A Summary of Three Regional Assessment Studies of Solar Electric Generation Opportunities in the Southwest, Southeast, and Northeast United States

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A SUMMARY OF THREE REGIONAL ASSESSMENT
STUDIES OF SOLAR ELECTRIC GENERATION
OPPORTUNITIES IN THE SOUTHWEST, SOUTHEAST,
AND NORTHEAST UNITED STATES

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SUMMARY

Market opportunities^(a) for solar generation of electricity for utility and for residential/commercial/industrial applications in the Northeast, Southeast, and Southwest regions of the United States were evaluated in three studies (JBF 1979, Stone & Webster 1979a, 1979b) and are summarized in this report. The evaluations were based on both economic analyses and user perception of what they would require to select or approve the use of solar electric generation for themselves or for their employers. Over 30 utilities and several industrial and commercial firms and homeowners were involved; input from homeowners was derived primarily in eight user workshops.

The studies projected that solar electric technologies could account for several percent of the forecast generation in year 2000 in the Southeast and Southwest regions, and up to 10 to 20 percent in the Northeast region. No single solar electric technology or application (for utility or industrial/commercial/residential use) arrived earlier at economic breakeven than other technologies in the Southeast region, but wind generation for both utility and industrial applications predominated in the Northeast region. The Southwest region, in which only utility applications were considered, showed wind energy and retrofit hybrid (a solar adjunct to an existing fossil-fueled plant) to be the most likely early applications.

Before this market penetration occurs, several important factors must take place.

- Through the year 2000 energy prices from conventional fuels must rise several percent per year faster than the rate of inflation.
- Department of Energy (DOE) cost and performance goals for solar electric technologies must be met on schedule.
- Enough solar electric technologies must be demonstrated successfully to overcome potential users' concerns.

(a) The term "market opportunities" is defined as those situations in which technically mature solar electric equipment will be preferred economically by prospective users compared to competing options for meeting their electrical (generating) needs.

- Incentives^(a) must be available to reduce risk and to overcome barriers that potential users perceive. To achieve a 5% market penetration of the Southwest region, financial incentive requirements were estimated at \$11 billion through the year 2000.

The three Regional Assessment Studies (RAS) were performed during a period of relatively stable fuel costs and in which petroleum fuel escalations averaged several percent per year above general inflation. The reports were completed just prior to the spectacular price increases of 1979-80 in which petroleum fuel costs doubled.

While such large increases (above general inflation) are unlikely to be an every-year occurrence, the actual increases experienced were significantly larger than those assumed in these studies. Coupled with the large fuel cost increases were significant government legislative and administrative actions that encouraged the development of renewable energy resources. Therefore, because the analyses made in the RAS do not reflect all the recent actions and economic factors, they may be conservative.

(a) In this report the term "incentives" is defined as any governmental action that is taken to encourage generation of solar electric energy.

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A SUMMARY OF THREE REGIONAL ASSESSMENT STUDIES
OF SOLAR ELECTRIC GENERATION OPPORTUNITIES
IN THE SOUTHWEST, SOUTHEAST, AND
NORTHEAST UNITED STATES

1.0 INTRODUCTION

This report summarizes and synthesizes the results of Regional Assessment Studies (RAS) completed for the Northeast, Southeast, and Southwest regions of the U.S. Using methods and assumptions selected by the study teams, each study estimated its region's market opportunities for solar electric generation to the year 2000.

The Northeast, Southeast, and Southwest studies were completed in early 1979. The Northeast study was performed by JBF Scientific Corporation, while Stone & Webster Engineering Corporation performed the Southeast and Southwest study.^(a) Each study involved electric utilities (referred to as central users or the central station case and listed in Table 1) in the respective regions. The Northeast and Southeast studies also involved residential owners and commercial/industrial firms (referred to as dispersed users or the dispersed user case) and included representatives of government, industry, financial institutions, taxation groups, consumer groups, environmentalists, and manufacturers. Dispersed users were primarily involved through workshops, listed in Table 2.

As shown in Table 3, the solar electric technologies considered included biomass, hybrid retrofit, ocean thermal energy conversion (OTEC), photovoltaic, solar thermal, and wind.

Utility systems were modeled using codes employed by utilities, or ones similar to them, in which solar electric options were substituted for more

(a) The remaining regions are being studied in contracts awarded by the Solar Energy Research Institute and include the following: North Central Region - Gilbert/Commonwealth Associates; South Central Region - Science Applications, Inc; and Northwest Region - JBF Scientific Corporation.

TABLE 1. Electric Utilities Involved in Central Case Studies

<u>Northeast</u>	<u>Southeast</u>	<u>Southwest</u>
Boston Edison Company	Baltimore Gas and Electric Company	Arizona Power Authority
Central Maine Power	Duke Power Company	Arizona Public Service Company
New England Gas and Electric Association	Florida Power Corporation	El Paso Electric Company
New England Power Pool	Florida Power and Light Company	Nevada Power Company
New England Power Service Company	Jacksonville Electric Authority	Portland General Electric Company
Niagara Mohawk Power Corporation	Puerto Rico Water Resources Authority	Public Service Company of Colorado
Northeast Utilities	Savannah Electric and Power Company	Salt River Project
Public Service Electric and Gas Company	Southern Company Services	San Diego Gas and Electric Company
	Tampa Electric Company	Sierra Pacific Power Company
	Tennessee Valley Authority	Southern California Edison
		Southwestern Public Service Company
		Utah Power and Light Company

TABLE 2. Dispersed Case User Workshops

<u>Northeast</u>	<u>Southeast</u>
Four Community Task Force Workshops Burlington, Vermont	Residential User Workshop, Orlando, Florida
New England Center for Energy Policy Workshop, Cambridge, Massachusetts	Residential User Workshop, Alexandria, Virginia
	Nonresidential User Workshop, Atlanta, Georgia

conventional generating options. The changes in system generating costs were calculated for a range of assumptions previously reviewed with participating utilities. Drawing upon utility practices, the amount of solar electric generation that could be incorporated in utility systems versus time was then estimated.^(a)

(a) The estimates included judgment considerations on several factors such as availability of incentives to defray cost penalties, engineering readiness of the solar electric option, and the need for demonstration plants.

TABLE 3. Solar Electric Technologies Evaluated in RAS

<u>Technology</u>	<u>Northeast</u>		<u>Southeast</u>		<u>Southwest</u>
	<u>Central</u>	<u>Dispersed</u>	<u>Central</u>	<u>Dispersed</u>	<u>Central</u>
Biomass	•		•		
Hybrid Retrofit					•
OTEC	•		•		
Photovoltaic	•	•	•	•	•
Solar Thermal	•	•	•	•	•
Wind	•	•	•	•	•

For the dispersed case, typical solar electric options, including cost data, were described to prospective users. Users were asked to decide when and under what conditions solar electric options would be of interest to them. Based on their responses, estimates were made of a) likely installed capacity for the dispersed user case, and b) the amount of subsidy required.

The remainder of this summary report describes the regions' electrical needs and solar resources, the availability and cost of solar generating options, locations and times when commercial solar electric systems will be available, regional market opportunities, and proposed strategies derived from synthesis of the regional studies. Note that the Northeast and Southeast studies used a 1978 data base, while the Southwest used a 1977 data base.

2.0 REGIONAL ELECTRICAL ENERGY NEEDS AND SOLAR RESOURCES

None of the regions studied have firm plans for solar electric generation, and present plans through the year 2000 depend on traditional resources. The ten-year National Electric Reliability Council forecasts no use of solar electric generation and estimates to the year 2000 are uncertain about its role. Fuel resource projections for electrical generation are listed in Table 4. Regional forecasts indicate that annual electrical demand is expected to grow 3.1% per year in the Northeast, 2.6% in the Southeast, and 5% in the Southwest. Population increases projected are 1/2% per year for the Northeast region and about 1-1/2% per year for the Southeast and Southwest regions.

All three regions look to nuclear for substantial generation of electrical power. The Southeast and Southwest regions plan to use more coal to reduce their dependence (percentage-wise) on gas and oil. However, both the Northeast and Southwest regions plan to increase their present consumption of gas and oil. The Northeast, without significant energy resources, is most heavily dependent on energy imports.

TABLE 4. Fuel Resources Projected for Electric Generation

<u>Central Generation</u>	<u>Northeast</u>		<u>Southeast</u>		<u>Southwest</u>	
	<u>Present (1978)</u>	<u>2000(a)</u>	<u>Present (1978)</u>	<u>2000(b)</u>	<u>Present (1977)</u>	<u>2000(c)</u>
Gas and Oil	51%	39%	26%	14%	67%	35%
Coal	11	11	50	42	20	32
Nuclear	24	39	13	40	3	27
Hydro, Geothermal and Energy Storage	14	11	10	4	1	6

(a) Based on JBF Scientific Corporation projections.

(b) Based on Electric Power Research Institute projections.

(c) Based on utility projections.

In the Northeast, wind is a very significant resource with many excellent sites potentially available with 500 watts/m^2 yearly average at 50 meter heights. Biomass in the form of wood products could supply up to about 4% of the region's fuel for electrical generation to the year 2000. The insolation resource is modest, averaging 3 to 4 $\text{kWh/m}^2/\text{day}$ and no OTEC resource is available.

In the Southeast, growing conditions are excellent for producing biomass. An ultimate biomass potential is estimated at 70 to 140 GWe, although that amount would require up to 40% of the land area. Using 1% of the land area, solar thermal could provide 250 GWe. The insolation resources are somewhat better than the Northeast, averaging 4 to 5 $\text{kWh/m}^2/\text{day}$. However, because the sunshine tends to be scattered by haze or clouds, concentrating devices are less effective in the Southeast than in other regions. Ocean temperature differences exceed 20°C on a yearly average in large areas of the Gulf of Mexico and offshore Puerto Rico, making OTEC a real possibility for the Southeast, with an estimated 200 to 600 GWe. The wind resources are not well characterized, but appear to be modest, perhaps as high as 300 to 400 watts/m^2 in selected areas and located away from load centers.

In the Southwest, the insolation resource is excellent. Numerous sites average $6 \text{ kWh/m}^2/\text{day}$ and could increase to $7.5 \text{ kWh/m}^2/\text{day}$ with clear air and concentrating devices tracking the sun. Some wind sites are believed to be as good as wind sites in other regions, but these are not well characterized and some appear to be remote from load centers. The region does not have sufficient water to support adequate land-based biomass production, and the ocean temperature difference is not enough to seriously consider OTEC.

The regional attitude that appears to characterize the potential users involved in the RAS studies can be summarized as follows:

- The Northeast appears to be more aware that it has a serious electrical energy problem and the temperament of the region is to act to solve it. Increasing electricity costs, coupled with a continued dependency on oil and gas, are motivating factors.

- The Southeast does not appear to perceive the same crisis in electrical energy that the Northeast does. The closer proximity to indigenous fuel resources, the lower electricity costs, and a warmer climate may be contributing factors to the difference.
- The Southwest appears highly aware that the solar potential can contribute to their energy requirements, but the region is not of a common mind concerning its energy supply. The region appears to be highly attracted to the solar option and is supporting it in legislation and through utility initiatives.

In summary, the three regions studied project significant growth in electrical generation to the year 2000; all have excellent solar resources for one or more technologies, yet none of the utilities are including significant quantities of solar electric generation in their projections.

3.0 FUTURE COSTS AND AVAILABILITY OF SOLAR ELECTRIC GENERATION

The three RAS provided an excellent opportunity to understand how prospective users view availability, cost, and institutional barriers of solar electric technology.

Utilities perceive the availability of solar electric generating options as beyond their usual planning horizon. Until generating options are proven to be ready for commercialization, they will not be considered in utilities' expansion plans. Twenty-five years ago a similar situation existed for nuclear power--the technicians and vendors considered it commercially viable at least 5 to 10 years before the users (utilities) did. Figure 1 (from the Southeast study) shows the dates solar electric options might be available for commercial operation, assuming that utilities will build plants soon after a full-sized demonstration plant begins operation. When utilities perceive that risk is great, several years of operation or additional demonstration plants may be required. It is apparent that a significant time elapses (typically 4 to 6 years) between successful operation of demonstration plants and operation of first generation utility plants.

This time elapse involves a) operation of a full-sized demonstration plant for at least one year to give utilities confidence to order similar units, and b) data collection, licensing, construction, and startup, which are estimated to consume four to six years or more if site selection has not been previously completed. Few additional orders are placed until a utility's first-of-a-kind electric plant comes on line and operational experience is gained. Because of these factors, not much utility solar electric capacity can be expected by the year 2000. Further, without successful operating experience from full-sized demonstration plants, utilities are not likely to include significant solar electric in their planning forecasts.

Dispersed users have little or no concept of future availability of solar electric options for their applications. Figure 2 (also from the Southeast study) represents the earliest probable technical maturity dates for onsite solar electric facilities.

- ▲ DENOTES FIRST OPERATION OF A FULL-SCALE DEMONSTRATION PLANT BASED ON DOE PROGRAM PLANS
 - DENOTES EARLIEST OPERATION OF FIRST GENERATION OF UTILITY ORDERS
- LEAD TIME INCLUDES 3 YEARS FOR DATA COLLECTION AND LICENSING, BUT EXCLUDES SITE SELECTION EFFORT

FIGURE 1. Utilities' Views of Earliest Probable Technical Maturity of Representative Solar Electric Central Stations from Southeast Study

FIGURE 2. Earliest Likely Technical Maturity of Representative Onsite Solar Electric Facilities

After onsite (i.e., dispersed) solar electric generating facilities are demonstrated, shorter lead times (compared to utility applications) are required to install additional units. Considerable additional time may be required, however, to develop an adequate infrastructure to support a dispersed market.

The technical maturity dates presented in Figures 1 and 2 assume that DOE cost goals for solar electric are met as presently forecast. Table 5 shows the estimated solar electric plant costs when balance-of-plant costs for the entire system are added to the DOE cost goals. The differences among regions reflect many regional factors, including different solar resource and balance-of-plant cost assumptions.

Some utility representatives expressed skepticism about achieving these estimated costs. Dispersed users expressed no uniform understanding of whether estimated costs for systems of interest to them were too high or too low.

TABLE 5. Solar Electric Total Plant Cost Estimates
(Circa 2000 Expressed in 1977 or 1978 Dollars)
(\$/kWe Installed Capacity)

<u>Technology</u>	<u>Region</u>		
	<u>Northeast</u> <u>(1978)</u>	<u>Southeast</u> <u>(1978)</u>	<u>Southwest</u> <u>(1977)</u>
<u>Central Station</u>			
Wind	\$500-700	\$800-1100	\$920-1230
Solar Thermal (Central Receiver Type)	1500-1800	2200-2700	1470-2200
Photovoltaic	900-1100	1300-1700	1300-1700
Retrofit Hybrid	--	--	1040-1740
OTEC	--	1500-2600	--
Biomass	1300	1100-1300	--
<u>Dispersed Applications</u>			
Photovoltaics	\$600-1000	\$500-1000	Not Studied
Wind	1000-1250	700-1000	Not Studied
Solar Thermal		6800-9100	Not Studied

4.0 WHEN AND WHERE SOLAR ELECTRIC GENERATION IS A GOOD INVESTMENT

Using the costs and time schedules from the preceding section, the various solar electric options were used in utility planning models to calculate their value to utilities. For dispersed users, the payback periods were calculated. Value and payback are not the only criteria users may apply to solar electric generation, but users are unlikely to buy if system costs cannot be recovered over a reasonable period. Results of these calculations are presented in the following sections.

NORTHEAST REGION

Biomass and wind are the best options for Northeast utilities. Assuming fuel escalation of 3% per year above inflation, biomass will have a positive net value to utilities as early as 1980, while a positive value for good wind sites will occur as early as 1991, as shown in Figure 3.

For the dispersed user, wind machines for large-scale industrial-commercial installations installed during or after 1980 achieve breakeven^(a) almost immediately on a life cycle basis;^(b) for medium-scale commercial--industrial break-even is achieved in 1982; and for residences break-even occurs in 1987. Photovoltaics achieve break-even if installed in 1987 for residences and medium-scale commercial-industrial applications, and break-even occurs in the late 1990s for large-scale commercial-industrial applications. Other solar electric options considered do not achieve life-cycle break-even for utilities or dispersed users before the year 2000.

If fuel escalates at the same rate as general inflation, then the dates for payback cited above will be delayed for five to ten years. An important factor that surfaced in dispersed user workshops was that most dispersed users will not purchase when the payback period is equal to the equipment lifetime, but rather, require a 3- to 5-year break-even period.

(a) Break-even is the point at which the savings in purchased electricity are equal to the investment (including capital and operating costs) for the facility.

(b) Life cycle is estimated at 15 to 30 years.

ASSUMPTIONS:

- 1978 ENERGY ACT EXTENDED
- ELECTRIC RATE ESCALATES 3% PER YEAR ABOVE 6% PER YEAR INFLATION; UTILITY FUEL PRICES ESCALATE AT 3% PER YEAR ABOVE 6% PER YEAR INFLATION
- UTILITY SELLBACK OF EXCESS ENERGY AT 1¢/kWh MINIMUM
- DOE HARDWARE COST GOALS ARE MET
- COMMERCIAL HARDWARE IS AVAILABLE
- BIOMASS SUPPLY PROBLEMS ARE SOLVED

FIGURE 3. Period in Which Solar Electric Payback is Achieved Over the Equipment Lifetime

SOUTHEAST REGION

For utilities, no central station solar electric options showed a net positive value before the year 2000 if fuel escalates at the same rate as inflation (Table 6). If fuel escalates 4% per year above general inflation, then OTEC and wind show positive values in the 1990s.

TABLE 6. Cost and Value of Solar Electric Options to Utilities
in the Southeast (In 1978 \$/kWe for Year 2000)

Plant Type	Estimated Range of Mature Plant Costs ^(a)	Estimated Amount Utilities Can "Afford" to Pay for the Plants	
		At 6% Fuel Inflation ^(b)	At 10% Fuel Inflation ^(c)
Central Stations			
Solar Thermal Electric	2,000-2,500	200-400	500-800
Photovoltaic	1,300-1,700	300-400	500-800
Wind	800-1,000	300-400 ^(c)	800-900 ^(c)
Biomass (Wood)	1,100-1,300	<400 ^(d)	<700
OTEC	1,500-2,600	800-1,300	2,000-3,100

(a) Assumes DOE cost goals are met; based on modeling two utility systems for the year 2000.

(b) Value is determined by modeling the fuel and capacity savings resulting from the operation of the solar unit for utility systems selected. Fuel inflation rates include general inflation of 6% annually based on 1978 assumptions.

(c) Based on results of the Southwest project for wind sites with 26% capacity factor.

(d) Based on simple comparison of 50 MW wood-fueled plant with 600 MW coal-fired plant.

For the dispersed user case residential photovoltaics can achieve payback (over equipment lifetime) in the late 1990s if fuel escalates at the same rate as inflation (Table 7). Wind can achieve payback in the early 1990s with a net 4% escalation in fuel costs.

SOUTHWEST REGION

No solar electric option achieved break-even in the Southwest based on fuel escalations assumed by the utilities for their systems (Table 8 - Note footnote C).

The value of the solar electric options depends partly on assumed fuel costs. The primary fuels for electric power generation in the Southwest are gas and oil, which are used to generate 67% of the electric power; coal provides 20%, nuclear 3%, hydro and diesel less than 1%.

TABLE 7. Break-Even Dates for Onsite (Dispersed) Solar Electric Options in the Southeast

	<u>Estimated Break-Even Dates(a,b)</u>	
	<u>6% Energy Inflation(c)</u>	<u>10% Energy Inflation(c)</u>
Onsite Power Generating Facilities		
Solar Total Energy Systems (Industrial)	After 2000	After 2000
Photovoltaic (Residential)	Late 1990s	Early 1990s
Wind	After 2000	Early 1990s

-
- (a) Assumes DOE cost goals are met; favorable rate structures are applied to user-owned systems.
 (b) The break-even date is the point at which the savings in purchased electricity are equal to the investment required for the facility.
 (c) Fuel inflation rates include general inflation of 6% annually based on 1978 assumptions.

Fuel costs for the Southwest Region are presented in Table 9. One Southwest utility, Salt River Project, achieved economic break-even by the year 2000 for solar thermal with an 8 to 10% fuel escalation rate (again including 6% general inflation) primarily because solar replaced expensive oil fuel and the utility has a low fixed-charge interest rate.

MAJOR FACTORS AFFECTING THE CALCULATED VALUE OF SOLAR ELECTRIC

A very clear conclusion from the RAS is that most solar technologies are not economical prior to the year 2000 if fuel costs and electricity prices are assumed to escalate at the same rate as general inflation. Even a substantially more rapid escalation of fuel costs (2 to 4% above general inflation) is still not sufficient for a many technologies to penetrate the market. Therefore, many incentives (including demonstration and financial-type incentives) appear to be required (barring increased long-term fuel escalation) before any significant installation of solar electric generation will occur before the year 2000 in each of the three regions studied.

TABLE 8. Cost and Value of Solar Electric Options to Utilities in the Southwest in 1985 (in 1977 \$/kWe)

Solar Concepts	Range of Plant Cost (a) (c)	The Estimated Amount that Utilities (b) Can "Afford" to Pay for the Plants					
		PSNM	SRP	ELP	SCE	PSC	APC
Solar Thermal Central Receiver Without Storage	1470-2240				620		
Solar Thermal Central Receiver With 200 MWh of Storage	1850-2800	730	990	550	830	580	450
Solar Thermal Central Receiver With 600 MWh of Storage	2550-3870		1430	720	1120	790	610
Photovoltaics Without Storage	2080-2900		870		640		310
Wind Energy Without Storage	920-1230			20	320	260	
Retrofit Hybrid	1040-1740	800	480				

(a) Plant costs include interest during construction and owner's costs, but not contingencies.

(b) PSNM--Public Service of New Mexico; SRP--Salt River Project; ERLP--El Paso Electric Company; SCE--Southern California Edison Company; PSC--Public Service Company of Colorado; APC--Arizona Public Service Company.

(c) Fuel escalation rates varied from 4 to 8% per year for coal; 5 to 8% for oil; and 4 to 8% for nuclear, based on 1977 assumptions.

The RAS suggested that initial opportunities for solar electric generation cannot be identified on a national or even regional basis. Initial opportunities must be sought utility by utility (or maybe within a single utility's service area) or on an individual, industrial, commercial, or residential basis. This situation exists for several reasons:

TABLE 9. Fuel Cost (mills/kWh) in Year 2000
for Utilities in Southwest Study

<u>Utility</u>	<u>Fuel Type</u>		
	<u>Coal</u>	<u>Oil</u>	<u>Nuclear</u>
PSNM	46.0	--	20.0
SRP	36.3	184.5	13.0
ELP	45.9	85.9	12.5
SCE	33.7	127.9	25.5
PSC	52.1	167.7	10.4
APS	26.4	83.2	15.9

1. Prices for fuel vary widely among and even within regions. In the year 2000, Southwest coal costs are estimated to vary from 26 to 52 mills/kWh, depending on the long-term contracts the utility has in place.
2. Electric costs reflect the current and anticipated mix of generating equipment. Some utilities expect to be, or will be, heavily dependent on oil far into the future. Fuel cost increases for these utilities can be expected to exceed general inflation.
3. Some solar resources are markedly different within the regions. Even within utility service areas, wind and biomass may vary considerably. Further, solar resources that are greatest at or near the peak electricity demand periods are of greatest value.
4. The value of solar electric generation depends on whether the electricity is generated by a utility or by a user who has his own facility. Solar electric central stations displace plants with more expensive fuels (and provide some generating capacity), while onsite systems replace retain electricity sensitive to rate structures.
5. The regulations, tax laws, and accounting rules differ from utility to utility and from dispersed user to dispersed user. Solar electric appears to have a greater value for public-owned (municipal) utilities (with lower fixed-charge rates) than for investor-owned utilities.

Early market opportunities will need to be sought through careful consideration of individual situations.

5.0 MARKET OPPORTUNITIES

The RAS unanimously concluded that no significant market opportunities will exist for solar technologies before the year 2000 unless:

- fuel and electricity prices rise at least several percent faster per year than the rate of inflation through the year 2000
- DOE cost and performance goals for appropriate solar electric options are met on schedule
- many demonstrations of each solar electric option are sufficiently successful to overcome user concerns
- incentives are available initially to reduce risk and overcome barriers that users foresee.

These factors were the present composite views of electric utilities involved in the studies. Dispersed users could not state their position as clearly, but the same factors generally apply in their case also.

Because most participating utilities do not believe that the probability of these factors occurring is great, negligible amounts of solar electric presently exist in the region's electrical generation plans for the year 2000. However, if the factors do occur, then the RAS projections of solar market opportunities are as presented in Table 10.

The most promising solar electric options for each region are discussed in the following sections.

NORTHEAST REGION

Market opportunities in the Northeast emerge primarily because of an excellent wind resource and high electricity costs. Some biomass resource also exists. For the dispersed market, the major users are likely to be industrial firms (pulp and paper, chemicals, refineries, and primary metals). This market potential was estimated to be about 400 large (2.5 MWe) wind machines by 1990 and double that number by the year 2000. The market opportunity for users accepting life cycle break-even costs occurs in early to mid-1980s.

TABLE 10. Estimated Regional Solar Electric Market Opportunity (Year 2000)

	<u>Solar % of Regions' Total Installed Electric Capacity</u>	<u>Forecast of Total Installed Solar Electric Capacity GWe</u>
Northeast	10-20	19-35
Southeast	0.5-3.0	4-14
Southwest ^(a)	3.5	8

(a) Southwest case includes central station case only extrapolated to all utilities in the southwest.

An estimated 190,000 homes could be equipped with photovoltaics by the year 2000, and about 28,000 homes could have wind machines, accounting for about 900 MWe. Apartment houses could add one-third more generation.

The utility market opportunity, based on economic analysis only, was estimated to be as high as 14,000 large (2.5 MWe) wind machines with a generating capacity of 35,000 MWe by the year 2000. Most utility planners feel that this figure is too high and cannot be achieved economically. In any case, the market entry opportunity is expected to occur about 1990.

The utility market opportunity for biomass (direct combustion) is estimated to be about 2000 MWe by the year 2000. In some situations biomass is economically viable today. Its long-range use depends partly on the competition for the wood resource.

The entire dispersed solar electric market could account for 2.3% of the Northeast's electrical requirement; the utility market could be as large as 20%, but siting and other problems will probably reduce this figure.

SOUTHEAST REGION

Based on the RAS, the market opportunities before the year 2000 for solar electricity in the Southeast are almost nonexistent for utilities (less than 1000 MWe for each of OTEC and biomass). Residential and other dispersed photovoltaics, a market that is very difficult to quantify, is estimated at between 2000 and 12,000 MWe by the year 2000. If fuel costs escalate at 4%

per year above general inflation, the higher figure will be more likely to be achieved, and the utility market may be expanded somewhat.

On the surface, Southeast market opportunities appear to be smaller than the Northeast's, despite a superior solar resource (apart from wind). However, by assuming similar fuel cost escalation rates, the Southeast market is likely to be somewhat larger, maybe 15,000 MWe, or approximately that which may be expected in the Northeast. The low cost of wind machines, the superior wind resource and higher electricity costs create the advantage for solar use in the Northeast. The Southeast has superior solar resources (again, apart from wind), but lower electricity costs, less dependence on high cost fuels, and superior fuel supplies. If the selected target year had been 2010 or 2020, the Southeast market might have been larger by comparison due to further maturity of the solar electric technologies most appropriate to the region.

A higher fuel escalation rate relative to inflation could change the opportunity for solar electric options in the Southeast. Utility planners tended to think in terms of fuel escalation rates close to those for general inflation. Also, if cost, schedule, and performance goals are achieved by DOE for OTEC, higher penetrations are likely; however, utility participants were skeptical that these goals would be achieved. Utilities are attracted to OTEC (and wood-fueled plants) because they have the potential to operate up to 80 to 90% of the time, whereas wind plants may operate only 10 to 30%, and photovoltaic plants 15 to 16% of the time. Thus, in terms of energy, 1 MW of wood or OTEC plant capacity may be worth 4 to 6 MW of wind or photovoltaic plant capacity due to greater availability.

The Southeast has an enormous solar resource, but limited short-term (year 2000) market opportunities. Achieving higher penetration rates may be possible by applying cost and risk sharing incentives and institutional arrangements. The Southeast's overall market penetration picture to the year 2000 is presented in Table 11.

SOUTHWEST REGION

Although the Southwest has the best insolation resource in the U.S., it has a continuing heavy dependence on oil and gas for electric generation.

TABLE 11. Estimated Solar Electric Generating Capacity and Resource Limits in Southeast to Year 2000

<u>Technology</u>	<u>Maximum Credible Penetration</u>
Wood-Fueled Central Station Generation	500-1000 MW
Ocean Thermal Central Station Energy Conversion	100-900 MW
Multi-Unit Wind Central Stations	<500 MW
Solar Thermal Central Stations	Negligible
Photovoltaic Central Stations	Negligible
Onsite Photovoltaic Residential	1000-7000 MW
Nonresidential	1000-5000 MW
Onsite Wind Residential	<50 MW
Nonresidential	Negligible
Solar Total Energy Systems	Negligible

Like the Southeast, the projected cost of solar electric plants, long-term (low-cost) fuel contracts, and other factors work against solar electric. No significant market potential was identified for solar electric through year 2000. However, assuming Federal incentives were available to compensate for differences between investment cost and value to the utilities, the installed capacity to the year 2000 (for the utilities participating) was optimistically estimated by the utilities to be as high as 8000 MWe. Federal incentives estimated at \$11 billion would be required to achieve this degree of regional penetration by the year 2000. These incentives would make up the difference between the cost of solar electric plants and their value to the utilities.

In general, increasing the fuel escalation rate to 10% (again including general inflation) through the year 2020 can double the value of solar electric generation to investor-owned utilities, displacing coal and oil-fired capacity. To summarize, the estimated market opportunities to the year 2000 for solar electric in three regions are presented in Table 12.

TABLE 12. Estimated Market Opportunities for Solar Electric to Year 2000

<u>Region</u>	<u>Utility Case</u>	<u>Dispersed Case</u>
Northeast	16,000 to 32,000 MWe	3000 MWe
Southeast	2000 MWe	2,000 to 12,000 MWe
Southwest	8000 MWe(a)	not estimated

(a) Extrapolated to all utilities in the Southwest region.

6.0 CONCLUSIONS

In addition to the conclusions that resulted from the analyses for the RAS, several strong, consistent messages were given by prospective users:

- Both central and dispersed users have positive attitudes toward the various solar electric technologies and wish to see them as available options, but the lack of convincing demonstrations and specific knowledge of the solar resource hinders them from formulating plans to implement solar electric systems in their organizations or locations even if the projected economics were attractive.
- Users are wary of the obstacles and pitfalls of installing solar electric technologies and want assurance, preferably in the form of demonstrations, that they won't suffer financially or otherwise be embarrassed. Most dispersed users require electric utility backup service.
- Dispersed users are sensitive to whether or not an installed solar electric technology will alienate or have a positive effect on neighbors or customers.
- Typically, users feel that they should not have to assume all the economic risk of early units, i.e., risks of early obsolescence or decreased resale value of homes.
- Users want a solar electric infrastructure in place or at least being developed to provide installation and maintenance services.
- Dispersed users especially need help in defining whether or not an adequate solar resource is available to them.

Based on prior analyses and these and other user inputs, several actions were proposed to accelerate solar electric use in the three regions studied:

- All regions need to have their solar resources better defined. Presently, a major deterrent to solar electric use is that sites with adequately defined solar resources cannot be selected.

- All regions need significant demonstrations of various solar electric technologies. Examples for the Northeast would be demonstration of a wind-energy farm (a cluster of several hundred large wind machines at a single site), several hundred large wind machines in dispersed locations in electricity-saver roles, and photovoltaics on several hundred homes. For the Southeast wood-fueled and wind central station applications, dispersed wood, wind, and photovoltaic, and an OTEC pilot plant are identified for demonstration. For the Southwest, several large (~ 100 MWe) demonstration plants (retrofit hybrid, solar thermal central receiver, and photovoltaics) appear warranted. Demonstration of full-size solar electric generating technologies will be critical to the establishment of investor and user confidence.
- A range of Federal and state incentives, costing as high as several billion dollars per region, is required for these and other demonstration units. A broad range of conventional incentives is appropriate for utilities. For residential users, loans that reduce the risk and facilitate resale may be appropriate.

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