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ABSTRACT

A comparison of quantitative and qualitative employment effects of solar and conventional systems can prove the increased employment postulated as one of the significant secondary benefits of a shift from conventional to solar energy use. Current quantitative employment estimates show solar technology-induced employment to be generally greater than for conventional technologies. Discussing the qualitative employment effects focuses on the relative size and spatial distribution of the various technologies. The effects of solar systems are more positive than those of conventional energy facilities. This is due to the small size, dispersed locations, and gradual implementation of solar heating and cooling of building (SHACOB) systems. (YLB)

EMPLOYMENT FROM SOLAR ENERGY: A BRIGHT BUT PARTLY CLOUDY FUTURE

by

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EMPLOYMENT FROM SOLAR ENERGY:
A BRIGHT BUT PARTLY CLOUDY FUTURE

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ABSTRACT

The current state of knowledge about employment impacts of solar versus conventional technologies is used to make quantitative and qualitative comparisons of these impacts across technologies. For purposes of quantitative comparison, employment requirements are standardized to employee effort per unit energy per year of operation. These current quantitative employment estimates show solar technology induced employment to generally be greater than for conventional technologies. The qualitative discussion focuses on the relative size and spatial distribution of the various technologies, concluding that the effects of solar are more positive than for conventional facilities because of smaller size, dispersed locations, and gradual implementation.

INTRODUCTION

Increased employment has been postulated as one of the significant secondary benefits of a shift from conventional to solar energy use. Recent estimates of the potential scale of this benefit support such a claim, though they must be considered tentative and almost speculative at this point in time.

For solar heating and cooling of buildings (SHACOB) systems, which include hot water heating, active heating, active heating and cooling, and passive heating and cooling systems, labor estimates are based on limited experience with modest numbers of systems. For solar systems which generate electricity, only wind systems have any real employment history; central thermal, photovoltaic, and ocean thermal systems' labor requirements are based almost wholly on engineering estimates and extrapolations from related industries. By contrast, conventional energy systems (coal electric, nuclear, oil electric, gas electric, and coal mining) have a considerable body of actual employment experience on which to base estimates of labor requirements. While a comparison

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of employment from systems with such widely varying degrees of reliable data is somewhat uncomfortable, it is the only alternative available if we wish to examine relative labor intensities today. The analyses to date yield overwhelming support for the contention that solar, especially SHACOB systems, will require more labor resources than conventional energy sources.

In addition to the relative magnitude of labor required by different energy systems, the issues of location, duration, and occupation of the labor required are also important and heretofore have been largely ignored. While also somewhat speculative, analyses of these issues points toward significant and positive benefits of solar energy relative to planned conventional electric energy sources.

While the employment effects of energy alternatives are complex, they can be classified as either quantitative or qualitative effects. The importance of each of these effects varies with the types of systems being compared, the proposed location of the system, the scale of the geographic area of concern, and the particular issue of interest to the analyst. This paper compares both the quantitative and qualitative employment effects of solar and conventional systems and presents an analytical framework for determining such effects.

Findings have been based on three principal sources of information:

1. Technology characterizations of the Technology Assessment of Solar Energy (TASE) program from work currently in progress at Argonne and the other Dept. of Energy national laboratories [1] ,

2. Published estimates of the labor requirements of solar energy from the Mitre Corporation, the U.S. Dept. of Energy, and several other sources [2 to 5], and

3. Previous work at Argonne on the employment impacts of conventional energy systems [6 and 7].

METHODS*

Quantitative Employment Effects

In order to estimate the total employment effect of a shift from conventional to solar energy sources, the following types of employment effects must be considered:

1. Direct Employment required for:
   A. Construction and/or installation
   B. Operation and maintenance (O&M)

*A detailed description of the methodology, data manipulations, data sources and shortcomings, and additional information are to be described in a forthcoming Argonne National Laboratory Technical Memorandum.

C. Fuel supply
D. Direct system manufacturing and/or assembly
E. Energy transmission and/or distribution (T&D)

2. Indirect or Secondary Employment required to support direct employment in sectors such as:
   A. Raw materials mining and processing
   B. Indirect or component parts manufacturing
   C. Business services such as communications, transportation, financing, research, legal, etc.
   D. Retail services for wage earners and stockholders

   It should be emphasized that these effects repeat themselves as expenditures and money recycle through the economy. They are generally estimated using either employment multipliers (ratios of total employment to direct employment) or by using input-output transaction tables.

3. Displacement Employment, especially for solar, where it may displace direct and indirect employment from conventional energy sources. Displaced energy employment is important but very difficult to estimate. It depends on the:
   - type of energy displaced
   - impact on: [illegible]acity constructed
     [illegible]el use
     -O&M, T&D
   - back-up system requirements for solar, and the
   - indirect effects of any direct employment decreases

   Analysis of these effects is a complex and situation-specific endeavor.

4. Employment effects from money available to be spent on other consumer or investment items if solar energy costs less (Respending Effects or money no longer available if solar costs more (Substitution Effects). This increase or decrease in available or disposable income will have employment impacts when spent. Determination of these employment impacts requires macroeconomic modeling with detailed information about:
   - the real [illegible]nomic cost of alternatives
   - the econo[illegible] sectors impacted
   - the labor [illegible]tensities of sectors
   - the timing of expenditure shifts
   - the state of the economy

Estimates of labor requirements for construction/installation, operation and maintenance, and fuel supply are first presented based on references 1, 2 and 7. Next total direct, indirect, and combined direct and indirect effects are analyzed based on data from references 2, 3 and 4. Net national energy employment including displacement effects are presented from reference 3. Respending or substitution effects are not presented, though Rodberg [5] has found them to be even greater in magnitude than direct and indirect combined.

Qualitative Employment Effects

The qualitative employment effects of energy alternatives vary with:

- Relative facility size
- Peak number of employees required
- Type and duration of jobs
- Expected locations of facilities
- Population shifts induced
- Community social structure

Where data is available [6, 7] to compare SHACOB, Solar Electric, and Conventional Electric facilities on these characteristics, it is presented. Otherwise, the issue is simply discussed based on current observations and expectations.

FINDINGS

Quantitative Employment Effects

Table 1 presents the basic quantitative data on construction/installation, operation, maintenance and fuel supply for the systems studied, including conversion to normalized employment per 10^{12} Btu delivered per year. Figures 1 and 2 demonstrate the range of employment requirements estimated for the different system types and also the impact which continuous operation, maintenance, and fuel supply requirements can have on employment. The range is greatest for SHACOB technologies, with passive systems requiring moderate amounts of additional construction labor and almost no operating and maintenance labor. The relatively high range of construction/installation labor intensities of SHACOB and solar electric systems can be been in Figure 1. Figure 2 shows the effect of adding operation, maintenance, and fuel supply requirements. The yearly cleaning and maintenance of active hot water systems (153 Emp. yrs./10^{12} Btu-yr) may be excessive. Other references do not show such a disparity between active hot water and heating systems. Coal mining, both strip

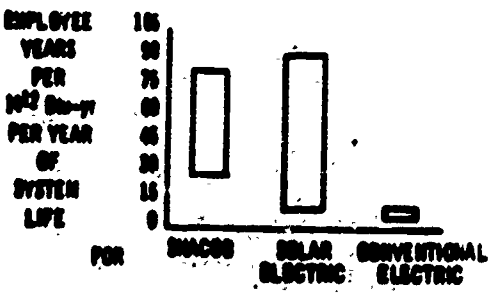

FIG. 1. CONSTRUCTION/INSTALLATION EMPLOYMENT REQUIREMENTS OF SOLAR VS. CONVENTIONAL TECHNOLOGIES [1, 2, 7]

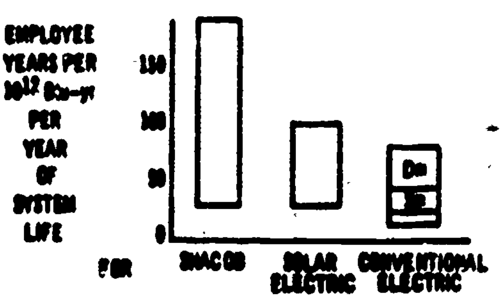

FIG. 2. CONSTRUCTION/INSTALLATION, O&M, AND FUEL SUPPLY EMPLOYMENT REQUIREMENTS OF SOLAR VS. CONVENTIONAL TECHNOLOGIES [1, 2, 7]

TABLE 1. CONSTRUCTION/INSTALLATION, OPERATION, MAINTENANCE, AND FUEL SUPPLY

System Type	Construction/Installation of Standard Systems: Btu/Yr/Syst.	Emp. Yrs/ Syst.[a]	Systems/ 10^{12} Btu-Yr	Emp. Yrs/ 10^{12} Btu-Yr	Yrs. of System Life	Emp. Yrs/ 10^{12} Btu-Yr/ System Life	Peak Employ. Estimates Per System[b]	Annual Operation & Mainten Emp. Yrs/ 10^{12} Btu-Yr.	Annual Fuel Supply Emp. Yrs/ 10^{12} Btu-Yr.	Total Cons-Install O & M, Fuel Supply Emp. Yrs/ 10^{12} Btu-Yr/ System Life
SHACOB [1]										
Active Hot Water	10×10^6	.016	55,555	889	20	44	-	153	-	197
Active Heating	65×10^6	.0585	15,385	900	20	45	-	51	-	96
Active Heating and Cooling	85×10^6	.142	11,765	1471	20	84	-	52	-	136
Passive Heating and Cooling	66×10^6	.0385	15,152	583	20	29	-	2	-	31
Solar Electric Systems–Approximately 100 MW [8]										
Central Rcvr w/storage	2.6×10^{12}	567	.3846	218	30	7	≤ 567	21	-	28
Thermal w/storage	1.5×10^{12}	1133	.6667	755	30	25	≤ 850	40	-	65
Photovoltaic										
- Silicon Crystal	$.837 \times 10^{12}$	1133	1.195	1354	30	45	≤ 1075	10	-	55
- Thin Film	$.777 \times 10^{12}$	1800	1.287	317	30	77	≤ 1930	10	-	87
- Concentrator	$.897 \times 10^{12}$	2333	1.115	2601	30	87	≤ 1784	10	-	97
Ocean Thermal [8]	2.9×10^{12}	4118	.345	1421	30	47	≥1176	12+	-	59+
Conventional Electric Systems [7]										
Coal* – 800 MW – Strip	14.35×10^{12}	4022	.0697	280	30	9	1490	10	5-18	24-37
Deep	14.35×10^{12}	4022	.0697	280	30	9	1490	10	50	69
Nuclear* – 1100 MW	17.75×10^{12}	7000	.0507	355	30	12	2000	4	?	16+
Oil** – 500 MW	7.5×10^{12}	1900	.133	253	30	8	728	12	?	20+
Gas** – 500 MW	7.5×10^{12}	1725	.133	229	30	8	792	9	?	17+

*Capacity factor of .6 assumed.

**Capacity factor of .5 assumed.

[a] Estimates of construction employment for solar electric technologies are not available and have therefore been assumed to be 2/3 of total direct employment, the modal value for SHACOB technologies.

[b] Solar electric estimates adapted from [8] with speculation on adjustment of future estimates.

(SM) and deep (DM) causes the peak of the conventional range to move up substantially with respect to solar electric.

Table 2 presents the total direct and indirect employment estimates for the same technologies as before, however, only solar electric estimates are based on the same reference [2] as in Table 1. Note also that the units (Employee-Hours/10^{12} Btu-Yr) are different but comparable. Tables 1 and 2 have been checked and are reasonably consistent Figure 3 shows the ranges for total direct employment, including direct manufacturing/assembly and transmission/distribution. SHACOB and solar electric systems are comparable and somewhat higher than conventional electric systems. When indirect employment is considered in Figure 4, the higher multipliers assumed for SHACOB systems (apparently based on higher material cost components of these systems) result in significantly higher indirect employment. Figure 5 shows the combined effects of direct and indirect employment.

Figure 6 shows the Domestic Policy Review of Solar Energy [4] figures for net employment under three different national scenarios, each providing the same amount of end-use energy but with increasing shares of solar technologies. The numbers are cumulative totals for 1978-2000, and include displacement effects, both direct and indirect, as solar contributes more energy and conventional sources contribute less. As can be seen in the future, total employment increases with increasing contributions from solar. This demonstrates that the increased employment from solar more than counterbalances the decreased employment from conventional sources.

Qualitative Employment Effects

Table 3 presents information on the average size of planned energy facilities, the peak number of employees required to build or operate the facility, and the number of counties in the nation in which that type of facility is planned to be constructed. These estimates are based on actual electric utility plans [6] and historical employment requirements [7]. Except for photovoltaic solar electric systems, conventional electric energy facilities cause several orders of magnitude higher peak

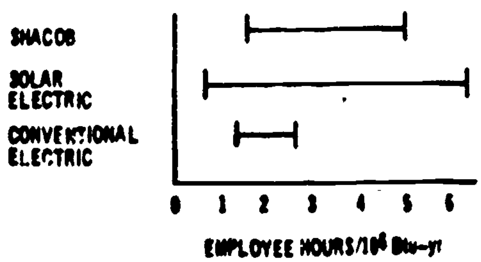

FIG. 3. TOTAL DIRECT EMPLOYMENT/ REQUIREMENTS INCLUDING MANUFACTURING/ ASSEMBLY AND T&D [2, 3, 4]

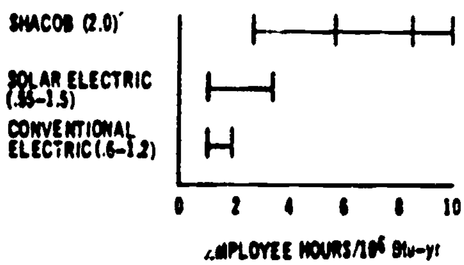

FIG. 4. TOTAL INDIRECT EMPLOYMENT REQUIREMENTS [2, 3, 4]

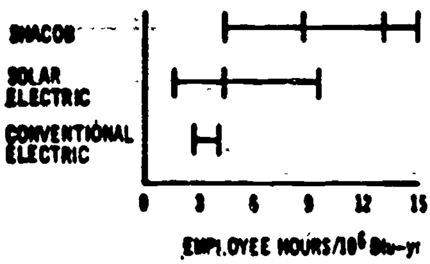

FIG. 5. TOTAL EMPLOYMENT REQUIREMENTS INCLUDING DIRECT AND INDIRECT EMPLOYMENT [2, 3, 4]

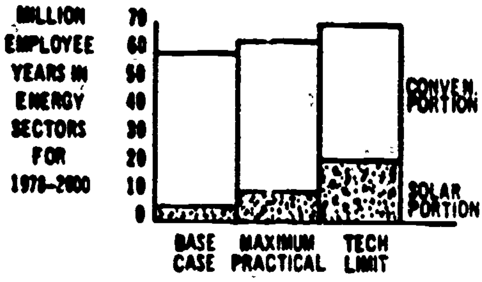

FIG. 6. TOTAL AND SOLAR U.S. ENERGY EMPLOYMENT ESTIMATES UNDER ALTERNATIVE SOLAR PENETRATION SCENARIOS [3]

TABLE 2. DIRECT, INDIRECT, AND COMBINED EMPLOYMENT ESTIMATES

System Type	Employee Hours per 10^6 Btu Output per Year			
	Direct	x Multiplier	= Indirect	Direct & Indirect
SHACOB [3], [4]				
Active Hot Water	2.81	2.0	5.62	8.43
Active Heating	4.23	2.0	8.46	12.69
Active Heating and Cooling	4.94	2.0	9.88	14.82
Passive Heating and Cooling	1.70	1.5	2.55	4.25
Solar Electric Systems [2]				
Central Wind	0.6-1.0	1.5	.9-1.5	1.5-2.5
Thermal	2.12	0.94	2.0	4.12
Photovoltaic	2.4-6.3	0.55	1.3-3.5	3.7-9.8
Ocean Thermal	1.5-2.6	0.6	0.9-1.6	2.4-4.2
Conventional Electric Systems [8]				
Oil	1.65	0.6	1.0	2.65
Coal - Low Btu Coal	1.95	0.7	1.37	3.32
High Btu Coal	1.68	0.7	1.17	2.85
Nuclear - HTGR	2.55	0.56	1.43	3.98
LWR	1.38	1.2	1.66	3.04

TABLE 3. SOLAR SYSTEMS COMPARED TO PLANNED ELECTRIC FACILITIES AND COAL MINING [1, 2, 6, 7]

	Average Size Planned in MWe	Peak Employment Required for Average Size Plant	No. of Counties
SHACOB	<1	5	3,069
Solar Electric	100	567-1,930	100-1,000
Oil Electric	750	1,024	10
Coal Electric	917	1,653	116
Coal Mining	1,209*	90-1,390**	82
Nuclear Electric	2,083	3,367	78

*320 MWe per million tons per year assumed for 3,777 million tons per year average. [7]

** Based on the extremes of 26-368 employees per million tons per year for strip mines in Wyoming to deep mines in Utah. [7]

employment requirements at the sites of the facilities due to their larger size. In addition, their larger size means that fewer areas will experience employment from these sources. SHACOB and solar electric technologies, on the other hand, are much more widely dispersed and of smaller size.

Many of the coal facilities and a number of the nuclear facilities are planned for relatively isolated rural counties with low assimilative capacities (low populations, low population densities, low numbers of available workers, and located at a distance from metrolopitan areas). Large new facilities (see peak employment column in Table 1) in this type of county can cause significant boom-town effects as construction workers and their families migrate to the work site for a period of several years. As can be seen by Figure 7, low and extra-low assimilative capacity counties receive a disproportionate share of new facilities (when compared to share of population). Figure 8 shows that, when receiving an average size conventional facility, these counties can experience significant population shifts into the county, sometimes more than doubling the population.

The location, duration, and type of jobs required by SHACOB technologies are much more benign in their impact on localities. In fact, there appear to be no significant drawbacks of these jobs. They will generally be:

- increasing steadily over time
- similar to construction and servicing jobs
- associated with smaller businesses
- where people (job seekers) already are because they are:
  - correlated with consumption, and
  - not in isolated areas

To the extent that SHACOB (and solar electric to a lesser degree) displaces conventional facilities, adverse impacts of conventional energy developments will be diminished. Solar energy may:

- decrease population and employment shifts
- lower government costs for servicing such shifts
- lower need for impact assistance aid
- increase community stability
- offer long-term local jobs

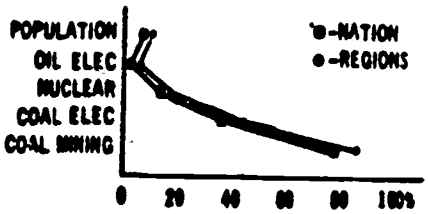

FIG. 7. % OF TOTAL PLANNED CAPACITY IN LOW AND X-LOW ASSIMILATIVE CAPACITY AREAS [6]

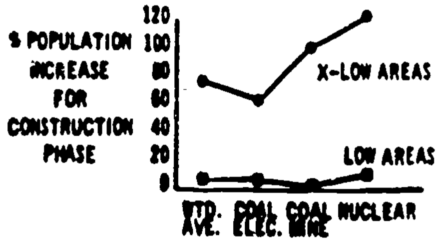

FIG. 8. PREDICTED PEAK POPULATION GROWTH DUE TO AVERAGE FACILITIES [6]

CONCLUSIONS

Current quantitative employment estimates show employment from solar technologies to be substantially higher than conventional electric facilities on a Btu-delivered basis. Depending on the solar technologies considered, Construction/Installation employment has been estimated to be from 1 to 11 times that of conventional electric sources. Total Direct employment is from 1/2 to 4 times, Indirect employment is 1 to 10 times, and Total Combined Employment is 1 to 5 times that of conventional energy source. <u>Net</u> total employment in the energy sectors for the nation under solar scenarios has been estimated to be higher as well.

Qualitative employment effects of solar are generally much more positive than conventional energy facilities due to their small size, dispersed locations, and gradual implementation.

REFERENCES

1. Technology Assessment of Solar Energy (TASE), Technology Characterization Data Worksheets, unpublished data, DOE National Laboratories.

2. Mitre Corporation, Metrek Division, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Vols. 1, 3, 7, Mitre Report MTR-7485, McLean, Va., June 1977.

3. Employment Impacts Task Force, Labor Impacts of Solar Energy Development, Domestic Policy Review of Solar Energy, Advanced Energy Systems Policy Division, USDOE, September 21, 1978.

4. Schachter, Meg, Creating Jobs Through Energy Policy, USDOE report, DOE/PE-0013, USGPO Washington, D.C., July 1979.

5. Rodberg, Leonard S., Employment Impact of the Solar Transition, U.S. Congress, Joint Economic Committee, April 6, 1979.

6. Santini, Danilo J., South, David W., and Stenehjem, Erik J., Evidence of Future Increases in the Impact of Conventional Electric Facilities on Rural Communities, Argonne National Laboratory Technical Memorandum ANL/EES-TM-52, Argonne, IL., May 1979.

7. Santini, D. J., Stenehjem, E. J., and Meguire P., Methods of Eliminating Potential Socioeconomic Constraints to Near-Term Coal Energy Development, Argonne National Laboratory Technical Memorandum ANL/EES-TM-47, Argonne, IL., April 1978.

8. Mitre Corporation, Environmental Data for Energy Technology Policy Analysis, Vol. 1: Summary, prepared for USDOE, HCP/EV-6119/1, January, 1979.