include solar systems, although one indicated that adoption of the IAPMO solar code was pending.

According to official building permit records, solar activity in the state thus far has been minimal. While many building officials expect to see an increase in activity in the years ahead, the generally insignificant activity thus far would not seem conclusive evidence to such officials that solar is an alternative energy source requiring expeditious examination by their departments. Only a scattering of permits had been issued as of late fall 1977. The most frequent type of solar permit was for space heating (16), with 9 permits each having been issued for heating/cooling units and for domestic hot water. Only one permit had been issued for solar

heating of a swimming pool. No respondent indicated that any solar application had been denied.

Concerning regulations and criteria used for approving new components not covered under present codes, the majority of respondents (24) replied that none were utilized. Of those who specified references, however, IAPMO (9) and ICBO (8) research reports were designated most often, although staff judgment appeared to play an equally significant role.

About a quarter of the building departments (13) indicated they would need more information from which to determine whether a solar system for heating would require a backup heat source. A few more (15) indicated that a 100% solar with no backup system could be approved if proven capable of carrying the load. Ten indicated that 100% backup would be mandatory. In asking for references used when such technical solar questions arose, 24 jurisdictions indicated they had none available, 12 said it was not applicable (they had never had a solar inquiry), seven mentioned IAPMO, and six had various other sources of information, including their own staff.

About one-third (23) of the responding jurisdictions indicated that their area had adopted an energy conservation code such as House Bill 98 or the 1977 Supplement to the Uniform Building Code. Several others stated that energy conservation legislation was being seriously considered for implementation in their areas in the near future.

If there was any near consensus to be noted among the respondent officials, it would clearly be the interest and

occasional enthusiasm expressed for a proposed solar workshop on solar applications and their relationship to building codes. Only five of the 64 officials responding to the questionnaire answered No to having an interest in attending such a meeting. Many areas for discussion were suggested, with "all" gathering the highest collective vote (8). Other items listed as needing elaboration were specific applications of the more general theme of minimum system requirements and approval procedures.

Officials were also questioned concerning problems they could foresee for solar approval due to building code provisions currently enforced by their departments. The most frequently repeated problems were those of mechanical and plumbing code requirements (4) and existing ventilation specifications (4), although 12 departments felt there were no real code impediments. The largest group (20) opted for no response to this question, however.

Finally, the questionnaire solicited opinions on the role of the state in certification and approval. The questions distinguished between whether the respondent felt that state administration of a certification program would be useful to his/her department and whether the respondent would furthermore recommend such action. Fewer responses came from the question of usefulness (26 saying yes, 25 no) than from the question of recommending state involvement. Thirty-two did not find such a plan favorable (five very emphatically), with 21 approving it. Those in opposition primarily considered it to be a responsibility of the national code organizations and felt that state efforts should not needlessly duplicate the model code work being done at the national level.

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