Toward a National Plan for the Accelerated Commercialization of Solar Energy

Guidelines for Regional Planning

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Toward a National Plan for the Accelerated Commercialization of Solar Energy

Guidelines for Regional Planning

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ABSTRACT

This document provides data and guidelines for the development of regional programs for the accelerated commercialization of solar energy. It estimates the solar potential for individual regions based on the solar resources, competing costs of energy, and specific regional characteristics. It also points out the primary decision makers, technology distributors, and potential barriers that should be addressed by a commercialization program.

ACKNOWLEDGEMENTS

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The MITRE project team was led by Gerald E. Bennington and Peter Spewak. Market sector analyses were performed by Marcia Bohannon, James Taul, Carol Moncrief, and Cynthia Payne (Residential and Commercial); Narasimhan Kannan, Michael Shulman, and Gena Hughitt (Industrial); Grant Miller and Marie Coluzzi (Utility); and Abu Talib and David Salo (Fuels and Biomass). Dispersed electric applications were analyzed by Ruth Hartzler and Robert Gerstein with engineering support from Arnold Cherdak, Willis Jacobsen, and Richard Manley. Kathy Rebibo coordinated the development of the macroeconomic scenarios and the integration of results across market sectors. Dyanne de Jong was responsible for administrative coordination and editorial assistance.

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EXECUTIVE SUMMARY

The federal government has undertaken a major commitment to the development of domestic sources of energy. As part of this initiative, the President has set a goal of solar energy technologies' providing 20 percent of U.S. energy requirements by the year 2000. This represents an increase in the use of solar energy from 4.8 quads in 1978 to 18.5 quads in the year 2000.

The 1978 figure of 4.8 quads is comprised of 3.0 quads of hydroelectric and 1.8 quads of biomass for industrial process heat and space heating. The year 2000 figure is equivalent to 20 percent of the projected total U.S. energy demand of 95 quads upon which the President's goal was based.[1] The energy would be supplied by the solar technologies and applications shown in Table S-1.

Estimates of solar technology market penetrations and energy contributions were projected using the MITRE System for Projecting the Utilization of Renewable Resources (SPURR) [Rebibo et al., 1977]. The data base, methodology, and assumptions of this analysis are described in Price/Demand Scenarios and Projections of Solar Utilization Under the National Energy Act, MTR-8057. On a national scale, these projections imply:

- reduction of oil and gas imports
- long-term reduction in levels of pollutants

[1]Office of the White House Press Secretary, Fact Sheet, The President's Message on Solar Energy, June 20, 1979.

Table S-I

SOLAR TECHNOLOGIES INCLUDED IN THE MITRE ANALYSIS

SOLAR TECHNOLOGY / MARKET SECTOR	HYDRO-ELECTRIC	BIOMASS	SOLAR THERMAL	WECS	PHOTO-VOLTAICS	OCEAN THERMAL
Buildings						
heating & cooling		X	X			
electric				X	X	
Process Heat		X	X	X	X	
Electric Utilities	X	X	X	X	X	X
Synthetic Fuels & Chemicals		X[1]				

[1]Biomass resources analyzed included only logging residues, mill residues, and silvicultural plantation products equivalent to approximately 2.7 quads of resources in the year 2000. Significant additional wood resource and crop residues are expected.

- significant levels of employment--over one million persons by 2000
- significant industry capacity--annual sales of approximately $35 billion by 2000

The SPURR analysis was carried out on the basis of U.S. census regions. The results, by census region, are summarized in Toward A National Plan for the Accelerated Commercialization of Solar Energy: The Implications of A National Commitment, MTR-79W00004.

The analysis in this document is presented on the basis of the areas encompassed by the Regional Solar Energy Centers (RSECs, see Figure S-1), since the RSECs are the primary agencies responsible for developing regional and local commercialization programs and actions to accelerate the market penetration of solar technologies.

Use of solar energy is expected to vary greatly from region to region in the U.S. due to variations in regional insolation and wind resources, energy demands, and prices of competing conventional fuels and technologies. From 12 to 35 percent of RSEC regional requirements for energy could be met by solar technologies by the year 2000 [Bennington et al., 1979]. Annual energy savings for the areas served by the four Regional Solar Energy Centers vary from about 2.8 quads per year in the Northeast Solar Energy Center (NESEC) region to between 5.4 and 8.0 quads per year for the Southern Solar Energy Center (SSEC) region. These estimates are based on MITRE/

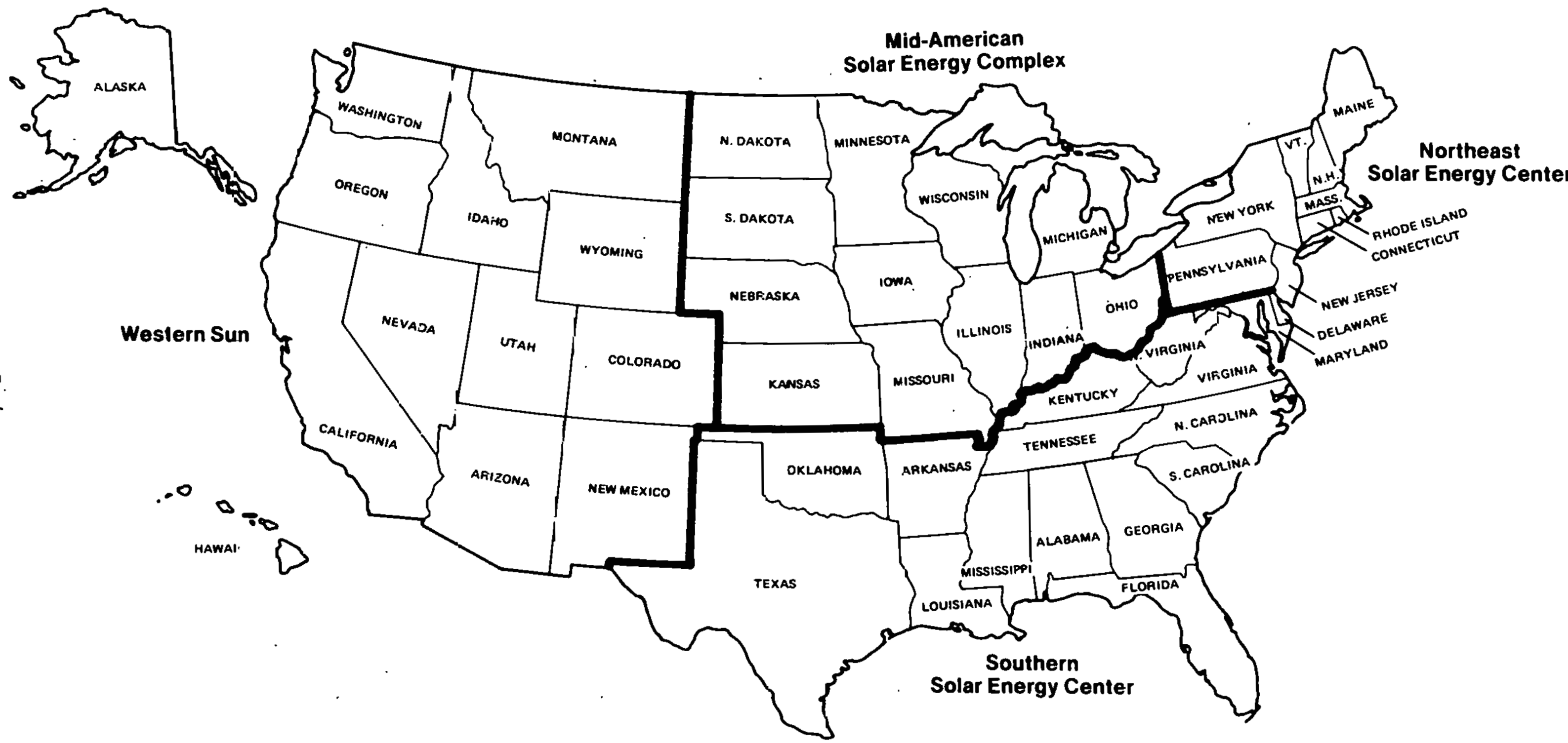


FIGURE S-1
REGIONAL SOLAR ENERGY CENTERS

Metrek analysis of contributions from specific solar technologies for each region of the U.S. [Bennington et al., 1979; Gerstein and de Jong, 1979]. They are consistent with estimates produced by the Domestic Policy Review Committee [Department of Energy, 1979].

The achievement of a 20 percent solar goal will require a large federal commitment of funding and programs to commercialize solar technologies. The RSECs have been charged with developing such commercialization programs on a regional basis. They will constitute a major contribution to the National Plan for the Accelerated Commercialization of Solar Energy (NPAC), the federal program to develop a comprehensive and unified solar commercialization plan.

MITRE/Metrek has developed an extensive data base and sufficiently detailed analyses to provide useful information and support to the RSECs in their effort to develop regional solar commercialization plans. This document presents an overview of the types of information used to support the RSECs and an example of the analyses carried out with the RSECs to identify: (1) solar applications which appear to have a high potential for near-term market penetration (targets of opportunity); and (2) people or organizations capable of affecting the decision process to purchase solar equipment (leverage points). Identification of these people and organizations constitutes a starting point in creating programs capable of reaching the decision makers and favorably disposing them toward solar technologies.

The information developed on a regional basis includes:

- primary energy displaced by solar technology, over time
- numbers of solar systems sold by type, over time
- costs of energy from solar and conventional technologies, over time
- levels of pollutants resulting from solar usage
- primary pollutant nonattainment counties
- solar resources
- solar market potential
- regional market characteristics
- regional institutional characteristics

An example of characterizing a solar market, identifying targets of opportunity, and identifying associated leverage points is provided for the residential market sector in the NESEC region. This market sector consists of applications of solar hot water and heating, which are expected to provide most of the early market penetration by solar technologies. It is a target of opportunity for this region. Characterization of the residential market in the NESEC region and resource requirements needed to support the developing solar industry are significantly different from those of other regions but they indicate the type of data developed for each of the regions.

MAJOR FINDINGS

- Solar energy can provide a significant fraction of the energy requirements for all regions. Under a scenario to achieve the 20 percent goal of the President, solar is expected to supply from 12 to 35 percent of the energy requirements of the regions.

- Individual solar technology contributions differ significantly from region to region due to differences in solar resources, competing fuel costs, and costs of capital.
- An extensive industry infrastructure will be required in each region to supply the millions of residential systems expected to be installed by the year 2000. For a specific region, required resource levels may be supplied from within the region or imported from other regions.
- Solar heating and hot water systems present an early target of opportunity for all regions.
- Process heat applications are attractive for all four RSECs. Biomass use in the pulp, paper, and lumber industries is expected to increase significantly in the SSEC and Western Sun (WSUN) regions. Food processing applications appear attractive in the midterm for the Mid-American Solar Energy Complex (MASEC) and WSUN regions.
- Wind energy conversion systems in all regions and solar thermal electric systems in the SSEC and WSUN regions appear to be targets of opportunity by 1990.
- Expansion of hydroelectric capacity in the WSUN region could significantly increase solar energy utilization for that region.

SECTION I

INTRODUCTION

The presidential policy statement on energy issues indicated that renewable energy sources, especially solar technologies, will have to play an increasing role in supplying the energy needs of the U.S. Increasing the production of solar energy over the near term implies a significant federal commitment to the commercialization of solar technologies. The Domestic Policy Review of Solar Energy [Department of Energy, 1977] established a set of broad policy guidelines to serve as the cornerstone for detailed programmatic planning and implementation. MITRE/Metrek analysis has been carried out within the guidelines of the Domestic Policy Review (DPR) and is consistent with the policy established.

Current Department of Energy, Conservation and Solar Applications' activities in support of solar commercialization programs are coordinated under the National Plan to Accelerate the Commercialization of Solar Energy (NPAC). NPAC is a commercialization planning process to define specific programs for achieving solar energy objectives. The basic goal of this process was defined by the President's goal of solar energy's providing 20 percent of our annual energy use. Goals for specific solar technologies were established by the DPR; they provided a basis for the Presidential policy. These goals were analyzed to determine specific objectives by region and technology in terms of cost, performance, and required market penetration levels.

Under the NPAC process the Regional Solar Energy Centers (RSECs, see Figure 1) are developing regional commercialization plans. Many of the solar resource, economic, technological, and institutional characteristics that intimately affect the competitiveness of solar technologies vary significantly on a regional or subregional level. The RSECs are familiar with the solar resources, institutional resources, manufacturing, installation and maintenance infrastructure, and competing costs of conventional energy sources for their region. The RSECs are also familiar with state and local concerns through advisory panels or state representatives. Thus the RSECs are familiar with the requirements and characteristics peculiar to their region that are expected to affect the market penetration of solar technologies. They are logical participants to generate commercialization programs to address the issues and concerns peculiar to their region, states, and localities.

The RSEC planning process includes:

- identification of target markets
- identification of leverage points
- identification of strategies to address the leverage points
- definition of commercialization programs

Target markets include specific markets that present relatively large opportunities for solar market penetration and unique early opportunities for solar technologies such as industries dependent on

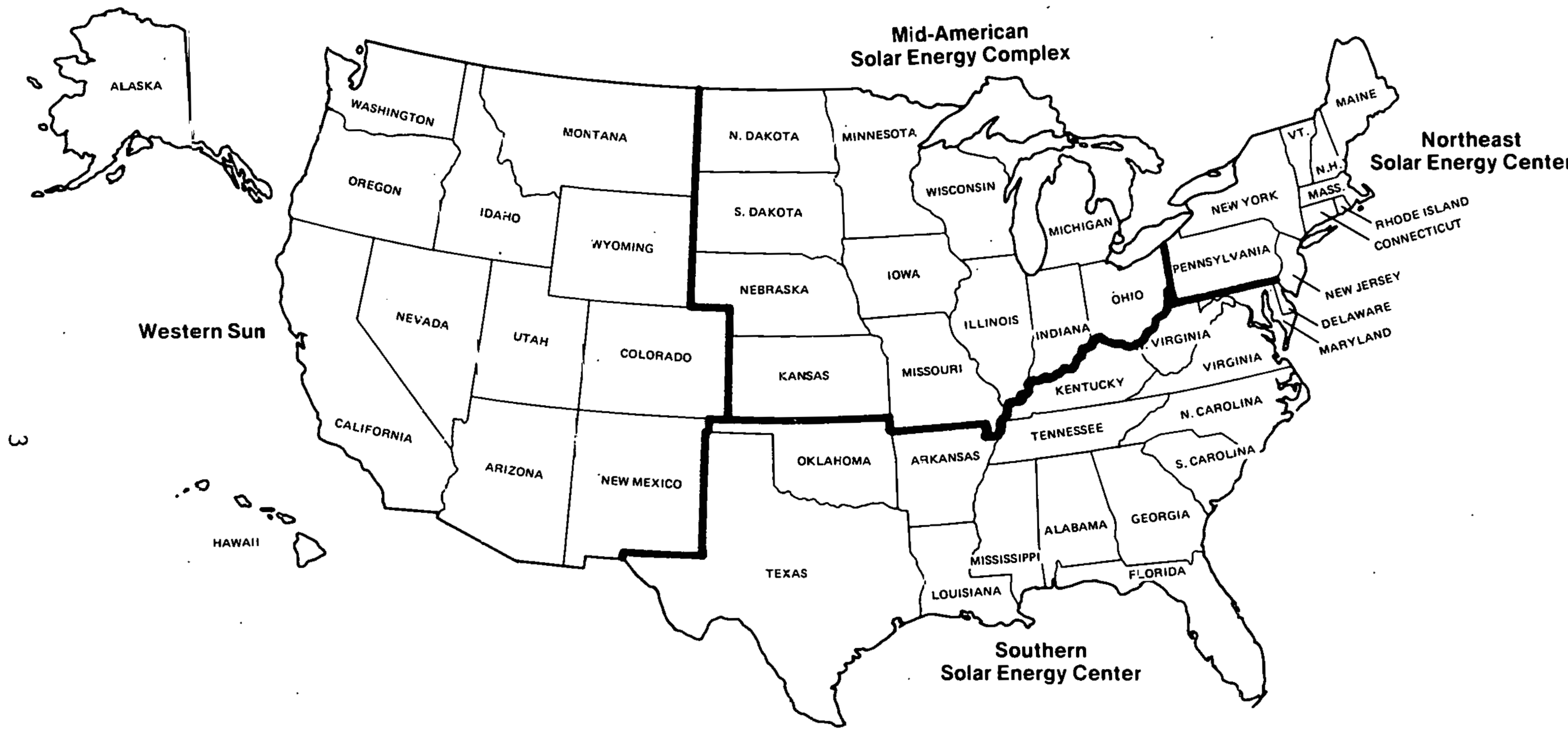


FIGURE 1
REGIONAL SOLAR ENERGY CENTERS

interruptible gas supplies. Early attention to the target markets could significantly accelerate market penetration by solar technologies resulting in early development of manufacturing, installation, and maintenance infrastructures.

Identification of leverage points concerns the identification of organizations, individuals, or associations which affect the decision makers of the target markets. For example, in the custom home market, this would include, at least, lending institutions, architects, contractors, owners, and inspectors. Although inspectors do not decide whether or not solar technologies will be installed on a home, they are included because they must approve the installation. They are a potential veto point or barrier for a solar installation.

Identification of strategies to address the leverage points includes definition of programs or incentives capable of affecting the decision processes at the identified leverage points. Educational programs, design competitions for regionally-specific active solar systems, or advertising in architectural journals are examples of programs which might reach architects/contractors for custom homes. Educational programs or model solar building codes could reach building inspectors. Tax incentives could affect the economic decisions of the custom homeowner.

The definition of commercialization programs involves selection, integration, time phasing, and setting funding levels to maximize benefits. The constraints on these programs are the established federal guidelines, the overall funding levels authorized for commercialization programs, and the limitations imposed by the developing market infrastructure.

SECTION II

REGIONAL ANALYSIS

MITRE/Metrek has developed an extensive data base and an analytical capability that has been used to provide information to the regional planners at the RSECs. The information provided includes estimates of market penetration, energy costs, rate of development of solar system production, and potential market for solar systems. These estimates are available for:

- each of the nine census regions of the U.S. (see Figure 2)
- each of the five market sectors--residential, commercial, industrial, utilities, and synthetic fuels and chemicals
- each of the 19 solar applications (see Table I)
- each of the 11 solar technologies [Gerskin and de Jong, 1979].

This level of detail will help RSEC planners identify targets of opportunity and deployment goals for their regions. Identification of such targets allows planners to focus on specific tasks which could accelerate the use of solar technologies and/or remove barriers which impede solar use. This is the starting point for developing a regional implementation plan.

Our analysis of solar market penetration indicates, for each RSEC, the expected energy savings due to the use of solar technologies, the rate of development of the solar industry, numbers of systems sold, costs of solar energy, and other information useful to regional solar planners. Significant solar market penetrations are

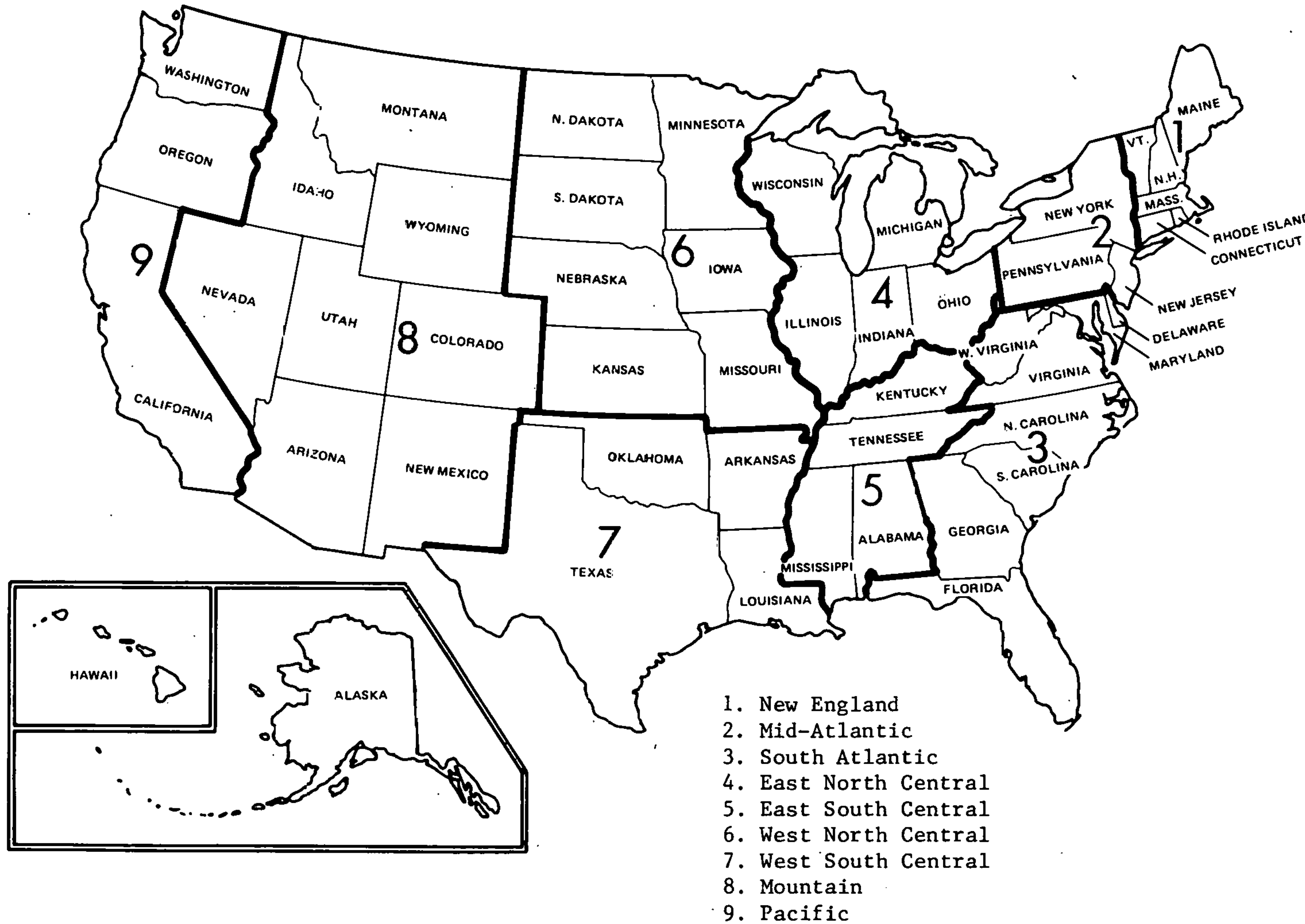


FIGURE 2
U.S. CENSUS REGIONS

TABLE I

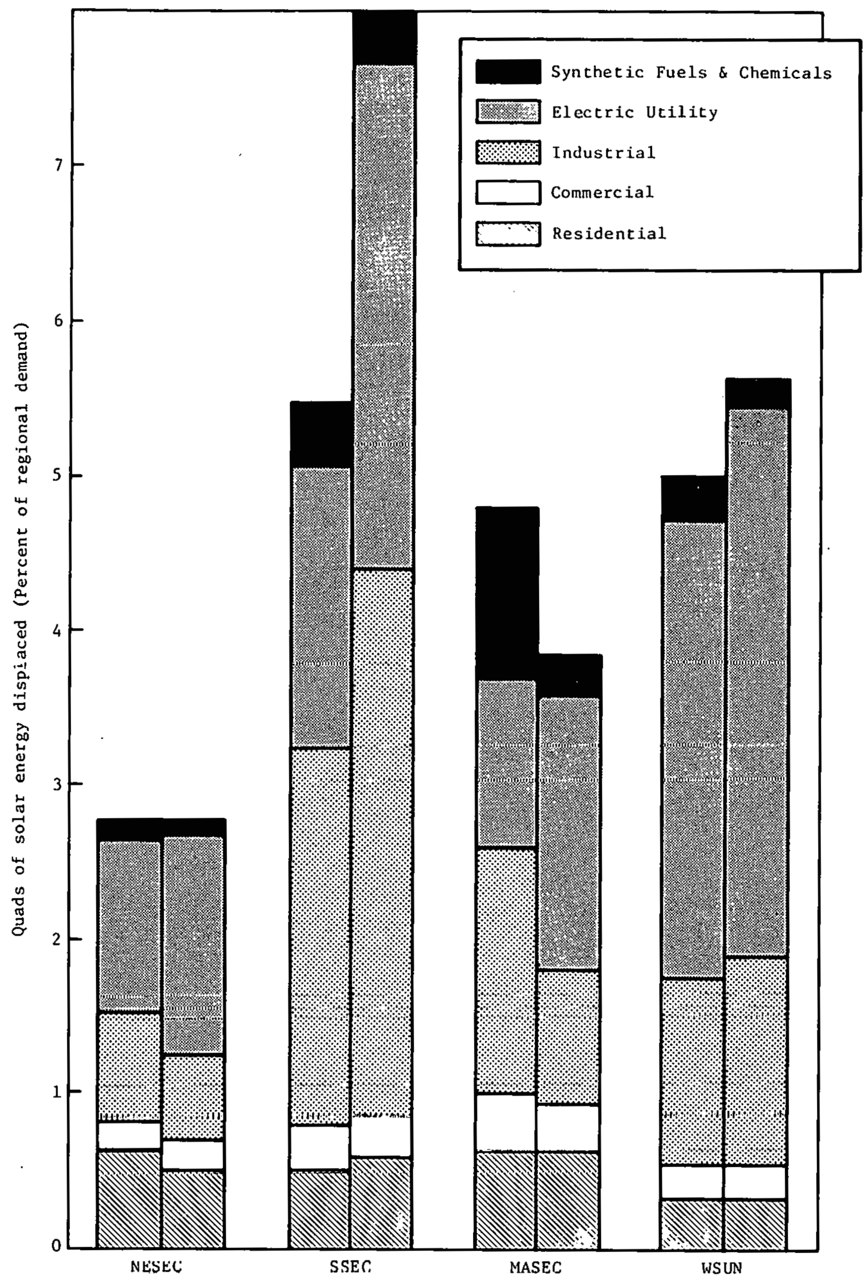
SOLAR TECHNOLOGIES ANALYZED

TECHNOLOGY	MARKET SECTOR/APPLICATION																			
	RESIDENTIAL				COMMERCIAL				INDUSTRIAL				UTILITY				SYNTHETIC FUELS			
	Hot Water	Heating	Cooling	Electricity	Hot Water	Heating	Cooling	Electricity	Low Temperature (to 100°C)	Medium Temperature (to 100°C-350°C)	High Temperature (over 350°C)	Electricity	Base	Intermediate	Semi-peaking	Fuel Savers	Methanol	Synthetic Crude Oil	Ammonia	Synthetic Natural Gas
Thermal	x	x	x		x	x	x		x	x	x									
Passive		x				x														
WECS				x				x				x	x	x		x				
Photovoltaics				x				x				x		x	x	x				
Solar Thermal Electric												x		x	x	x				
Biomass		x				x				x	x		x	x						
Solar Total Energy Systems									x											
Hydro Electric									x			x	x	x						
OTEC													x							
Wood Conversion																	x	x	x	x
Animal Waste																				x

projected for each RSEC by the year 2000 (see Figure 3). If solar energy supplied 20 percent of our national energy needs, solar technologies would provide between 12 and 35 percent of the total energy requirements for an RSEC region. Greater market penetrations are expected in southern and western regions where insolation levels are higher. The levels of solar energy use shown in Figure 3 require the production and installation of large numbers of solar systems. The numbers of systems for residential and commercial, industrial, and utility sectors of the economy are shown in Figures 4, 5 and 6. The large numbers of residential and commercial systems shown in Figure 4 result from the relatively small average size of these systems. By 2000, 49 million active systems and 14.6 million passive systems are expected to be installed for residential and commercial applications.

THE NORTHEAST SOLAR ENERGY CENTER (NESEC) REGION

Solar energy is expected to provide approximately 13 percent of the energy requirements of the NESEC region by the year 2000 primarily because of high fuel costs for conventional systems. Wind energy conversion systems (WECS) and the direct combustion of biomass for residential, industrial, and utility applications will capture significant markets because of their relatively high resource availability. Between 10,000 and 14,700 1.5 MWe WECS units are projected to be installed by the year 2000. Over 15 million solar hot water heating and cooling systems are expected to provide the



Note: Variations in regional contributions represent ranges based on DPR estimates (left side) and MITRE analysis (right side).

FIGURE 3
REGIONAL SOLAR MARKET PENETRATION IN THE YEAR 2000

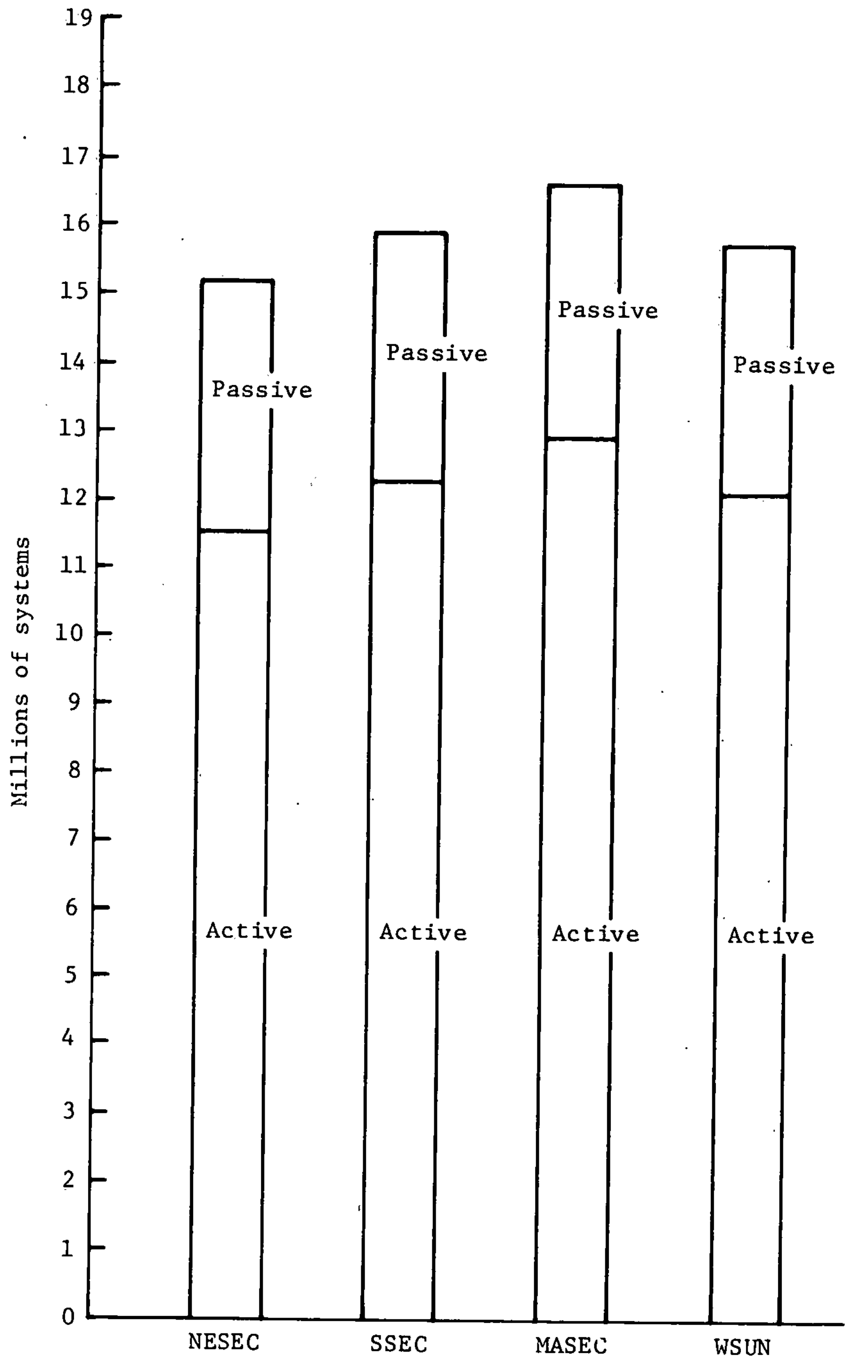


FIGURE 4
NUMBERS OF RESIDENTIAL AND COMMERCIAL SOLAR SYSTEMS SOLD TO THE YEAR 2000, OPTION II

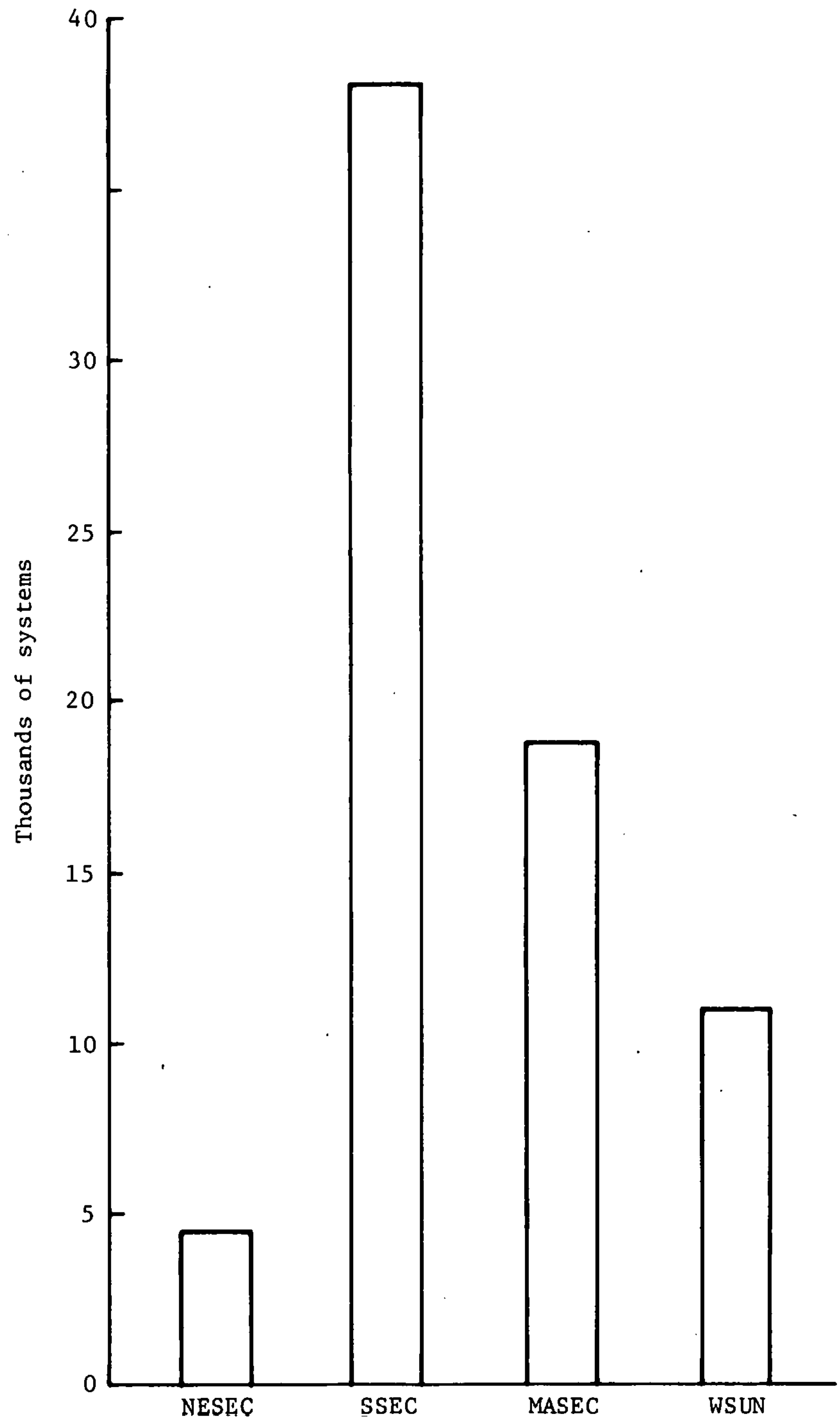


FIGURE 5
NUMBER OF SOLAR THERMAL PROCESS HEAT SYSTEMS SOLD TO THE YEAR 2000, OPTION II

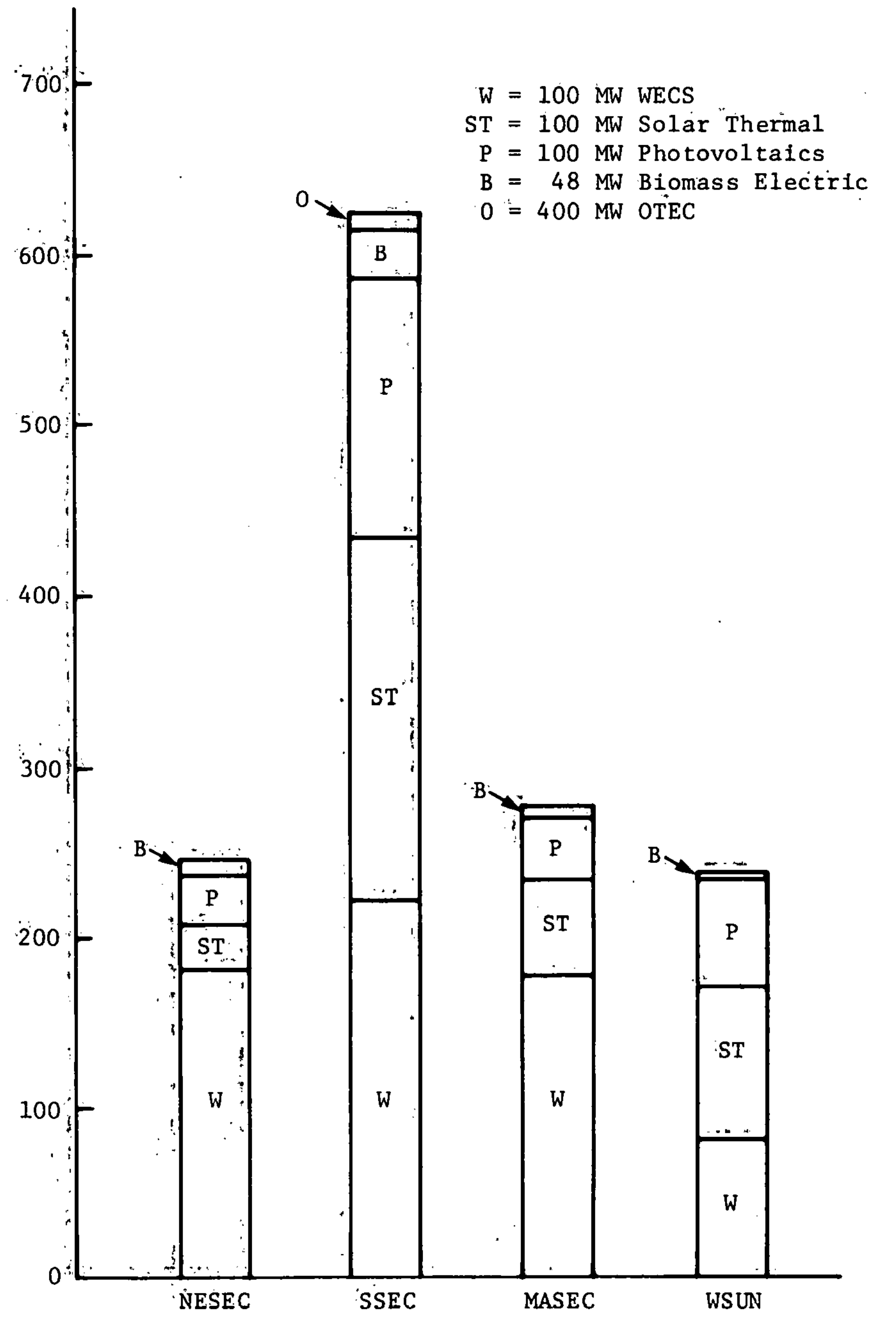


FIGURE 6
NUMBERS OF SYSTEMS SOLD IN THE UTILITY SECTOR TO THE YEAR 2000, MITRE ANALYSIS

region with between 0.7 and 0.9 quads of energy, primarily in the more southerly part of the region where both solar insolation and population are larger.

THE SOUTHERN SOLAR ENERGY CENTER (SSEC) REGION

The SSEC region is expected to derive the greatest amounts of energy from solar technologies, between 5.4 and 8.0 quads per year by the year 2000. Every solar technology shows promise partly because of high prevailing conventional fuel costs and partly because of the high availability of solar resources. The eastern area of the region is expected to be the largest user of biomass for process heat and for conversion to synthetic fuels and chemicals.

Between 12,000 and 17,600 1.5 MWe WECS units are expected to be in use in the SSEC region by the year 2000. Almost 16 million solar hot water, heating and cooling systems (12.3 million active, 3.6 million passive) are expected to displace from 0.7 to 0.8 quads of primary energy.

THE MID-AMERICAN SOLAR ENERGY COMPLEX (MASEC) REGION

The MASEC region encompasses a large fraction of the corn and wheat producing land in the U.S. The biomass resources from crop residues, mill residues, excess foodcrops and animal residues are expected to be significant for this region. These resources could be used for the production of synthetic fuels and chemicals or process heat for industry. The region could displace between 0.4 and 2.2

quads of energy use by the year 2000 utilizing these biomass resources.

A significant amount of energy (0.9 to 1.0 quads) is also expected to be displaced by approximately 16.7 million solar hot water, heating and cooling systems. 10,000 to 15,000 WECS units are expected to displace between 0.5 and 0.7 quads of fuel use annually.

THE WESTERN SUN (WSUN) REGION

The WSUN region is expected to derive a large fraction (31 to 35 percent) of its energy requirements from renewable resources. Out of an estimated 5 to 5.7 quads of solar in this region, 2.3 to 2.6 quads are expected to be supplied by hydroelectric. Other solar technologies are also expected to do well in this region as there are ample supplies of biomass, wind and solar insolation. Between 30 and 100 solar thermal electric systems are projected to be in use by the year 2000 and 15.8 million solar hot water, heating and cooling systems are projected to displace approximately 0.55 quads of energy use. Over one-half quad of energy is expected to be displaced by the use of approximately 11,000 process heat installations by 2000.

SECTION III

IDENTIFYING TARGETS OF OPPORTUNITY: CRITERIA AND RESULTS

Targets of opportunity represent solar resources, technologies or applications which could have a significant impact on a region or a specific market sector within a region. They can be identified on the basis of:

- the availability of solar resources or technologies
- a large potential market based on competing fuel costs, solar resources and technology characteristics
- physical/market characteristics unique to a region, including gas curtailments
- institutional characteristics unique to a region

On a regional basis, targets of opportunity are summarized in Table II for the near term and Table III for the midterm and long term.

Most regional planners are particularly concerned about near-term targets of opportunity. Most of the near-term opportunities are for hot water and heating of buildings, wind energy conversion systems, and biomass for industrial process heat applications. Over the midterm, additional solar technologies become technologically available and commercially competitive, especially solar thermal electric technology and cooling systems for buildings. The primary regions where these systems offer a midterm target of opportunity are shown in Table III.

OTEC for utility production of baseload electricity is the primary technology which appears to offer a long-term (after 1990)

TABLE II

NEAR-TERM TARGETS OF OPPORTUNITY

APPLICATION	MARKET SECTOR	REGION	TECHNOLOGY
Hot Water	Residential/ Commercial	1,2,3,4	Active
Heating	Residential/ Commercial	1,2,3,4	Active
Heating	Residential/ Commercial	1,2,3,4	Passive
Heating	Residential/ Commercial	1,2,4	Biomass
Process Heat	Industrial	2,4	Solar Thermal
Process Heat	Industrial	1,2,4	Biomass
Electricity	Utility	1,2,3,4	WECS
Electricity	Residential/ Commercial	1,2,3,4	Small-scale Wind
Electricity	Utility	4	Hydroelectric
Methanol	Synthetic Fuels & Chemicals	2,4	Biomass

Region 1 = NESEC
2 = SSEC
3 = MASEC
4 = WSUN

TABLE III

MIDTERM AND LONG-TERM TARGETS OF OPPORTUNITY

APPLICATION	MARKET SECTOR	REGION	TECHNOLOGY
Midterm			
Electricity	Utility	2,3,4	Solar Thermal
Process Heat	Industrial	2,3,4	High Temperature
Long-Term			
Electricity	Utility	2	OTEC
Methanol	Synthetic Fuels & Chemicals	2,3	Silviculture

Region 1 = NESEC
2 = SSEC
3 = MASEC
4 = WSUN

target of opportunity and this occurs primarily in the SSEC region since OTEC resources are greatest off the coast of Florida and in the Gulf of Mexico (see Table III).

The fact that a solar technology offers primarily a midterm or long-term target of opportunity for a region does not indicate that commercialization activities for these technologies can be ignored until the mid- or long-term. Considerable effort over the short term could help assure the technological and commercial competitiveness of such technologies. For example, early participation by utility representatives in the SSEC region in OTEC demonstrations could give the utilities valuable operating experience on OTEC units so as to foster their confidence in the technology and their early consideration of interface problems.

SOLAR RESOURCES

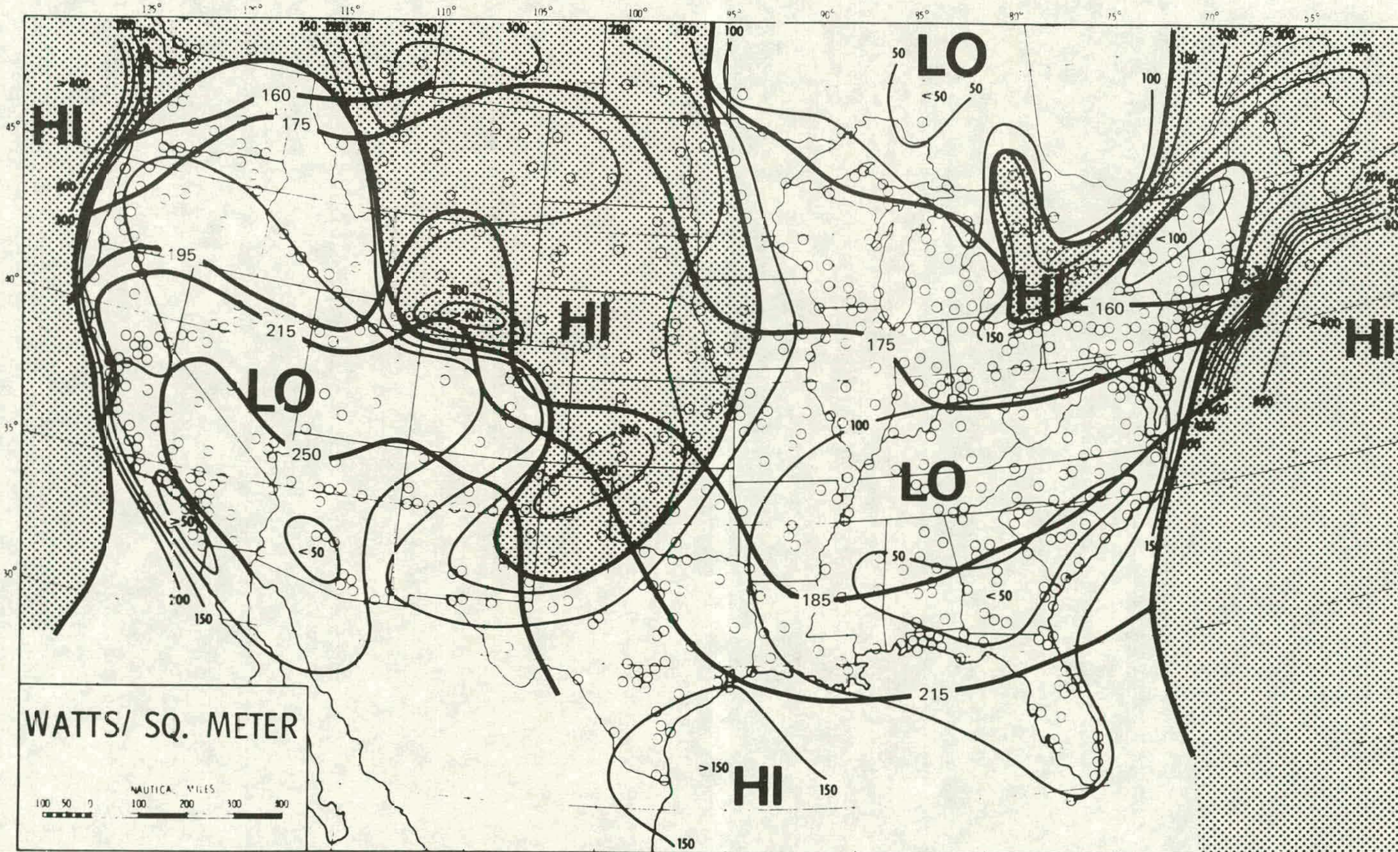
Solar resources are found throughout our environment in a variety of forms. Direct solar radiation can be captured by collectors as thermal energy (solar thermal) or converted directly to electricity (photovoltaics). Wind energy is a solar resource since winds derive from differential heating of the atmosphere by solar radiation. Wind energy conversion systems generally use rotors to capture the energy in the winds to convert it into electricity or usable mechanical power. Thermal gradients in the oceans caused by heating of the upper layers of the ocean by sunlight also constitute a solar resource and may be used to generate electricity (OTEC). Biomass in the form of trees, crop residues, animal residues and municipal wastes is considered a form of solar resource since it derives from photosynthetic processes.

The distribution of solar insolation and wind resources in the U.S. is shown in Figure 7. Insolation is expected to be greatest in the southern and desert regions of the U.S. These constitute the "sun belt" regions which have experienced recent influxes of population and development. Solar technologies could logically supply part of the substantial increases in energy demands implied by such population and economic shifts.

Wind resources tend to be more widely distributed throughout the U.S. Areas of high expected wind resources are in the mountain states, the panhandle region of Texas/Oklahoma, the Adirondak Mountains, Cape Cod, and other shore areas. However, specific sites of high potential wind resources may be found throughout the U.S.

The distribution of standing forest resources is shown in Figure 8. Most of the resources are located in the WSUN and the eastern area of the SSEC regions. These resources are used primarily by the lumber, paper, and pulp industries in these regions. Since these industries are the primary potential users of industrial biomass, this solar application presents a target of opportunity for the regions.

The distribution of crop residues and animal residues, by state, is shown in Table IV [Miller and Croaks, 1978]. This table indicates

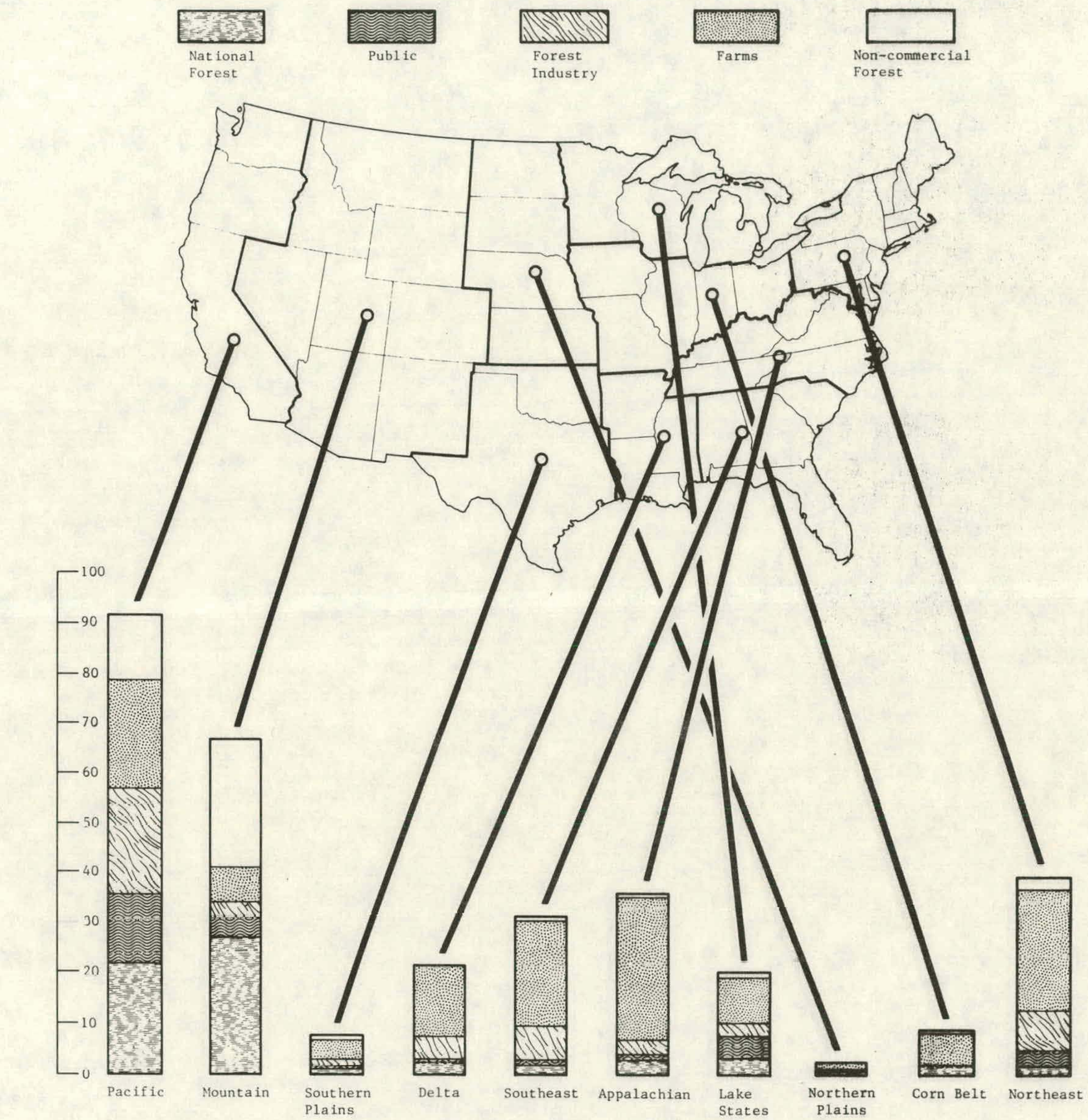


Available Wind Power, Annual Average

Available Solar Power, Annual Average (Horizontal Plane)

Areas in which Wind Power Exceeds Solar Power

FIGURE 7
INSOLATION AND WIND RESOURCE AVAILABILITY



Source: Based on data derived from <u>Forest Statistics of the U.S., 1977, Review Draft</u>, U.S. Department of Agriculture, Forest Service, U.S. Government Printing Office, Washington, D.C., 1978.

FIGURE 8
DISTRIBUTION OF THE STANDING FOREST RESOURCE (QUADS BY REGION)

that most of the residues are produced in the corn belt states (35 percent) and the North Plains states (25 percent). Both these areas are in the Mid-American Solar Energy Complex (MASEC) region. In the corn belt states most of the residue is generated as corn residues or soybean residue. In the North Plains states most of the residue is generated during the production of wheat. These resources and excess grain crops are a valuable resource for the production of liquid fuels or chemicals. They constitute an important target of opportunity for the MASEC region.

Hydroelectric resources offer a significant potential for increased energy production in the U.S. The distribution of the potential for development of hydroelectric resources at existing dams is shown in Figure 9. Large potential resources exist in the WSUN region which currently produces significant amounts of hydroelectric power.

Ocean Thermal Energy Conversion (OTEC) systems rely entirely on thermal gradients in the ocean. The only area of the continental U.S. where a sufficient thermal gradient exists to exploit currently proposed technology is in the Gulf Coast region and off the east coast of Florida. Thus OTEC resources are limited to the SSEC region of the U.S. It constitutes a long-term target of opportunity for the region.

MARKET POTENTIAL

If a solar resource is to be exploited to any significant

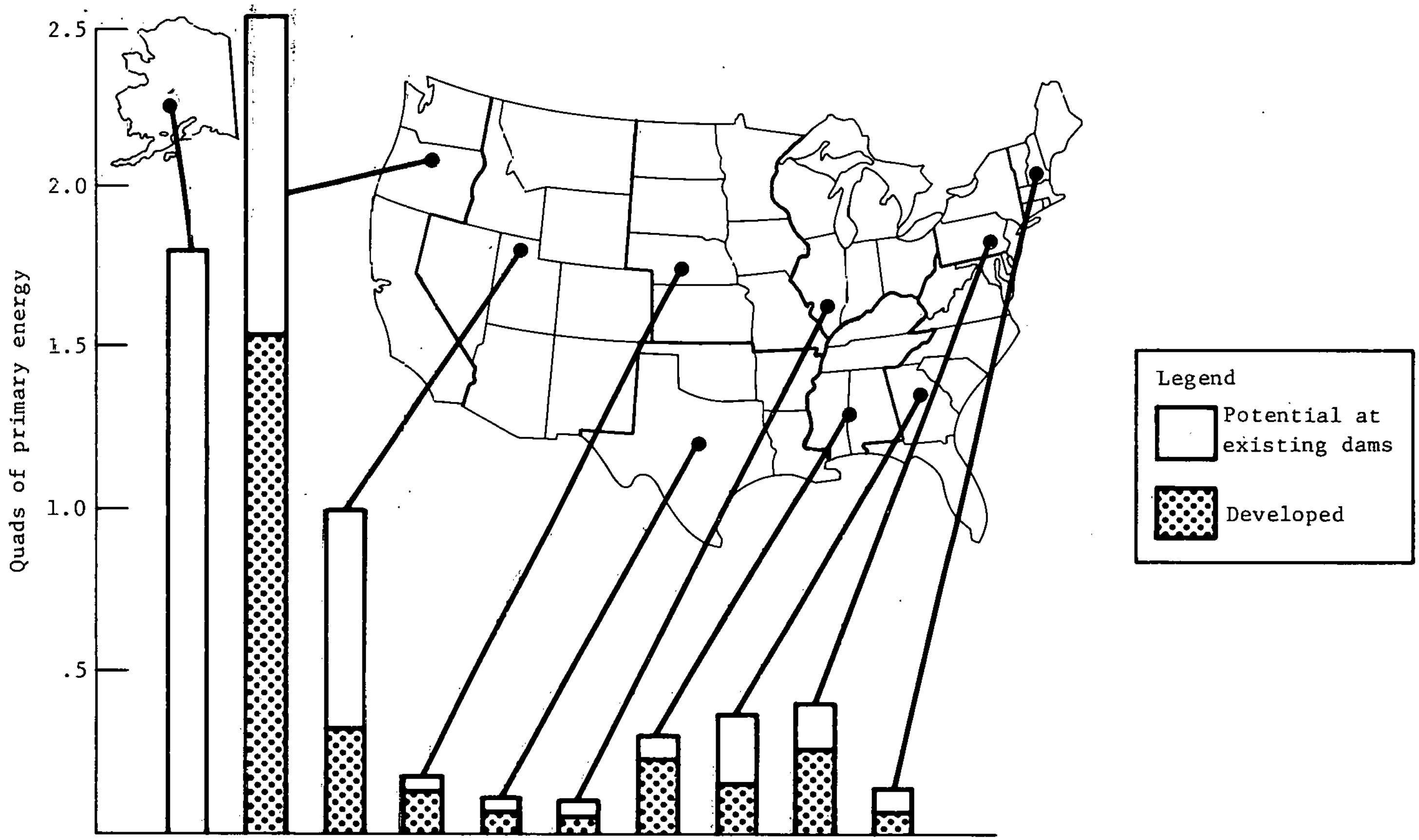
TABLE I'

RESIDUE PRODUCTION - 1975*
(Thousand Dry Tons)

	High Moisture						Low Moisture									Collected Trash and Hulls				Animal Manure						
	Corn	Cotton	Grain Sorghum	Sugar Beets	Sugar Cane Field	Total High Mosi-ture	Peanut Hay	Rice Straw	Seed Grass	Barley	Oats	Rye	Wheat	Soy beans	Total Low Mois-ture	Rice Hulls	Sugar Beet Pulp	Sugar Cane Ba-gasse	Total Trash and Hulls	Cattle on Feed	Dairy Cattle	Hogs Market	Broilers/ Fryers	Hens/ Pullets	Total Animal Manure	Total Residue Production
Northeast	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2996	122	147	532	3797	3797
Maine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	91	91	91
Maryland	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	147	--	147	147
New York	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1756	--	--	146	1902	1902
Pennsylvania	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1240	122	--	295	1657	1657
Southeast	--	--	--	--	1546	1546	1227	--	--	--	--	--	--	--	1227	--	--	1574	1574	--	--	111	1032	742	1885	6032
Alabama	--	--	--	--	--	--	279	--	--	--	--	--	--	--	279	--	--	--	--	--	--	--	438	236	674	953
Florida	--	--	--	--	1346	1346		--	--	--	--	--	--	--		--	--	1574	1574	--	--	--	--	124	1124	3044
Georgia	--	--	--	--	--	--	948	--	--	--	--	--	--	--	948	--	--	--	--	--	--	111	594	382	1087	2035
Lake States	8096	--	--	368	--	8464	--	--	--	1054	3841	93	4431	5729	15148	--	242	--	242	--	4200	129	120	98	2547	28001
Michigan	--	--	--	170	--	170	--	--	--	--	--	20	--	--	20	--	112	--	112	--	568	--	--	--	568	870
Minnesota	8096	--	--	198	--	8294	--	--	--	1054	2662	73	4431	5729	13949	--	130	--	130	--	1222	129	120	98	1569	23942
Wisconsin	--	--	--	--	--	--	--	--	--	--	1179	--	--	--	1179	--	--	--	--	--	2410	--	--	--	2410	3589
Corn Belt	51871	--	--	--	--	51879	--	--	--	--	2317	14	--	49150	51481	--	--	--	--	2183	2859	1388	--	215	6645	101997
Illinois	17698	--	--	--	--	17698	--	--	--	--	490	14	--	16439	16943	--	--	--	--	--	448	118	--	--	566	35207
Indiana	9320	--	--	--	--	9320	--	--	--	--	--	--	--	7472	7472	--	--	--	--	--	293	243	--	91	627	17419
Iowa	20146	--	--	--	--	20146	--	--	--	--	1311	--	--	13782	15093	--	--	--	--	2183	964	451	--	--	3598	38837
Missouri	--	--	--	--	--	--	--	--	--	--	--	--	--	6227	6227	--	--	--	--	--	379	383	--	--	762	6989
Ohio	4707	--	--	--	--	4707	--	--	--	--	516	--	--	5230	5746	--	--	--	--	--	775	193	--	134	1092	11545
Delta States	--	739	--	--	839	1578	--	3650	--	--	--	--	--	9797	13447	543	--	1686	2229	--	--	--	785	273	1058	18312
Arkansas	--	246	--	--	--	246	--	1971	--	--	--	--	--	5978	7949	287	--	--	287	--	--	--	518	131	649	9131
Louisiana	--	129	--	--	839	968	--	1679	--	--	--	--	--	--	1679	256	--	1686	1942	--	--	--	--	--	--	4589
Mississippi	--	364	--	--	--	364	--	--	--	--	--	--	--	3819	3819	--	--	--	--	--	--	--	267	142	409	4592
North Plains	8567	--	5575	170	--	14312	--	--	--	3244	4093	548	53639	--	61524	--	--	--	--	3853	--	436	--	--	4289	80125
North Dakota	--	--	--	--	--	--	--	--	--	2674	1722	160	18191	--	22767	--	--	--	--	--	--	--	--	--	--	22767
South Dakota	--	--	--	--	--	--	--	--	--	550	1960	273	4314	--	7097	--	--	--	--	--	--	111	--	--	111	7208
Nebraska	8567	--	2027	170	--	10764	--	--	--	--	411	81	6996	--	7488	--	--	--	--	2088	--	218	--	--	2306	20558
Kansas	--	--	3548	--	--	3548	--	--	--	--	--	34	24138	--	24172	--	--	--	--	1765	--	107	--	--	1872	29592
South Plains	--	749	5429	--	--	6178	308	1825	--	--	--	--	11428	--	13561	282	--	--	282	3037	--	122	251	84	3494	23515
Oklahoma	--	--	--	--	--	--	--	--	--	--	--	--	7463	--	7463	--	--	--	--	--	--	--	--	--	--	7463
Texas	--	749	5429	--	--	6178	308	1825	--	--	--	--	3965	--	6098	282	--	--	282	3037	--	122	251	84	3494	16052
Mountain	--	120	--	691	--	811	--	--	--	2682	--	--	15508	--	18190	--	450	--	450	2638	--	--	--	--	2638	22089
Arizona	--	120	--	--	--	120	--	--	--	--	--	--	--	--	--	--	--	--	--	873	--	--	--	--	873	993
Colorado	--	--	--	259	--	259	--	--	--	--	--	--	4081	--	11081	--	172	--	172	1765	--	--	--	--	1765	6277
Idaho	--	--	--	432	--	432	--	--	--	1089	--	--	4081	--	5170	--	179	--	179	--	--	--	--	--	--	5781
Montana	--	--	--	--	--	--	--	--	--	1593	--	--	7346	--	9939	--	--	--	--	--	--	--	--	--	--	8939
Wyoming	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	99	--	99	--	--	--	--	--	--	99
Pacific	--	300	--	1136	--	1436	--	1606	3427	2073	--	--	7929	--	15035	238	751	--	989	2316	2652	--	191	418	5577	20037
California	--	300	--	871	--	1171	--	1606	2574	1558	--	--	--	--	5738	238	576	--	814	2316	2342	--	191	418	5267	12990
Oregon	--	--	--	--	--	--	--	--	853	--	--	--	--	--	853	--	--	--	--	--	--	--	--	--	--	853
Washington	--	--	--	265	--	265	--	--	--	515	--	--	7929	--	8444	--	175	--	175	--	310	--	--	--	310	9194
All other	25606	532	2334	679	47	29198	749	218	282	2650	2992	247	23673	18349	47166	39	463	27	529	4955	4510	1270	1460	1276	13471	92364
Total	94140	2440	13338	3044	2232	115194	2284	7279	3709	11711	13243	902	116608	83025	238779	1102	1906	3201	6295	18982	17217	3578	3986	3638	17401	407669

*Preliminary estimates provided in: N. Miller and G. Crooks, Availability and Cost of Agricultural and Municipal Residues for Use as Alcohol Feedstocks, prepared for Alcohol Policy Review Group by Stanford Research Institute, September 1978.

TABLE IV
RESIDUE PRODUCTION — 1975*
(Thousand Dry Tons)



SOURCE: Hydroelectric Power Resources of the United States
Federal Power Commmission, January 1, 1976

FIGURE 9
POTENTIAL HYDROELECTRIC RESOURCES AT EXISTING DAMS (BY CENSUS REGION)

extent, a demand for energy resources must exist. Solar technologies capable of transforming the solar resource into usable forms of energy must be technically viable and cost competitive with alternative forms of energy production. The potential market for solar technologies is summarized in Tables V through VIII for the residential, commercial, process heat, and utility sectors, respectively. In Table V it is assumed that all residential energy use is for hot water, space heating, cooling, or electricity. Eleven percent of the end-use energy for residences is used to provide hot water heating. On the basis of the primary energy required to satisfy residential energy requirements, only 10 percent of the primary energy is used for hot water heating. Table V also indicates the form of energy resource (coal, oil natural gas, electricity, LPG, other) used to supply the demand for energy. Fifty-eight percent of the end-use of electricity for hot water heating is supplied by natural gas.

The proportion of residential energy in each census region of the U.S. is also shown in Table V. The Mid-Atlantic region for example, uses 22 percent of the residential energy use in the U.S. Although the southern desert regions of the U.S. have relatively high insolation levels, the market potential for residential heating systems is limited since there are few homes in this area and the heating requirements for these homes are small.

TABLE V

POTENTIAL RESIDENTIAL MARKET FOR SOLAR ENERGY

APPLICATION	PERCENT OF DEMAND		PRESENT PERCENT OF FUEL CONSUMED						SUITABLE SOLAR TECHNOLOGY
	End-Use	Primary	COAL	OIL	N. GAS	ELEC	LPG	OTHER	
Hot Water	11	10	0	10	58	32	0	0	Active Thermal
Space Heating	36	34	0	32	58	10	0	0	Active & Passive Thermal
Space Cooling	38	34	0	0	10	90	0	0	Active Thermal Distributed Electric
Electricity	15	21	0	0	0	100	0	0	Small-scale Wind Photovoltacis

Regional Solar Energy Center	Northeast		Southern			Mid-American		Western Sun	
Census Region	New England	Mid-Atlantic	South Atlantic	East South	West South	East North Central	West North Central	Mountain	Pacific
Percent cf End-use Thermal Demand	3	22	20	7	15	15	6	4	8

TABLE VI

POTENTIAL COMMERCIAL MARKET FOR SOLAR ENERGY

APPLICATION	PERCENT OF DEMAND		PRESENT PERCENT OF FUEL CONSUMED						SUITABLE SOLAR TECHNOLOGY
			COAL	OIL	N. GAS	ELEC	LPG	OTHER	
	End-Use	Primary							
Hot Water	5	3	0	48	44	8	0	0	Active Thermal
Space Heating	22	14	0	48	47	5	0	0	Active & Passive Thermal
Space Cooling	17	11	0	0	13	87	0	0	Active Thermal Distributed Electric
Electricity	56	72	0	0	0	100	0	0	Small WECS Photovoltacis

Regional Solar Energy Center	Northeast		Southern			Mid-American		Western Sun	
Census Region	New England	Mid-Atlantic	South Atlantic	East South	West South	East North Central	West North Central	Mountain	Pacific
Percent of End-use Thermal Demand	3	22	20	7	15	15	6	4	9

TABLE VII
POTENTIAL INDUSTRIAL MARKET FOR SOLAR ENERGY

APPLICATION	PERCENT OF DEMAND	PRESENT PERCENT OF FUEL CONSUMED						SUITABLE SOLAR TECHNOLOGY
		COAL	OIL	N. GAS	ELEC	LPG	OTHER	
	End-Use							
Hot Water	.4	19.1	14.9	42.9	13.1	---	9.4	Flat Plate, Evacuated Tube
Direct Air 350°	1.1	1.8	18.3	69.6	9.7	---	.2	Line Concentrator, Flat Plate, Evacuated Tube
Direct Air 350°	20.9	39.3	10.5	26.8	2.3	.4	20.6	Line Concentrator, Parabolic Dish
Steam 350°	23.0	14.0	17.8	43.0	0.0	.5	24.0	Line Concentrator, Evacuated Tube, Parabolic Dish
Steam 350°	4.5	14.0	17.8	43.0	0.0	.5	24.0	Parabolic Dish
Electricity	11.1				100.0			Wind, Solar Total Energy System

Regional Solar Energy Center	Northeast		Southern			Mid-American		Western Sun	
Census Region	New England	Mid-Atlantic	South Atlantic	East South	West South	East North Central	West North Central	Mountain	Pacific
Percent of End-use Thermal Demand	2.3	13.9	10.4	8.2	26.9	23.6	4.2	2.4	8.4

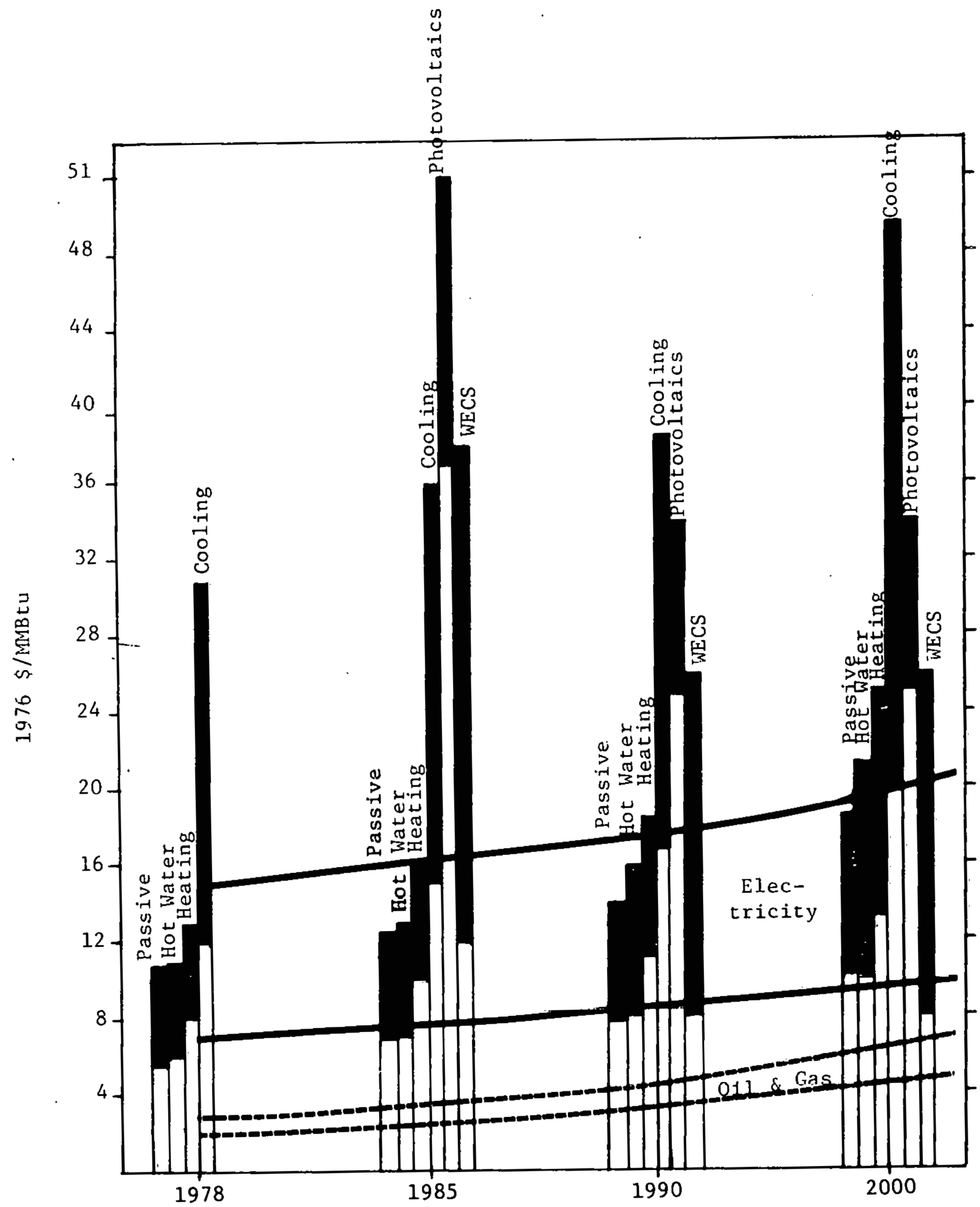
TABLE VIII
POTENTIAL ELECTRIC UTILITY MARKET FOR SOLAR ENERGY

APPLICATION	PERCENT OF SERVICE DEMAND	PRESENT PERCENT OF PRIMARY FUEL CONSUMED							SUITABLE SOLAR TECHNOLOGY
		COAL	OIL	N. GAS	ELEC	LPG	NUCLEAR	HYDRO	
Baseload	.65								WECS-Gas turbine backup WECS water saver OTEC Biomass Electric
Intermediate	.22	.46	.17	.14	--		.12	.11	WECS, Gas turbine backup Solar thermal electric and gas turbine Solar thermal electric and storage Biomass electric Photovoltaics
Semipeaking	.11								Photovoltaics Solar Thermal
Peaking	.02								None
Fuel Saver	.10*								WECS Photovoltaic Solar Thermal

Regional Solar Energy Centers	Northeast		Southern			Mid-American		Western Sun	
Census Region	New England	Mid-Atlantic	South Atlantic	East South Central	West South Central	East North Central	West North Central	Mountain	Pacific
Percent of Demand	4	15	18	10	11	18	7	5	12

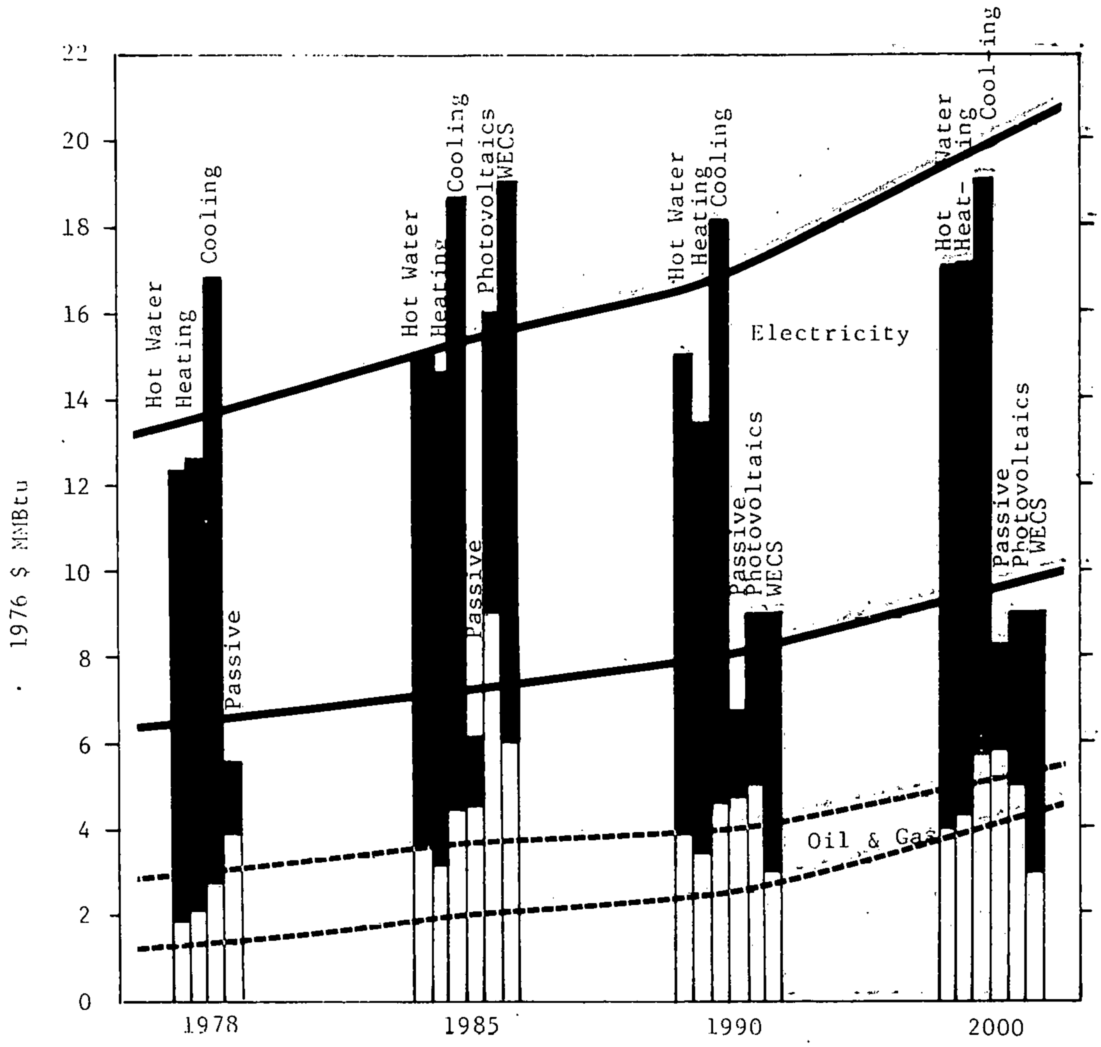
The competitive position of solar technologies relative to alternative conventional technologies is summarized in Figures 10 through 14 for the residential, commercial, process heat, utility, and synthetic fuels and chemicals sectors of the economy, respectively. A detailed description of the data, assumptions, and methodology supporting these results is provided in Toward A National Plan for the Commercialization of Solar Energy: Price/Demand Scenarios and Projections of Solar Utilization Under the National Energy Act, MTR-8057. The market penetration results which provide the basis for these figures are presented by census region in the market sector workbooks [G. Miller, 1979; M. Shulman and N. Kannan, 1979; and J. Taul, 1979].

In the near term, active and passive solar heating and hot water systems are competitive with electricity for residential and commercial applications. Process heat systems are competitive with electric and oil systems. In general, the cost competitiveness of solar technologies increases with time as mass production of solar systems reduces solar system costs and as the costs of competing fossil fuels increases. By 1990, wind energy conversion systems and solar thermal systems for utility applications are expected to be cost-competitive with coal generation technologies in several regions of the U.S.



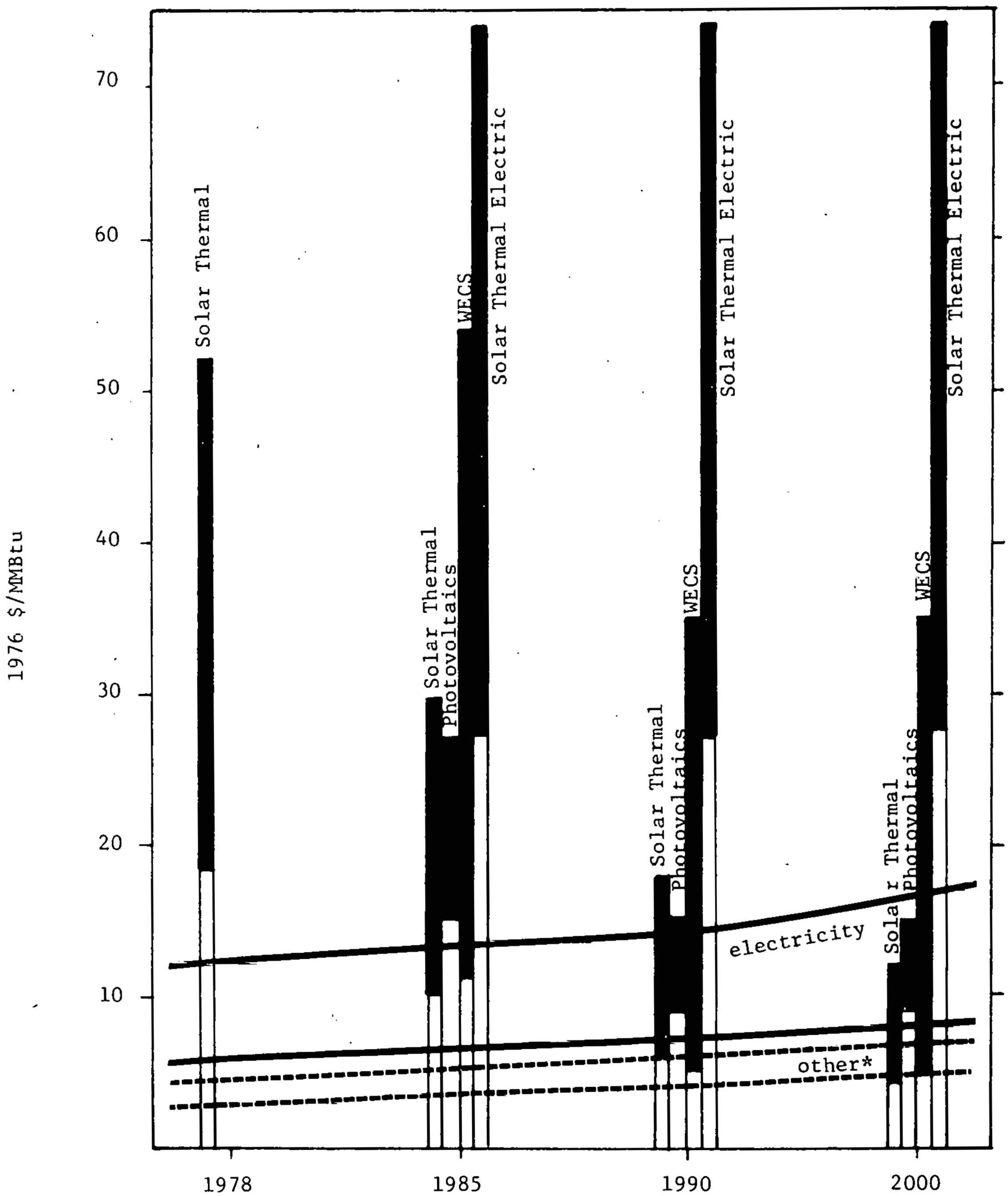
Note: Shaded areas represent regional ranges. Heating includes hot water. Cooling includes hot water and heating. Areas for oil and gas and electricity prices correspond to expected regional variations.

FIGURE 10
COST OF DELIVERED ENERGY IN THE RESIDENTIAL SECTOR



Note: Shaded areas represent regional ranges. Heating includes hot water. Cooling includes hot water and heating. Areas for oil and gas and electricity prices correspond to expected regional variations.

FIGURE 11
COST OF DELIVERED ENERGY IN THE COMMERCIAL SECTOR



*Average fuel cost for heat pump, oil, gas, coal and synthetic fuels.

Note: Shaded areas represent regional ranges.

FIGURE 12
COST OF DELIVERED ENERGY IN THE INDUSTRIAL SECTOR

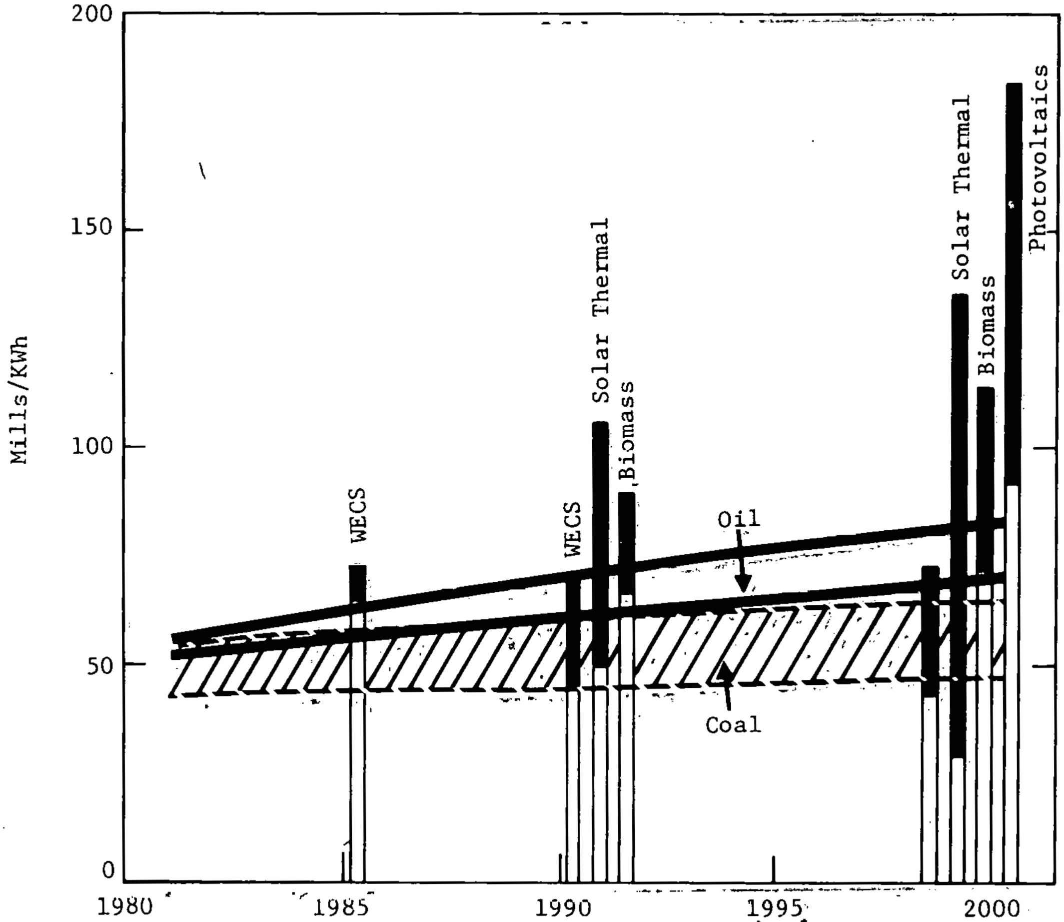
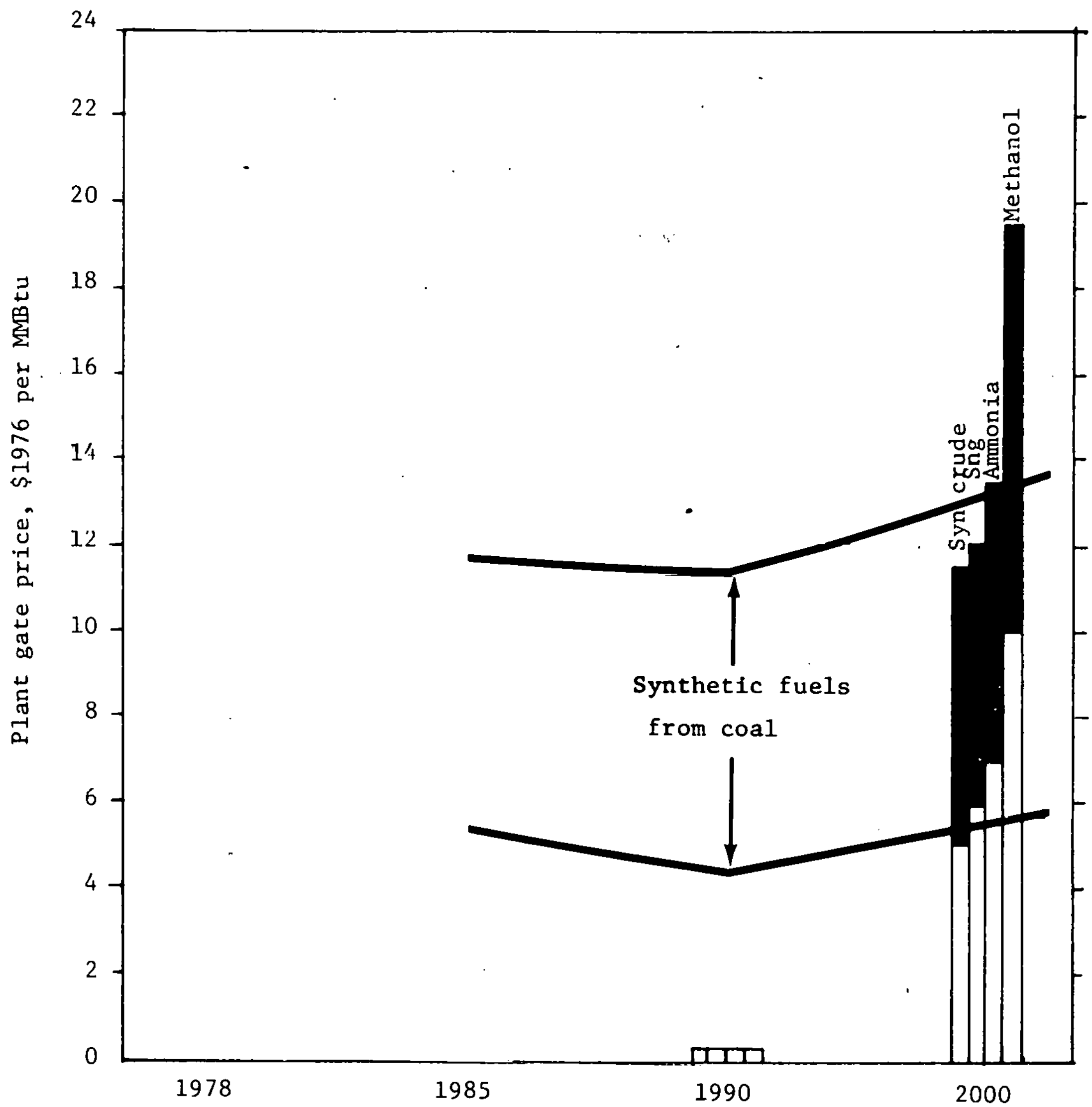


FIGURE 13
BUSBAR COST OF ELECTRICITY IN THE UTILITY SECTOR[1]

[1]Intermediate electric systems only. Range of costs represents regional variations in prices of fuels, variations by application type, and regional variation of system output.



Note: Shaded areas represent regional ranges.

FIGURE 14
COST OF DELIVERED ENERGY IN THE
SYNTHETIC FUELS AND CHEMICALS SECTOR

PHYSICAL/MARKET CHARACTERISTICS UNIQUE TO A REGION

Each region of the U.S. exhibits unique market characteristics or physical characteristics which may be favorable to the use of solar technologies. As previously discussed, biomass resources occur primarily in the South Atlantic and Pacific census regions of the U.S. The lumber, pulp and paper industries are the largest potential users of this resource for process heat and tend to be located near biomass resources. Thus, increased use of biomass for process heat appears to be a target of opportunity in these two regions. Other unique market characteristics involving the location of a solar resource with a significant industry capable of using that solar resource include:

- food processing industries in the WSUN and MASEC regions
- textiles in the SSEC region
- plastics and metal fabrication in the MASEC region

Some local areas of the U.S. exhibit high levels of air pollutants and are designated as nonattainment areas. They are generally associated with high concentrations of industry, motor vehicles, or utility generation facilities which produce the pollutants. The nonattainment areas for sulfur dioxide (SO_2) and total suspended particulates are shown in Figures 15 and 16, respectively. They include significant areas of the WSUN and MASEC regions. Solar technologies used to retrofit existing energy facilities in these areas could significantly reduce ambient levels of pollutants. New facilities using

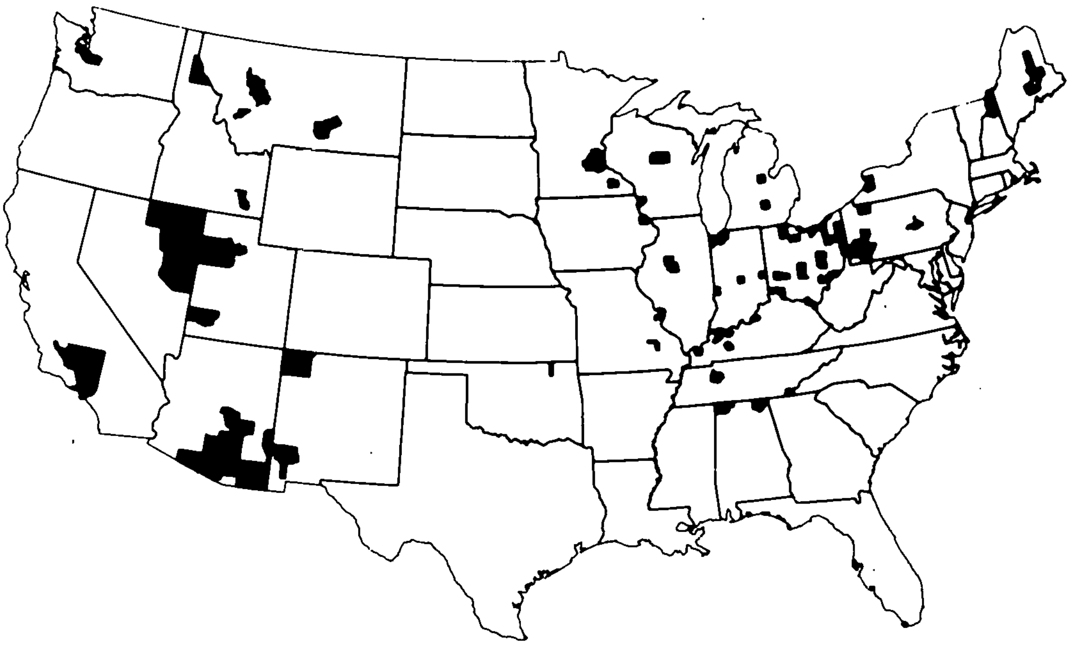


FIGURE 15
SULFUR DIOXIDE NONATTAINMENT COUNTIES[1]

[1]A nonattainment area is one which violates the national ambient air quality standards for a given pollutant. Shaded areas represent whole counties. In many cases, however, nonattainment areas constitute only a small portion of the county in which they are located.

Source: The MITRE Corporation, National Environmental Impact Projection No. 1, MTR-7905, December, 1978.

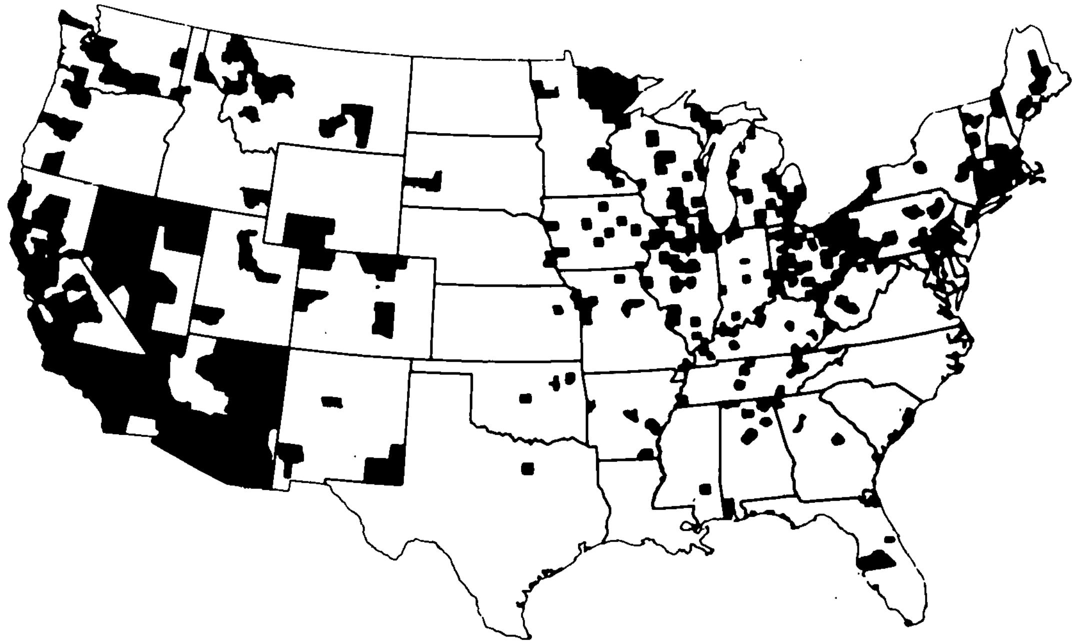


FIGURE 16
TOTAL SUSPENDED PARTICULATES NONATTAINMENT COUNTIES [1]

[1] A nonattainment area is one which violates the national ambient air quality standards for a given pollutant. Shaded areas represent whole counties. In many cases, however, nonattainment areas constitute only a small portion of the county in which they are located.

Source: The MITRE Corporation, National Environmental Impact Projection No. 1, MTR-7905, December, 1978.

solar technologies could help minimize new additions of pollutants toan already polluted environment.

Although solar technologies are considered to be environmentally benign, they use a diffuse energy source and generally require larger amounts of materials per unit of energy output than corresponding conventional generation technologies. The production processes required to manufacture these materials implies some form of pollution. In general, higher pollution levels are expected during the manufacture of solar collectors than for conventional generation technologies. However, lower pollution levels are expected during the operating life of the solar technologies. By the year 2000, the mix of solar technologies projected under the National Energy Act is expected to result in lower pollution levels for oxides of nitrogen (No_x), oxides of sulfur (So_x), and industrial sludges. Pollution levels of total suspended particulates (TSP) and total suspended solids (TSS) are expected to increase slightly. Biological oxygen demand (BOD) is expected to remain approximately constant. The regional trends projected for the year 2000 for various levels of solar production are shown in Table IX for the 10 federal regions indicated in Figure 17.

Table IX indicates that total levels of NO_x, BOD and TSS are expected to decline in the U.S. between 1975 and 2000. This is primarily a response to increasingly stringent environmental

TABLE IX

REGIONAL TRENDS FOR SELECTED POLLUTANT RESIDUALS (Millions of tons)

	RESIDUAL	REGION I	II	III	IV	V	VI	VII	VIII	IX	X	TOTAL
1975	TSP	0.23	0.53	2.56	3.04	3.99	1.27	0.89	0.60	0.65	0.38	14.2
	SO_x	0.51	1.23	4.27	6.05	10.64	1.71	1.96	0.81	2.04	0.39	29.6
	NO_x	0.70	1.32	2.37	3.41	4.37	2.93	1.06	0.69	1.82	0.50	19.2
	BOD	0.21	0.24	0.27	0.55	0.51	0.29	0.13	0.08	0.32	0.22	2.8
	TSS	0.26	0.30	0.64	1.06	1.10	1.50	0.16	0.18	0.40	0.30	5.9
	Industrial Sludges	0.26	0.39	1.12	1.43	2.00	0.94	0.21	0.39	0.64	0.33	7.7
9.4 Quads of Solar Energy 2000	TSP	0.26	0.38	1.08	2.50	2.01	1.72	0.60	0.54	0.67	0.45	10.2
	SO_x	0.56	0.98	3.08	6.57	7.72	2.78	1.79	0.86	1.23	0.73	26.3
	NO_x	0.63	1.17	2.53	4.97	5.15	3.89	1.45	1.13	1.88	0.70	23.5
	BOD	0.14	0.15	0.19	0.31	0.35	0.16	0.06	0.08	0.18	0.10	1.7
	TSS	0.13	0.15	0.22	0.35	0.40	0.17	0.10	0.11	0.18	0.08	1.9
	Industrial Sludges	0.95	2.12	12.64	34.21	27.13	17.20	7.42	2.39	2.68	1.45	108.2
16.8 Quads of Solar Energy 2000	TSP	0.31	0.40	1.12	2.61	2.12	1.73	0.62	0.60	0.69	0.51	10.7
	SO_x	0.57	0.80	2.86	6.27	7.25	2.48	1.78	0.80	1.15	0.72	24.7
	NO_x	0.60	1.02	2.40	4.77	4.71	3.43	1.41	1.05	1.95	0.76	22.1
	BOD	0.14	0.15	0.19	0.31	0.35	0.15	0.06	0.08	0.18	0.10	1.7
	TSS	0.14	0.15	0.22	0.39	0.45	0.19	0.16	0.13	0.18	0.09	2.1
	Industrial Sludges	0.94	2.90	11.54	32.41	22.18	12.42	7.63	2.25	3.32	1.70	97.3
27.5 Quads of Solar Energy 2000	TSP	0.36	0.43	1.17	2.74	2.27	1.79	0.64	0.64	0.69	0.57	11.3
	SO_x	0.37	0.76	2.70	5.91	7.00	2.39	1.62	0.73	1.05	0.66	23.2
	NO_x	0.59	1.07	2.28	4.57	4.64	3.38	1.25	1.00	1.83	0.79	21.4
	BOD	0.14	0.15	0.19	0.31	0.35	0.15	0.06	0.08	0.18	0.10	1.7
	TSS	0.15	0.16	0.24	0.50	0.59	0.26	0.33	0.19	0.19	0.13	2.7
	Industrial Sludges	2.52	2.62	9.95	31.85	25.25	11.33	5.22	2.15	3.03	1.96	95.9

Source: "Residential Trends Associated with Solar Energy Development," MITRE Draft WP, Andrew Lawrence, et al., January 5, 1979.

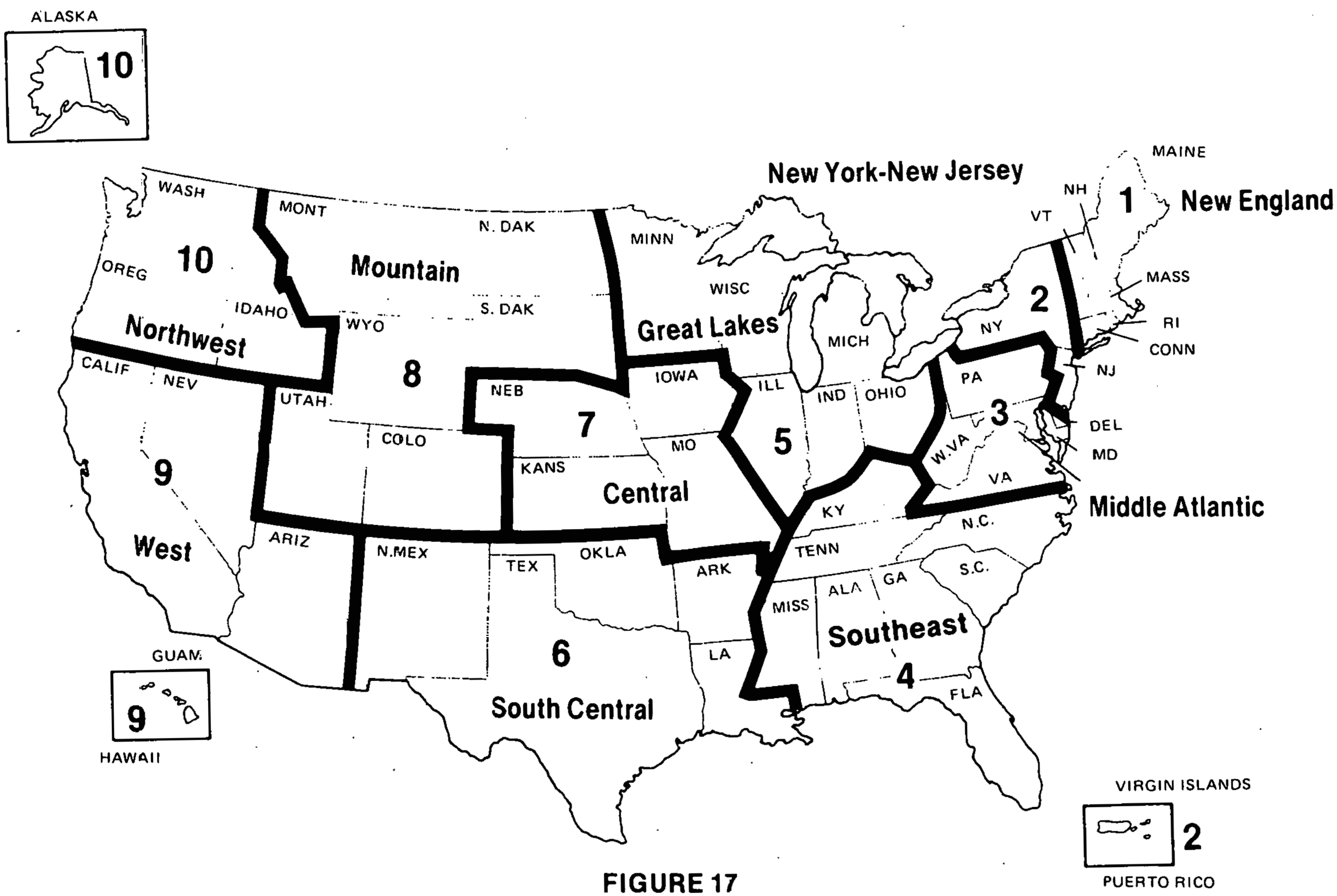


FIGURE 17
THE FEDERAL REGIONS[1]

[1]Names of regions added by The Mitre Corporation for identification purposes. They are not so designated by the federal government.

regulations which are expected to result in lower ambient pollution levels for individual industries. On the other hand, the higher economic activity (larger numbers of manufacturing facilities) is expected to result in increased levels overall of some pollutants--TSP, TSS, SO_x, and industrial sludges.

Increasing levels of solar energy production result in both increases and reductions of pollutants by the year 2000. Levels of TSP are increased when solar energy production increases from 9.4 quads to 27.5 quads. For federal region 4, the increase is from 2.50×10^6 tons/yr to 2.74×10^6 tons/yr. Levels of TSS are also increased in the year 2000 by higher levels of solar technologies.

Counterbalancing these increases in pollutants, the building of solar technologies is expected to result in lower pollutant concentrations of SO_x and NO_x and no appreciable difference in the pollutant concentration of BOD. For federal region 3 with an increase in solar energy production from 9.4 quads to 27.5 quads, the SO_x concentration declines from 3.08×10^6 tons/yr. to 2.70×10^6 tons/yr.

INSTITUTIONAL CHARACTERISTICS

Each region of the U.S. encompasses unique institutional programs or authorities which are expected to affect the commercialization of solar technologies. Within a region, state and local government organizations offer an available mechanism to address potential barriers to solar utilization. Often these authorities are directly concerned with the interest of local users, manufacturers, and installers of solar systems. For example, solar hot water, heating and cooling of buildings technologies must conform to local building codes. State legislative offices could write model building codes to expedite the acceptance of solar technologies. State or local energy extension services are usually aware of resources or problems inherent to their region of the country.

Many states and localities have established or proposed programs to address barriers to solar utilization. The potential economic barriers that might be ameliorated by state or local programs are identified in Table X for eleven groups of solar technologies [Page, 1978]. In addition to preferential tax treatment and rate structure policies, state information programs can clarify or expedite costs other than capital costs such as insurance, financing, feasibility studies, environmental studies, or resource assessment.

As noted before, while solar technologies are expected to be environmentally benign relative to conventional technologies, some environmental barriers to solar utilization will exist. These are shown in Table XI and those barriers that might be addressed by state or local programs are identified. Pollution risk, health, and aesthetic standards are particularly amenable to state and local programs or actions.

TABLE X

ECONOMIC BARRIERS TO ELEVEN GROUPS OF SOLAR TECHNOLOGIES

ECONOMIC BARRIERS	OTEC	Central Solar Elec.	Central Wind Elec.	Central Biomass	Dispersed Photovoltaic	Dispersed Wind	Dispersed Biomass	Solar IPH	Low-head hydro	Active Solar H&C	Passive Solar Design
	APPLICABLE TECHNOLOGIES										
*High initial cost	●	●	●	●	●	●	●	●	●	●	●
Low relative cost of alternatives	●	●	●	●	●	●	●	●	●	●	●
Uncertain future cost of alternatives	●	●	●	●	●	●	●	●	●	●	●
*Uncertain future cost of the biomass resource				●			●				
High cost of transmission	●	●	●	●					●		
High cost of storage		●	●		●	●		●		●	
*High cost of land		●	●	●				●	●		
*High cost of site-specific feasibility studies		●	●	●				●	●		
*High cost of site-specific environmental studies		●	●	●				●	●		
**Lack of firm and advantageous rate structure policies		●	●	●	●	●			●		
Cash flow problems in early years									●		
*Difficulty in obtaining financing		●	●	●	●	●	●	●	●	●	●
*Difficulty in obtaining insurance		●	●	●	●	●	●	●	●	●	●
**Lack of uniform and advantageous property tax treatment					●	●	●			●	●
Disruption of work schedules during retrofit							●	●		●	
High cost of purchase (biomass fuels)				●			●				
Lack of generous definition of techniques and materials that should qualify for tax exemptions											●

*State and/or local governments can be helpful in reducing these barriers.

**State and/or local government action can be instrumental in reducing these barriers.

TABLE XI

POSSIBLE ENVIRONMENTAL BARRIERS TO ELEVEN GROUPS OF SOLAR TECHNOLOGIES

POSSIBLE ENVIRONMENTAL BARRIERS	APPLICABLE TECHNOLOGIES: OTEC	Central Solar Elec.	Central Wind Elec.	Central Biomass	Dispersed Photovoltaic	Dispersed Wind	Dispersed Biomass	Solar IPH	Low-head Hydro	Active Solar H&C	Passive Solar Design
Effects on marine biota	●		●								
Effects on terrestrial biota		●	●						●		
Climatological impacts	●	●	●								
Explosion hazards	●										
**Fire hazards							●				
**Health risks (toxic materials)		●			●					●	
*Other safety hazards (falling blades, breaking dams)			●			●			●	●	
*Noise			●			●					
**Air emissions				●			●				
**Water pollution (residues)				●							
*Thermal pollution				●							
*Erosion		●						●			
Seismic effects									●		
**Landclearing		●		●							
**Harvesting impacts				●			●				
*Increased pesticide and fertilizer use				●							
Increased demand for water				●							
**Aesthetic intrusions		●	●			●				●	

*State and/or local governments can be helpful in reducing these barriers.

**State and/or local government action can be instrumental in reducing these barriers.

Institutional barriers to solar use are shown in Table XII. Such barriers as solar resource access protection, utility regulation, and permitting and licensing procedures are directly affected by state or local programs.

State agencies that could take action to expedite or promote solar use include, among others: state energy departments, multi-state regional commissions, consumer protection departments, departments of transportation, standards and codes department, Public Utility Commissions, energy extension services, and environmental protection departments. The potential programs or actions by these departments/agencies/authorities to address barriers to solar use are even more numerous. They include programs to promote technology development, market assessment, industrial development, legal and institutional barrier removal, and information and educational outreach.

FEDERAL INSTITUTIONAL RESOURCES

Several regions of the U.S. encompass federal institutional resources such as Tennessee Valley Authority, Bonneville Power Administration, Bureau of Land Management, or the Bureau of Indian Affairs. Often these institutions provide special opportunities to develop solar resources. The Bureau of Reclamation of the Department of the Interior has proposed, for example, to demonstrate an installation of forty-nine 2-MWe WECS units near Medicine Bow, Wyoming using existing hydroelectric capacity in the area to provide reliable backup electricity for the solar units.

TABLE XII

INSTITUTIONAL BARRIERS TO ELEVEN GROUPS OF SOLAR TECHNOLOGIES

INSTITUTIONAL BARRIERS	APPLICABLE TECHNOLOGIES: OTEC	Central Solar Elec.	Central Wind Elec.	Central Biomass	Dispersed Photovoltaic	Dispersed Wind	Dispersed Biomass	Solar IPH	Low-head hydro	Active Solar H&C	Passive Solar Design
**Lack of solar access protection		●			●			●		●	●
**Lack of wind access protection			●			●					
*Competition with other land/resource uses		●	●	●			●		●		
**Lengthy lead time for permits and houses		●	●	●				●	●		
*Additional lead time for land acquisition		●	●	●				●	●		
**Lack of site banking		●	●	●							
*Public resistance to utility ownership		●	●	●	●	●			●		
*Lack of utility cooperation		●	●	●	●	●			●		
**Lack of attention by public utility commissions		●	●	●	●	●			●		
**Possible PUC jurisdiction over cooperatives					●	●		●	●		
**Zoning and building code limitations and conflicts		●	●	●	●	●	●	●		●	●
**Aesthetic/architectural controls					●	●				●	●
Lack of marketing, installation and service personnel					●	●	●		●	●	●
Absence of industry-wide standards and performance criteria					●	●	●	●		●	●
Absence of product testing and certification					●	●	●	●		●	●
Lack of adequate consumer information							●			●	●
Lack of a stable biomass supply				●			●				
Unavailability of conforming fuels							●				
Local citizen opposition									●		
Labor problems								●		●	
TV Interference			●								
Lack of a field test or demonstration	●										
Unclear status of Law of the Sea	●										
Leasing requirements for offshore tracts	●										

*State and/or local governments can be helpful in reducing these barriers.

**State and/or local govenrment action can be instrumental in reducing these barriers.

Source: Abbie Page, "Accelerating the Commercialization of Solar Energy: The Role of State and Local Governments", MITRE WP-22054, McLean, Virginia: The MITRE Corporation, December, 1978

SECTION IV

THE REGIONAL PLANNING PROCESS

Estimates of solar market penetrations were produced using the MITRE System for Projecting the Utilization of Renewable Resources (SPURR) [Rebibo, 1979]. The information available from SPURR or any other market penetration data base and model can be used as a starting point in designing a regional solar commercialization plan. However, day to day deviations from the expected path are very important to commercialization planning and cannot be modeled. Situations specific to a region are only occasionally accounted for in more aggregated data bases and analyses. Planners are encouraged to revise and expand the aggregate view of the world using real world experience and specific knowledge of how local conditions affect the market potential for solar energy.

Given a characterization of solar technologies and the marketplace based upon initial estimates and firsthand knowledge when available, the planner is provided with structured information that can be used to identify potential leverage points to accelerate solar utilization (financial/nonfinancial incentives) and barriers (institutional, resource limitations, etc.) which will require action and the key decision makers to whom efforts should be addressed. Projections through time of technology availability and cost and rates of market response/industry growth provide a rationale for time phasing the activities.

An example of characterizing a solar market, identifying targets of opportunity, and identifying associated leverage points is provided in the following sections for residential hot water, heating and cooling in the Northeast Solar Energy Center (NESEC) region of the U.S. These data are useful for regional planners in developing strategies to address the identified leverage points and in formulating coordinated and comprehensive commercialization programs.

The data is intended to illustrate the types of data that can be developed for a market sector. The data is by no means comprehensive or complete but should be supplemented as needed by the regional planners and local advisory groups.

Programs that are initiated will require continuous monitoring, evaluation, and updating. In the development of implementation strategies, the planner should define specific objectives to be achieved so that, to the greatest extent possible, progress can be evaluated.

THE RESIDENTIAL HOT WATER HEATING MARKET IN THE NESEC REGION

Current Status of the Industry/Market

There are now approximately 11,000 residential solar systems in the NESEC region. Approximately 80 percent of these systems are domestic hot water systems. Several collector manufacturers and installation contractors are active in the region. Thirty-three contractors and 18 manufacturers took part in the New England Electric hot water experiment. Although some are no longer in business, it is reasonable to assume that these numbers represent minimum levels of manufacturing/installation activity. In 1978, there were approximately two million conventional hot water heaters sold in the NESEC region and there were approximately 2,000 solar hot water systems sold. Although solar hot water heater sales were better in this region than in some other regions, the market was somewhat depressed due to unfortunate experiences under the HUD hot water initiative and the New England hot water experiment. Some purchases may also have been delayed in anticipation of ultimate passage of the NEA tax credits. Following extrapolation of growth prior to 1978, annual sales should have doubled in 1978 relative to 1977. Manufacturers have claimed that this has not happened.

The net growth rate in single-family residences in the NESEC region is approximately .7 percent per year with a current stock of approximately 20 million single-family residences [U.S. Dept. of Commerce, 1976]. The residential market is characterized by a high proportion of oil use. At present, roughly 54 percent of the existing residences are heated with oil, 34 percent with gas, and 4 percent with electricity. By the year 2000, oil will still predominate with approximately 48 percent (gas 22 percent, electric 13 percent) (see Figure 18). Approximately 65 percent of the homes currently being built use oil for heat (16 percent gas; 19 percent electric). Although there is a large proportion of oil usage for

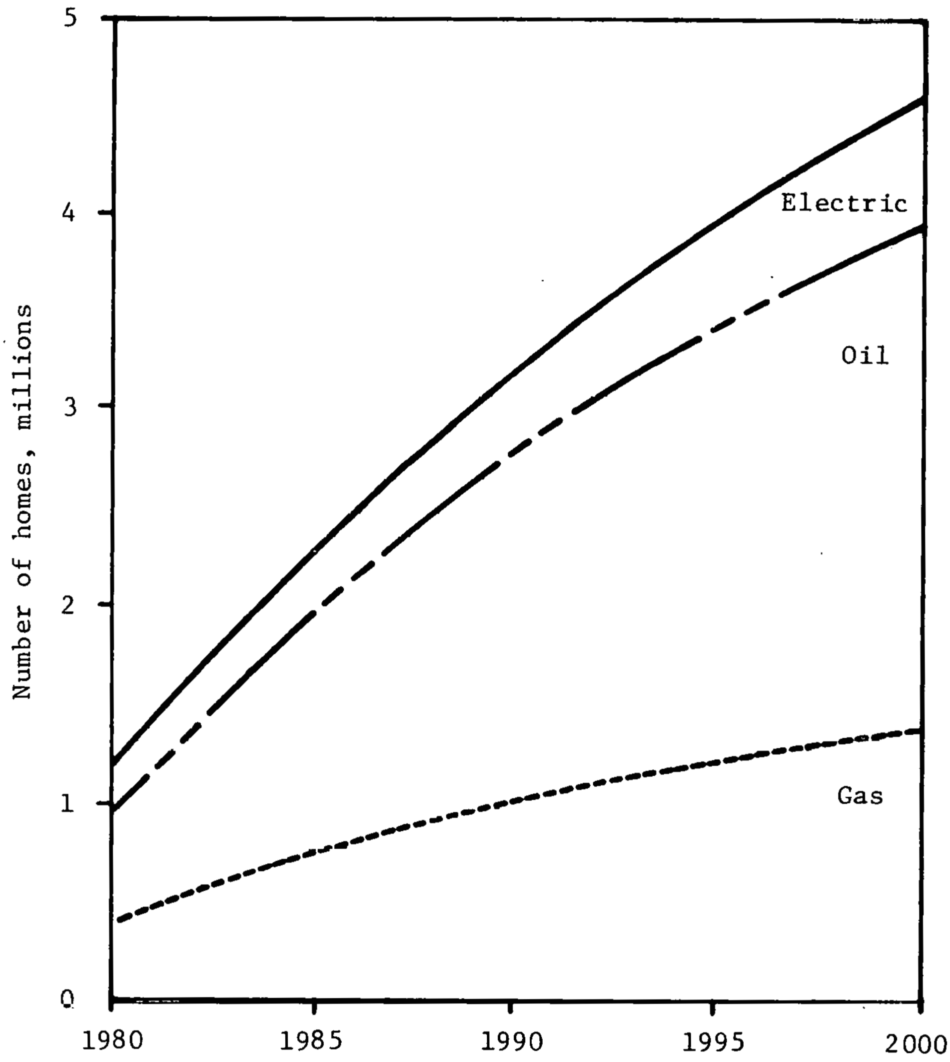


FIGURE 18
CUMULATIVE RESIDENTIAL SOLAR HOT WATER SYSTEMS MARKET POTENTIAL BY HOME HEATING FUEL, NESEC REGION, NEW AND RETROFIT MARKETS

heating and a relatively small proportion of electric heating, there is probably a large proportion of electric hot water heaters relative to gas hot water heaters. Typically, a residence will not have gas hot water unless it also has gas heating. Most oil-heated homes probably have electric hot water heaters against which solar hot water heaters are competitive.

Figure 19 presents the distribution of home values for the NESEC region as of 1974. The median value is approximately $32,100. The median value for the U.S. in 1974 was $22,000. The high median income for the region, approximately $14,000 compared to $8,900 for the entire U.S., indicates homeowners may better be able to afford solar systems. Figure 20 shows the value/income ratio for single family residences in the region. The median value of 2.3 suggests that on the whole, owners are not overextended in terms of mortage commitments assuming the widely held 2.5 rule of thumb for new mortgages. However, owners are not greatly undercapitalized either. Roughly 60 percent of the owners have some type of mortgage commitment.

Owner-occupied residences, which constitute approximately 40 percent of the residential market, are a more appropriate market for solar hot water in the near term than renters because renters rarely make capital improvement decisions of the order which we are discussing. In addition, owners of rental properties have much less impetus to invest in solar due to tax considerations and the fact that utility bills are usually passed directly through to the renter.

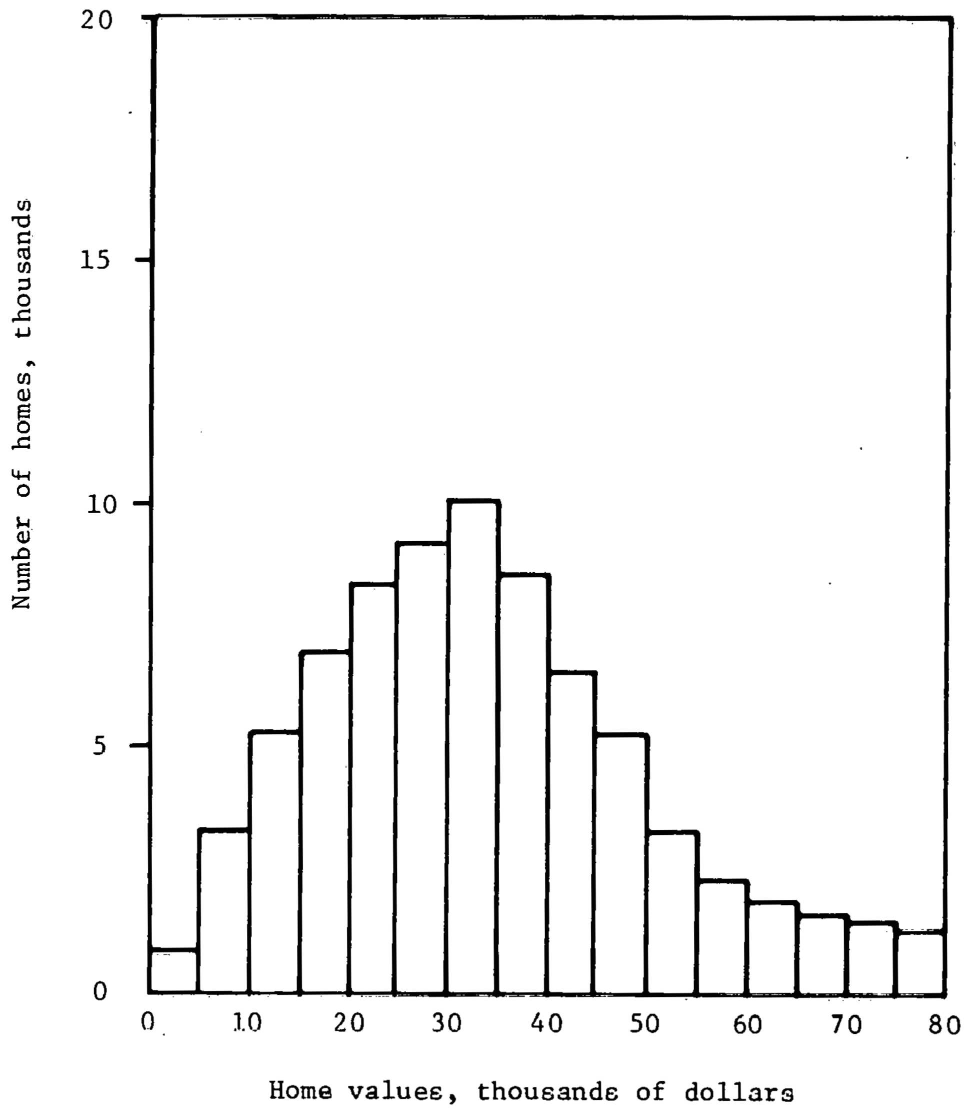


FIGURE 19
DISTRIBUTION OF RESIDENTIAL HOME VALUES,
NESEC REGION, 1974

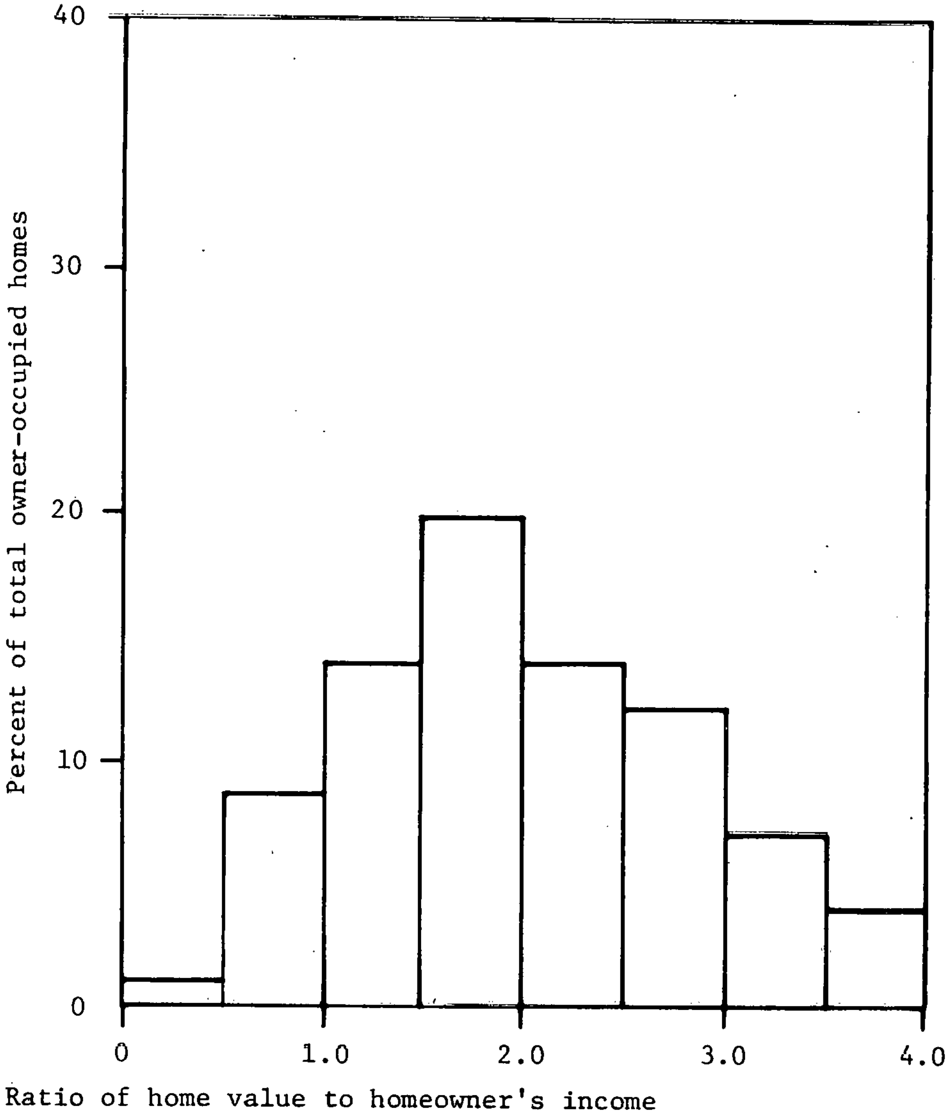


FIGURE 20
HOME VALUE/INCOME RATIO, NESEC REGION, 1974

In summary, the residential solar hot water and heating market in the NESEC region may be characterized as follows:

- A small manufacturing/distribution network currently exists. It has been adversely affected by the delay of pending incentives for the purchase of solar systems.
- Solar hot water can be economically competitive now in many cases and will become even more competitive in the future.
- There is a high proportion of oil used for home heating and a high proportion of electric hot water heaters
- The median home value is substantially higher than the rest of the country as is the median income. Owners are not significantly over- or undercapitalized.
- Over one half of the single family residences in the region are not owner-occupied.

Targets of Opportunity and Associated Leverage Points

Residential Buildings in the NESEC Region

Leverage points, i.e., people or associations capable of affecting the decision of potential users to purchase solar systems, have been identified for submarkets and targets of opportunity for the residential buildings market sector. These are outlined below along with the major reason the leverage points are considered to have an influence:

multipliers--people or organizations that have contact or influence a significant number of potential solar system purchasers

primary decision makers--generally the person who will be directly responsible for making the decision to buy or not buy a solar system

veto point--an organization or individual who could impose an insurmountable barrier to the installation of the solar system such as a building inspector or construction financier.

Owner-occupied Single-family Detached Homes. Forty-eight percent of all housing units are single-family detached; 88 percent of these units are owner-occupied.

a. New Homes

(1) Custom Homes--5 percent of the owners of new, single-family homes, high cost, can afford solar

- Multipliers, primary decision makers: contractors/architects
- Primary decision maker: owner
- Veto points: building inspectors; lenders/insurers

(2) New Speculative Homes--largest portion of new single-family detached home construction

- Multipliers/primary decision makers: developers/contractors
- Multipliers: realtors
- Veto points: building inspectors; lenders/insurers; construction financers

(3) New owner-built homes are a small portion of new, single-family, detached home construction

- Primary decision maker: owner
- Multiplier: nonarchitectural design sources
- Veto points: lenders; building inspectors

b. Existing Homes--Retrofit Applications

(1) Urban and Suburban Homes--68 percent of existing, owner-occupied, single-family, detached homes

- Multipliers: HVAC contractors; plumbers and plumbing contractors; realtors; hardware stores
- Primary decision maker: owner
- Veto point: lenders/insurers

(2) Rural Homes--32 percent of existing, owner-occupied, single-family detached homes

- Leverage points: all of those for urban and suburban retrofit

- o Other multipliers: LPG distributor; REA; Co-ops

(3) Farm Homes--only 2 percent of all single-family detached homes are on farms, 86 percent of these homes are owner-occupied, and only 5 percent of all owner-occupied, single-family, detached rural homes are on farms

- o Leverage points: all of those for urban and suburban/rural retrofit
- o Other multipliers: farm equipment sales; Agricultural Extension Service

Renter-occupied Single-family Detached Homes. Only 8 percent of all occupied single-family detached homes are renter-occupied. The absolute number of renter-occupied single-family detached homes is decreasing.

a. New Homes--a very small market; not considered

b. Existing Homes--retrofit applications

(1) Urban and Suburban Homes--55 percent of existing renter-occupied, single-family, detached homes

- o Primary decision maker; owner
- o Multipliers: HVAC contractor: plumbers and plumbing contractor; realtors; hardware stores
- o Veto point: lenders/insurers

(2) Rural Homes--45 percent of existing renter-occupied single-family detached homes

- o Leverage points: all of those for urban and suburban retrofit
- o Multipliers: LPG distribution; REA; Co-op

Large Multi-family Residences. Five or more units per structure. Twenty-two percent of all housing units are in large multi-family residences. Between 1970 and 1976 there was only a 6 percent increase in the number of units of this type. The percentage of housing units of this type is higher than in any other region, 40 percent higher than the U.S. average.

a. Renter-occupied--The number of renter-occupied housing units of this type decreased in absolute numbers between 1970 and 1976. Ninety-seven percent of the renter-occupied units of this building type are in urban or suburban areas.

   - Primary decision maker: owner
   - Multiplier; veto point: investor consortium
   - Multipliers: building managers/operators; rent control authority
   - Veto point: financiers/lenders

b. Owner-occupied, New and Existing--Between 1970 and 1976 there was a 17 percent increase in the number of owner-occupied units in structures of five or more units. Ninety-eight percent of the owner-occupied units of this building type are in urban or suburban areas. In 1976, 6 percent of all large multi-family residences were owner-occupied, up from 5 percent in 1970.

   - Primary decision maker: owner
   - Multiplier; veto point: investor consortium
   - Multipliers: building managers/operators; rent control authority
   - Veto point: financier

<u>Small Multi-family Residences</u>. Two to four units per structure. Between 1970 and 1976 there was only a 6.7 percent increase in the number of units of this type, while the U.S. average was 13 percent. The percentage of housing units of this type is higher than in any other region, 62 percent higher than the U.S. average.

a. Renter-occupied, primarily existing applications--The number of renter-occupied housing units of this type increased by only 4 percent between 1970 and 1976. Ninety-one percent of the renter-occupied units of this type are in urban or suburban areas

- o Primary decision maker: owner
- o Multipliers: investor consortium; building managers/operators; rent control authority
- o Veto point: financier

b. Owner-Occupied, New and Existing--The number of owner-occupied housing units of this type decreased by 2 percent between 1970 and 1976. Ninety-two percent of the owner-occupied housing units of this type are in urban or suburban areas.

- o Primary decision maker; multiplier: owners/co-op associations
- o Multipliers: contractors; building managers/operators
- o Primary decision makers: condo developers
- o Veto point: financers/lenders

Single-family Attached Residences. Seven percent of all housing units in the region are of this building type. Ninety-two percent of the units of this type are in urban or suburban locations.

a. Owner-occupied, Urban and Suburban--Seventy percent of the occupied units of this building type are owner-occupied. The number of owner-occupied, single-family, attached homes has increased by 17 percent between 1970 and 1976. Ninety-four percent of the owner-occupied units of this type were in urban and suburban locations in 1976, 97 percent in 1970.

- o Primary decision maker: owner
- o Multipliers; primary decision makers: developers/contractors; realtors; HVAC contractor; hardware stores
- o Veto points: building inspector; lenders/insurers; construction financiers

b. Owner-Occupied, Rural--This submarket represents only 0.3 percent of the total occupied housing stock in the region, yet it has increased by 159 percent from 1970 to 1976. It is a quickly developing market on relatively inexpensive land and may thus be suitable for solar.

- o Leverage points: all of those for owner-occupied, urban, single-family, attached homes
- o Multipliers: LPG distributions; REA; Co-ops

c. Renter-Occupied, Urban and Suburban--Thirty percent of the occupied units of this building type are owner-occupied. Ninety percent of the renter-occupied units of this type were in urban and suburban locations in 1976, 95 percent in 1970.

   o Leverage points: all of those for owner-occupied, urban, single-family, attached homes

d. Renter-Occupied, Rural--This submarket represents only a fraction of a percent of the total occupied housing stock in the region, yet it has increased by almost 250 percent between 1970 and 1976. It is a rapidly developing market and may be suitable for solar because of inexpensive land and flexible designs.

   o Leverage points: all of those for owner-occupied, rural, single-family, attached homes.

Mobile Homes and Trailers--Two percent of all housing units in the region are of this type. Eighty-five percent of these are owner-occupied. Eighty-five percent of all mobile-homes in the region are in rural areas.

a. New Mobile Homes

   o Multipliers; primary decision makers: mobile home manufacturers
   o Primary decision maker: owner
   o Multiplier; veto point: mobile home parks
   o Veto points: building inspector; lender/insurer

b. Existing Mobile Homes, Retrofit

   o Leverage points: all of those for new mobile homes
   o Multipliers: LPG distribution; REA; Co-op
   o Multiplier Resource Requirements: hardware store

RESOURCE REQUIREMENTS

The sales of significant numbers of solar systems will require adequate supplies of solar equipment, labor, and capital. These resources may be supplied from within the region or imported from other regions. This analysis assumed that the region will furnish its own resource requirements.

Estimates of equipment, labor, and capital requirements may be used to imply a rate of industry expansion to ensure that adequate resources are available to satisfy demand. If current capacities cannot be adequately expanded, programs to assure additional supplies or to accelerate capacity expansion will be required.

The amount of solar collectors required to support sales of solar hot water, heating and cooling systems as projected for the NESEC region by the MITRE/SPURR analysis is indicated in Figure 21. By the year 2000 over two million square feet of collector are projected to be installed in the region every year. At present, 95 percent of all collector manufacturers produce less than 100,000 square feet per year. It has been determined that a mass production flat plate collector facility will produce roughly one million square feet per year. An evacuated tube production facility may produce as much as 20 million square feet per year. Given adequate capital, current capacity could probably be expanded by at least a factor of 10 using mass production techniques. Annual sales in the region (in terms of square feet for residential heating and hot water) are expected to expand by a factor of 20 between now and 2000.

The development of a successful residential solar industry in the NESEC region will require a trained labor force of approximately

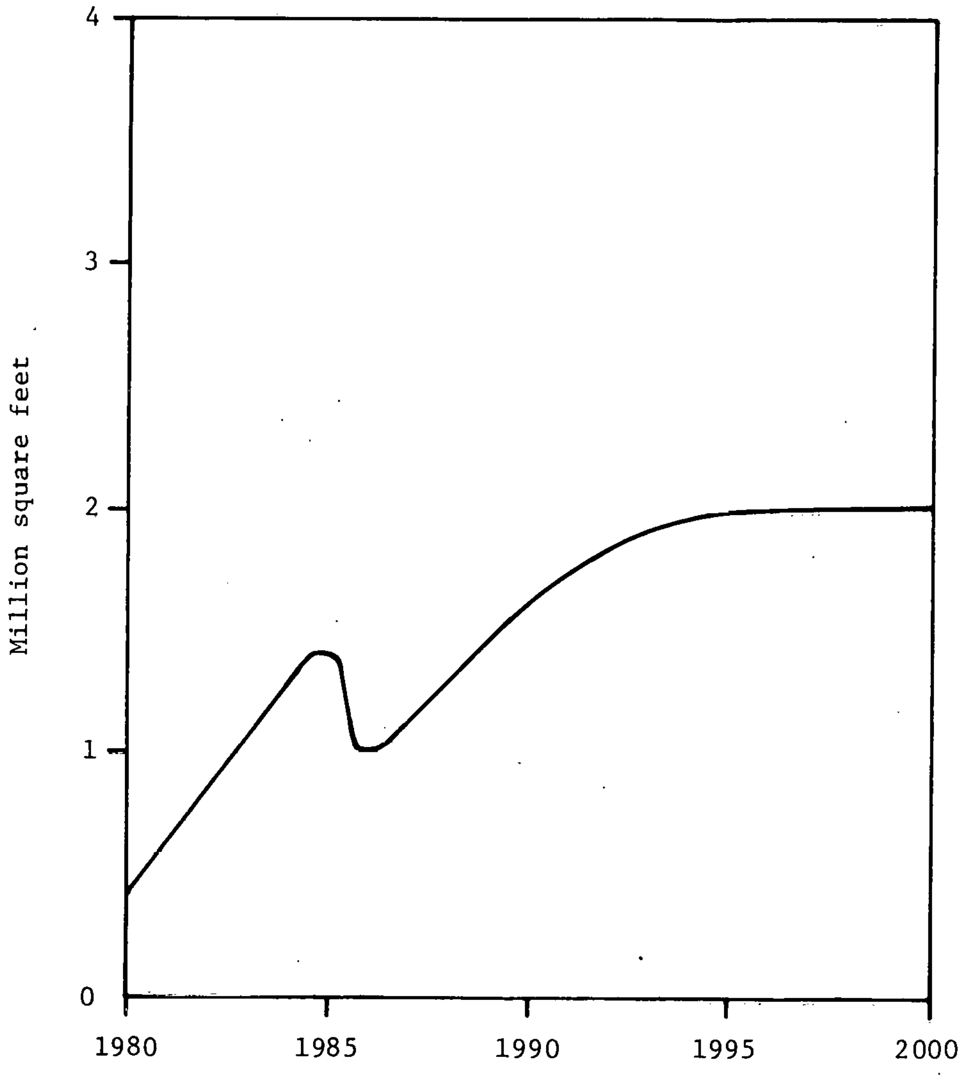


FIGURE 21
PROJECTED COLLECTOR SALES FOR RESIDENTIAL SOLAR HOT WATER SYSTEMS, NESEC REGION, NEW AND RETROFIT MARKETS

5000 persons by the year 2000 (see Figure 22). Assuming an average job turnover rate of five years, an average of 1000 persons will have to be trained each year for the next 20 years in some aspect of solar manufacture, design, and installation. This should pose no great problem in that there are currently over 100,000 plumbers, pipe fitters, sheetmetal workers, and HVAC systems technicians in the region. Since these trades are highly unionized, training programs can probably be effectively established through the unions. However, they should be initiated over the near term.

Private consumers in the NESEC region should not generally have trouble obtaining solar loans. However, banks will require a certain amount of capital available to lend to both consumers and the industry. Figure 23 presents the level of private expenditures that will be required. Figure 24 presents the amount of capital (plant investment, inventory, and installation overhead) that will be invested in the manufacture and distribution of solar heating and hot water heaters. Again, it should be pointed out that a large portion of the investment associated with manufacturing may be from outside the region.

These capital requirements are not extraordinary. But, the availability of this capital for consumption and production of solar systems will depend primarily on exogenous economic factors. Programs which provide consumers, lending institutions, or potential industry investors with technical/financial background information

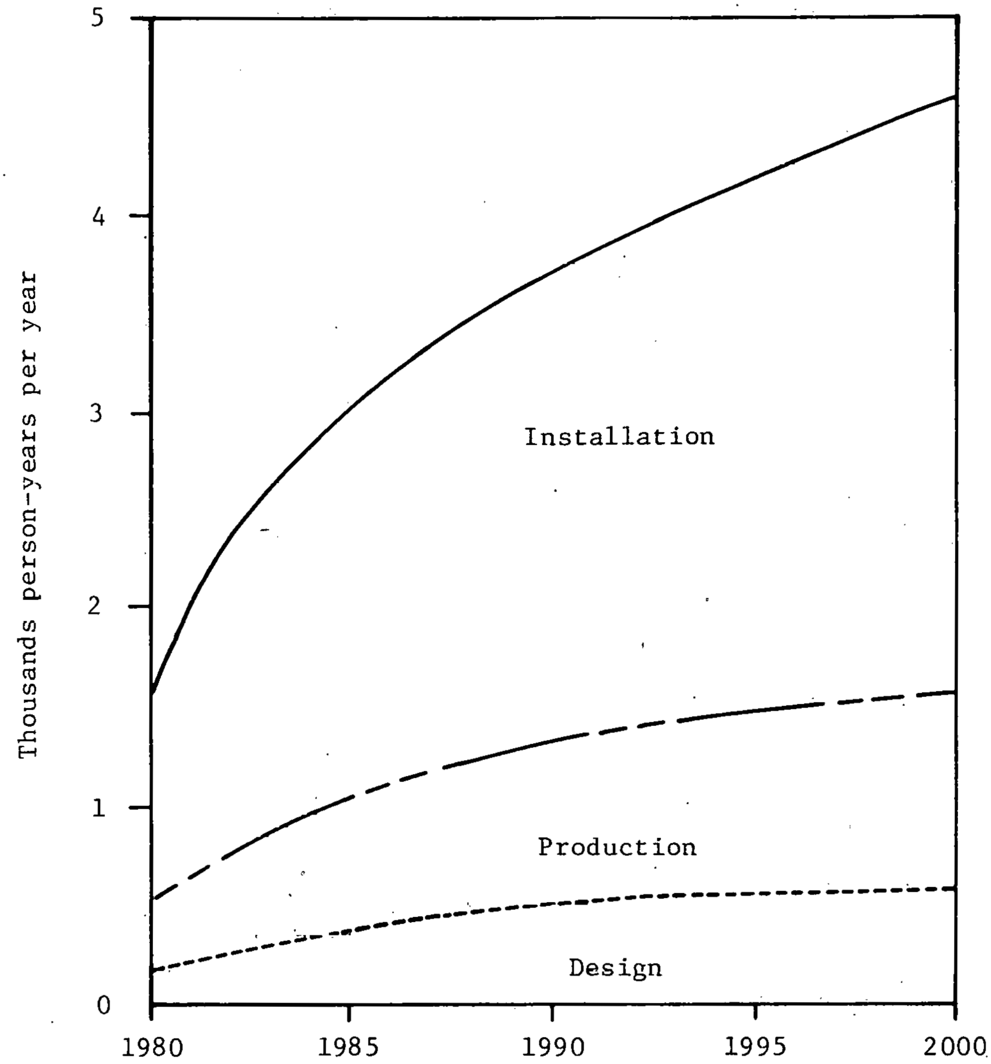


FIGURE 22
ANNUAL LABOR REQUIREMENTS FOR THE DESIGN PRODUCTION, AND INSTALLATION OF SOLAR HEATING, COOLING AND HOT WATER SYSTEMS, NESEC REGION, RESIDENTIAL AND COMMERCIAL, NEW AND RETROFIT MARKETS

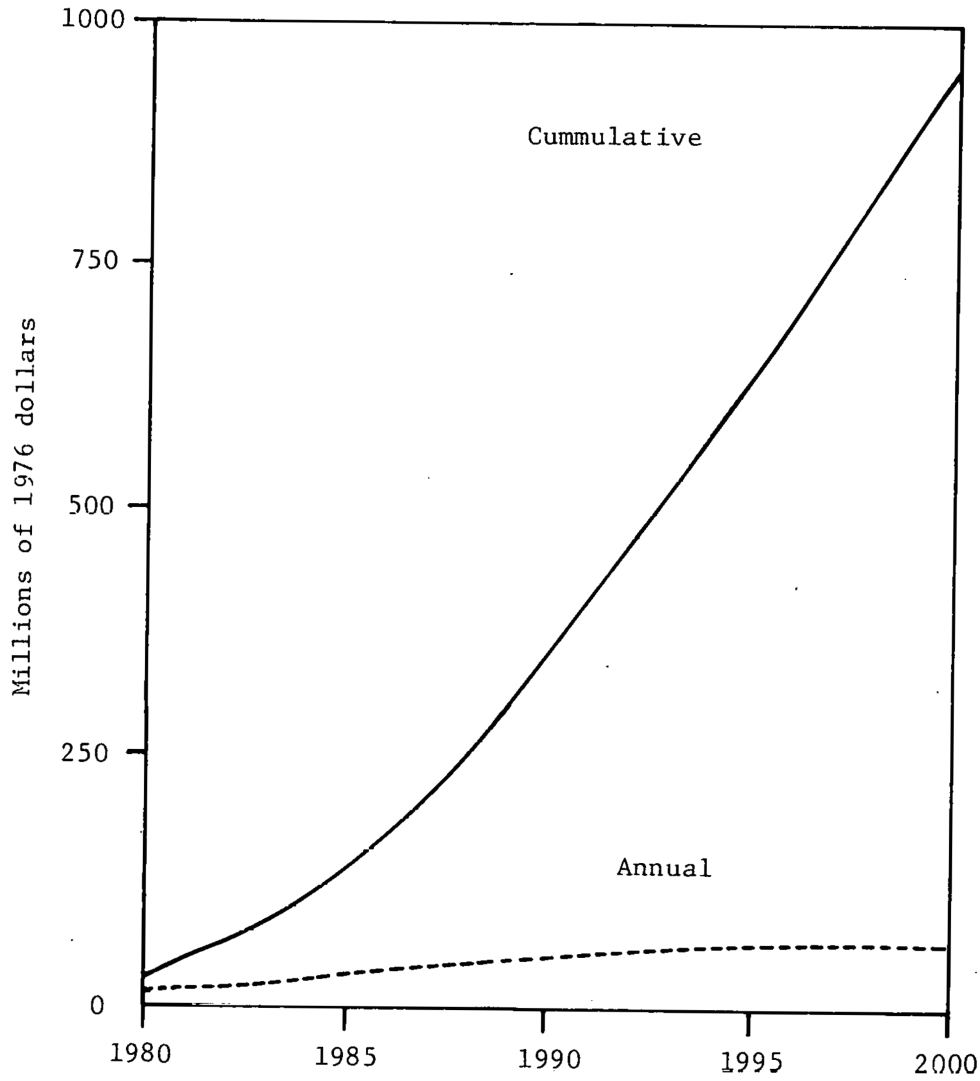


FIGURE 23
PROJECTED PRIVATE EXPENDITURES FOR RESIDENTIAL SOLAR HOT WATER SYSTEMS, NESEC REGION, NEW AND RETROFIT MARKETS

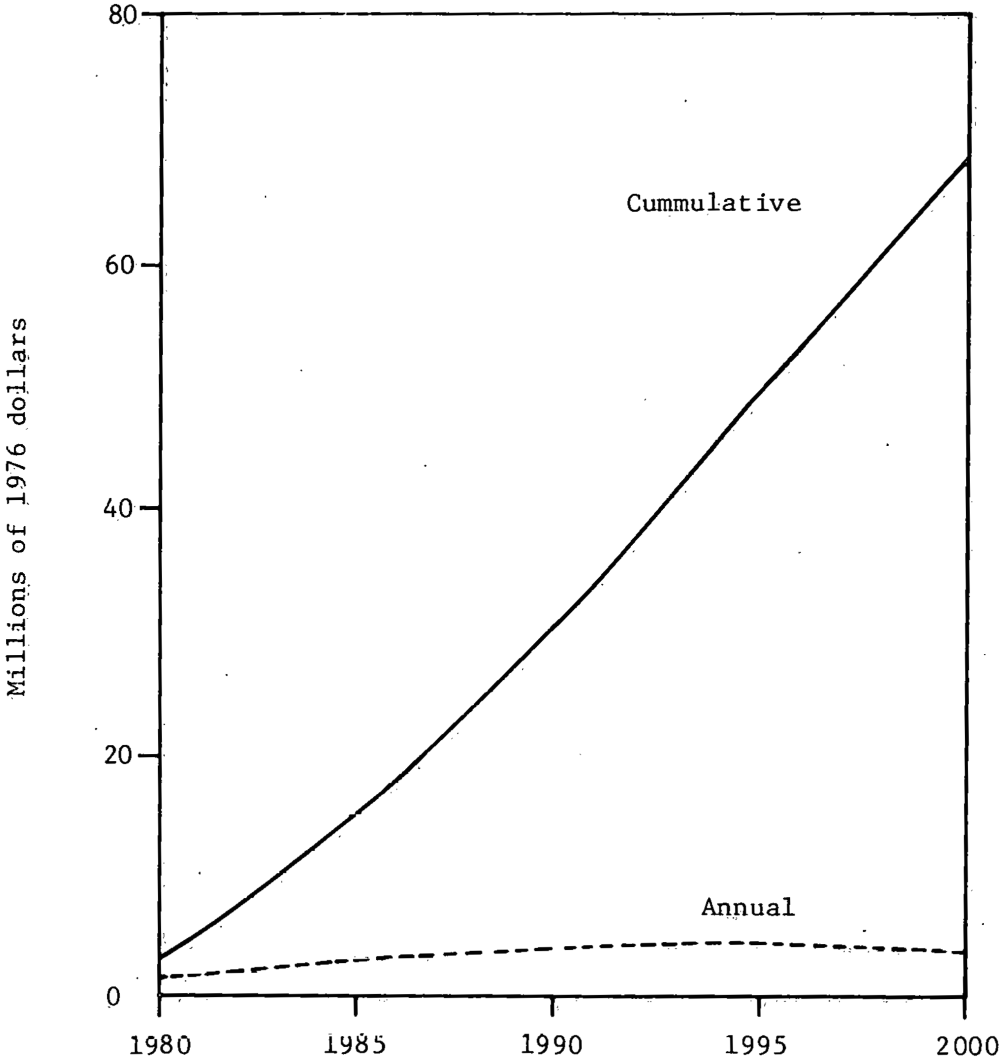


FIGURE 24
PROJECTED PLANT INVESTMENT FOR RESIDENTIAL SOLAR HOT WATER SYSTEMS, NESEC REGION, NEW AND RETROFIT MARKETS

could help assure that solar investments receive priority in the allocation of existing funds.

DEVELOPMENT OF REGIONAL ACTION PLANS

The four Regional Solar Energy Centers have been charged with developing regional action plans for the commercialization of solar technologies. The plans are being developed for each of three market sectors addressing:

- solar hot water, heating and cooling technologies for residential and commercial applications
- process heat applications of solar thermal and biomass resources
- utility and synthetic fuels and chemicals

Each market sector action plan summarizes available background information relating to the market sector by drawing upon materials and expertise developed by DOE, SERI, MITRE, regional consultants and in-house expertise. This information includes:

- market potential for solar technologies
- current and projected demands for energy
- current and projected fuel use and fuel costs by fuel type
- unique regional institutions
- current status of solar (number of installations)
- industry infrastructure (production capacity, distribution networks)

The primary objective of the regional action plans is to address market penetration goals for the region by solar technology type.

These goals are derived from the Presidential goal of 20 percent solar energy by the year 2000 and from DPR estimates of the potential for solar technologies. Target markets and qualitative market penetrations for the region are identified to assist in the development of recommendations for specific programs, program timing and program funding. These programs are intended to provide the necessary incentives to accelerate the commercialization of solar technologies to meet the regional goals. These recommended programs constitute the regional action plans.

The programs of regional activities are characterized by six generic categories of actions and plans including:

- baseline activities-activities which should be addressed for all solar technologies in the market sector
- industrial interface-activities designed to assist manufacturers to bring a solar product to the marketplace or to assist in development of an industry infrastructure
- legal and institutional-resolution of potential legal and regulatory constraints that might affect solar technologies
- market development-activities designed to accelerate acceptance of solar technologies in the marketplace including provision of financial incentives and advertising
- product definition-programs to define and/or develop solar technologies for specific applications within the region
- technology programs-programs to develop a technology capability including RD&D programs

Each region is expected to propose programs, activities and plans within each of these six areas for five market sectors--residential, commercial, process heat, utilities, and synthetic fuels and chemicals. These programs constitute regional action plans which are central to the development of the National Plan to Accelerate the Commercialization of Solar Energy.

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