CREATING SOLAR JOBS

options for military workers and communities

Robert DeGrasse, Jr. • Alan Bernstein • David McFadden
Randall Schutt • Natalie Shiras • Emerson Street

a report of the mid-peninsula conversion project

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A Report of the Mid-Peninsula Conversion Project
November 1978

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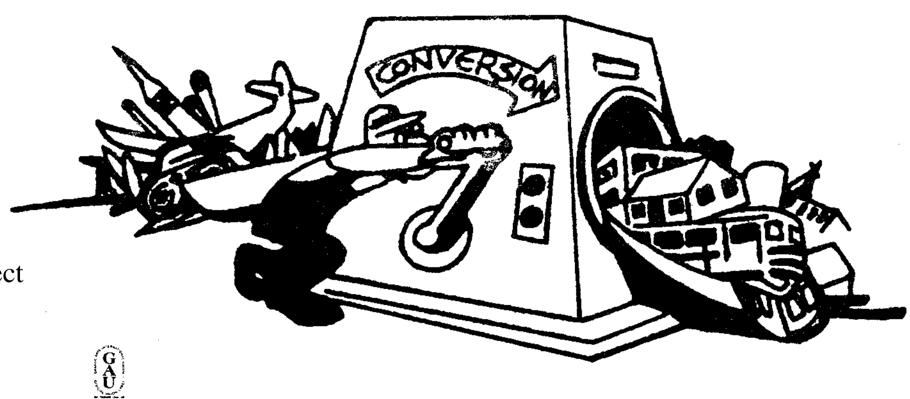
[**Note**: The Mid-Peninsula Conversion Project (MPCP) changed its name to the Center for Economic Conversion (CEC) in 1982 and went out of existence in 2000.]

[This electronic version was prepared by Randy Schutt, July 2011. The text is the same as the original. The layout is slightly different.]



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Mid-Peninsula Conversion Project

The Mid-Peninsula Conversion Project (MPCP) is facilitating the conversion of military industry to socially useful production in the Santa Clara Valley, 40 miles south of San Francisco. MPCP is incorporated in the state of California as a non-profit organization, and has a 20 member Community Board which oversees its work. It publishes 10,000 copies of a bi-monthly newspaper, the *Plowshare Press*, which generates dialogue about conversion issues. The Santa Clara Valley has one of the highest ratios of prime military contracts to population in the United States. The valley, once covered with fruit orchards, is now the military-electronics capital of the world, "Silicon Valley." The three-person staff of MPCP facilitate economic planning for conversion by speaking publicly, setting up meetings with labor, management, government, and community people, arranging public hearings, and serving as a national resource center on conversion issues and organizing.

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MPCP's newspaper, the *Plowshare Press*, costs $6.00 for 6 issues.

[**Note**: MPCP is no longer in existence so there is no current address or phone number.]

Although this report was prepared with the advice and assistance of many people, it does not necessarily reflect the views of any organization or any persons other than the authors.

Acknowledgements

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Robert DeGrasse coordinated the study, with overall responsibility for process and content. Alan Bernstein directed research on community development of solar energy. David McFadden coordinated conversion research and shared administrative oversight with Natalie Shiras. Randy Schutt examined the technical aspects of solar energy systems and assessed job skills required for their production. Emerson Street, former Business Representative of the Santa Clara County Central Labor Council (AFL-CIO), acted as labor consultant, providing an important link with labor organizations.

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To anyone we may have neglected to mention, our apologies.

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Glossary of Technical Abbreviations

W watt, a small unit of electrical power

kW kilowatt = 1,000 watts

MW megawatt = 1,000 kilowatts

GW gigawatt = 1,000 megawatts

MWe megawatt (electric), to distinguish it from MWt

MWt megawatt (thermal), thermal energy equivalent to a megawatt of electrical energy. These terms are used when discussing electrical power plants. Typically, a plant has a thermal rating three times its electrical rating because 2/3 of the thermal energy must be lost as waste heat, due to the laws of physics.

Wp peak watt, the measurement of power for a solar cell on a sunny day at noon.

kWh kilowatt-hour, a unit of electrical energy. A 60-watt light bulb burning for one hour uses 60 kWh of electrical energy.

°F degree Fahrenheit, the American system of temperature measurement. Water boils at 212°F (at sea level).

LNG liquefied natural gas. Natural gas is chilled and compressed to –260°F to make it a liquid.

sq ft square feet

SSPS Satellite Solar Power Station (see chapter 3)

BTU (formerly known as British Thermal Unit), a small unit of thermal energy equal to the energy required to raise one pound of water one degree Fahrenheit.

quad 10^{15} BTUs = the energy required to heat about 10 million homes for one year.

CETA Comprehensive Employment Training Act: government program whereby workers' salaries are subsidized by the government for an initial training period.

Methodology

During the Mid-Peninsula Conversion Project's three-year history, many people have asked for detailed information about the conversion potential of military industries in the Santa Clara Valley. Since our inception, we planned to undertake a technical study examining alternative uses for the resources currently employed in military production.

We began our research in February 1978. To insure input from a variety of sources, we created an advisory panel composed of energy researchers, solar businesspeople, representatives from labor unions, environmentalists, and government officials.

We followed two main courses in gathering information:

First, we performed a general literature search on job creation resulting from solar energy development and opportunities for converting military industry to civilian use. From our review we learned that new information about solar energy made obsolete most studies older than a few years. The opposite is true regarding conversion studies. Except for a handful, most major studies discussing policy options for limiting the economic impact of reductions in military spending were performed before 1970.*

Through business journals and discussions with solar entrepreneurs, we analyzed patterns of ownership and trends in the structure of the solar industry. We investigated high technology solar projects and assessed their economic and environmental impact, using information in scientific magazines as well as the research of investigative journalists. We also reviewed the basic secondary literature on community economic development and alternative technology to analyze business problems and possibilities. We examined community development corporations, cooperatives, municipal utilities, and the alternate use of pension funds. Particularly useful was the work of the Center for Community Economic Development in Cambridge, Massachusetts, the Community Ownership Organizing Project in Oakland, California, and the Institute for Local Self Reliance in Washington, DC

Second, we gathered information through interviewing primary sources — solar business people, trade unionists, and representatives of military contractors diversifying into solar production. Additionally, we interviewed researchers and consultants concerned with solar energy, conversion, and community development.

From solar business people we gained employment data, tours of their facilities, and general impressions of market conditions. Our interviews were primarily with flat plate collector and photovoltaic firms. While opinion about the commercial viability of solar technologies varies little within the flat plate collector industry, we found no such agreement within the photovoltaic industry. Variance in projections and technologies is comparable to the diversity of people and firms developing solar cells. Large oil firms, aerospace giants, communications companies, and small businesses are all competing for a piece of the limited market. Reliable data on future employment impact of photovoltaic production was not found, yet firms contacted were willing to discuss their strategies and projections for photovoltaic markets. Since little production of wind machines exists, we were forced to rely heavily upon secondary source material for data.

It was initially difficult to get interviews with representatives from military corporations. However, through utilizing contacts friendly to MPCP and being persistent and friendly in our approach, we gained access to several military firms.

From trade union representatives we hoped to get specific data on their membership's employment in military firms, and data on job skills which could be compared to solar job skills. However, because of a lack of general statistical information on jobs and job skills in military industry, the best data came from rank and file members of the International

* No major study has been performed by the Arms Control and Disarmament Agency since 1970 on the economic impact of military spending. The Office of Economic Adjustment, Department of Defense, has performed a few studies where military bases have been closed or weapon systems cancelled, but none have focused closely on job skills.

Association of Machinists (IAM) who are longtime friends of MPCP. They gave us employment and job skill information on IAM membership at Lockheed Missiles and Space Company in Sunnyvale. We were also able to gain a general picture of jobs within the military industry through interviewing union officials.

Interviewing union leaders was made considerably easier by the Santa Clara County Central Labor Council's (AFL-CIO) endorsement of our study. The Labor Council also provided a consultant who made preliminary contacts with local labor representatives. Union officials were often interested in meeting with us because of our work assessing the employment potential of solar energy development.

We also interviewed small solar business people to find out the problems of access to capital and competition with large corporations.

To gain an understanding of how business enterprises function on a community level, we sought and found several examples of alternative solar businesses. We interviewed the staff and watched on-site operations at two community development corporations in Southern California, and two democratically owned and managed solar businesses in the San Francisco Bay Area.

Summary

Solar Job Skills and Employment

The four solar technologies examined, active and passive space heat, photovoltaics, and wind turbine generators, can provide many jobs.

Active solar heaters are becoming more commonplace, but their cost is still high. However, on an equally subsidized basis, these heaters cost the same or less than conventional energy sources. To produce and install active solar heaters, the solar industry may create as many as 100,000 jobs in California in the next decade — many more than other energy sources would generate. These jobs include a wide variety of skills from laborers to engineers and technicians.

The passive solar heating industry is in a similar situation. Passive solar heaters cost less than active heaters, but there are more institutional barriers to their implementation, such as obsolete building codes. Jobs in this industry include building trades, technicians, and engineers. Jobs created in California will number in the tens of thousands.

The situation· is less clear in the photovoltaic (solar) cell and wind energy fields. Solar cells are now too costly for widespread use, but their cost may drop drastically by the 1990s. Until mass production begins, most of the work will involve research and prototype development, performed by design engineers and technicians.

Wind energy systems once powered farms across the country, and they may power dwellings nationwide once again. Currently these machines cost too much to compete with conventional electricity generating stations, but as new designs are developed, the cost should drop. Many thousands of jobs will be created, and these will probably be very similar to jobs in other heavy manufacturing and aerospace industries.

Solar process heat will soon be a major field employing many professional and skilled workers.

Options for Military Workers

In general, clerical and support workers can transfer from military industry to solar work with little or no retraining. Semi-skilled assembly workers have highly transferable skills and can move immediately to solar assembly. Skilled craft workers and machinists can move readily into solar technologies, although certain highly skilled workers will need retraining. Technicians, many of whose skills are highly specific to defense work, will have difficulty matching their exact jobs in solar work, but minimal retraining will fit them for solar jobs. Engineers and managers will require major reorientation, but their transfer can be effected with careful planning.

Wind energy systems offer the clearest job skill match for aerospace workers of any solar technology studied.

Two Santa Clara Valley firms doing military work, Acurex Corporation and Varian Associates, have already entered the solar market. Acurex has major research and development contracts for concentrator collector systems for industrial process solar heat. Acurex's engineering staff has made the transition from military to solar work without difficulty.

Varian has shifted a portion of its scientific research from military night vision devices to photovoltaic cells. Varian demonstrates the flexibility a research firm has to change its R&D focus.

It is critically important for conversion to be planned beforehand, with input from the workforce at each plant. For Lucas Aerospace, the top British military firm, a Combine Shop Stewards Committee from thirteen unions drew up a detailed plan for alternative production that utilizes the machinery and worker skills already present. Among the socially useful products proposed include combination electric-diesel engines, solar heating components, fuel cell devices, kidney machines and other medical equipment, and wind energy systems.

Community Solar Development

Through our interviews with solar business people, and analysis of trends in the solar industry, it seems likely that large corporations with assets over $100 million may dominate the solar industry. This is particularly true in photovoltaic and active systems production. Energy, aerospace, electronics, and large-scale manufacturers have already moved into the solar field, and provide tough competition for smaller businesses.

Analyzing large scale corporate projects such as the Satellite Solar Power Station and the solar "power tower," and the past performance of existing energy companies, we conclude that control of solar energy by major corporations would not maximize the potential benefits which solar would bring in terms of cost, employment, and efficiency.

The current movement fighting for an appropriately scaled solar industry is weak and fragmented. Small solar businesses and environmentalists need to unite in a coalition with organized labor and minority and low-income communities. This coalition could have the necessary local and national strength to challenge corporate control.

Coalition programs can include municipal, community, and private business enterprises for neighborhood solar energy programs. The most promising area of entry for community businesses is in the installation of solar systems. To be maximally effective, solar projects should be combined with housing rehabilitation and conservation programs. Production of active systems is more risky, but potentially feasible if certain barriers can be overcome.

The solar coalition must also focus on generating favorable government incentives and policies. Existing and proposed financial mechanisms, regulatory measures, and government procurement policies will play crucial roles in determining the pace of solar energy development and in shaping who will control the industry.

Introduction

This study is a preliminary assessment of ways in which military workers and communities can utilize their skills to develop solar energy.

Our study focuses on job skills and military workers as part of our commitment to a significant shift in national priorities away from military spending. We live and work in the heavily defense dependent Santa Clara Valley, where over 100,000 workers rely directly on military production for their livelihood. Heavy local and national dependence on military spending accelerates inflation, hinders the development of civilian technologies, and creates fewer jobs than comparable civilian investments. In Santa Clara County, union members in military production have lost jobs due to the increasingly capital-intensive nature of military industry. Moreover, military spending has skewed economic development in the region, leaving cities like San Jose with high unemployment, a poor tax base, and underfunded social services.

In order to reduce dependence on military spending, we must take a serious look at the job transfer possibilities for military workers. Conversion plans must involve exploring alternative production in housing, transportation, health care, and energy. We chose to focus on solar energy because of its particular importance in shifting energy use in the United States from fossil fuels to renewable energy resources.

Solar Energy Development

As a renewable resource, solar energy can contribute significantly to our economic well-being by fostering energy self-sufficiency and expanding job opportunities through community growth.

Inflation. The current U.S. energy system depends upon fossil fuel and uranium supplies. These sources are non-renewable, and as supplies are exhausted, their prices increase — fueling inflation. More than 40 percent of our oil is imported, draining U.S. trade dollars and increasing the pressure to expand military sales to oil producing nations. Solar energy provides non-inflationary heating sources because the cost of energy produced depends only on the initial investment rather than on escalating fuel prices. In an inflationary economy, solar energy prices will actually *decrease* in real dollars over the life of the investment.

Mismatched energy. Current energy policies lead to inefficient uses of our limited energy resources. For example, about 30% of all new California homes are electrically heated, burning limited supplies of fossil fuels to produce high-quality electricity for simple space heating. Two-thirds of the fossil fuel's energy is lost as waste heat and up to 10% more in transmission. This expensive waste is required just to raise the temperature of a building from 20°F to 70°F, something the sun can do easily. Solar energy sources are efficient and nonpolluting, and used directly for the purpose intended.

Employment. Government spending for solar energy development will create more jobs than a comparable expenditure in military production. For example, Lockheed Missiles and Space Company in Sunnyvale received $918 million in 1977 in prime contracts from the Department of Defense for production of Trident and Polaris missiles, satellites, and reconnaissance systems. This $918 million employs 16,000 people. An equivalent commitment of $918 million per year for 30 years to solar energy technologies would provide from 446,000 to 840,000 job-years, compared to 480,000 in military systems over the same period of time.* These jobs would employ skilled craftspeople, factory workers, engineers, and architects, mostly in communities where the solar equipment would be installed.

Community development. Solar and conservation projects could form the basis for neighborhood revitalization and local economic growth. Solar development could, however, become another expensive, federally subsidized boondoggle under corporate control. For example, the Sunsat Council, a

* Lockheed prime contract figures from the Department of Defense, Comptroller. Lockheed job figures from the *Palo Alto Times*, January 18, 1977. Solar job figures calculated on the basis of a combined wind and active/industrial systems approach, from California Public Policy Center and the Exploratory Project for Economic Alternatives use of MITRE Corporation data. See Table 2.1, Chapter 2, and note [16].

lobby of aerospace, energy, and electronics multinationals, hopes to secure massive government contracts to develop the electricity-producing Satellite Solar Power Station (SSPS). This orbiting satellite, spanning 36 square miles, would beam microwaves through the atmosphere to a 5 by 7 mile earth antenna, creating unknown health and environmental hazards. For solar development to remain locally-oriented, labor, small business, and community groups must work together to insure public accountability.

This report spans three major topics. The first section, *Solar Job Skills and Employment*, examines four solar technologies and assesses the commercial viability, potential for job creation, and skills required for production. The second section, *Options for Military Workers*, explores the job skill transferability of defense industry employees to solar energy production, cites case studies of the diversification into solar energy technologies by two Santa Clara Valley defense firms, and describes the experience of British workers at Lucas Aerospace who planned in detail for the conversion of existing facilities, in part to solar technologies. The third section, *Community Solar Development*, points up the danger of large corporate control over solar energy technologies and discusses the need for a coalition of labor, small business, and community groups to guide their implementation. This section also examines policy options facilitating community-based solar energy projects.

In assembling the findings of our study, we found that the solar fields most likely to create job opportunities for military workers were in high technology ventures such as the solar "power tower" and the Satellite Solar Power Station. We did not explore job transfer in these areas because these technologies are expensive, centralized, inefficient, and potentially dangerous. Due to their capital-intensive nature of production, they will probably create fewer jobs than comparable investments in smaller scale solar technologies. Instead, we focus on solar options which provide heat and electricity and maximize social benefits.

This study only begins to address the need for technical data upon which comprehensive alternate use planning should be based. Such planning requires two components: (1) defining options available to employ the existing workforce and capital equipment, and (2) insuring that these plans will be economically viable. We believe that any conversion process with alternate use planning must be carried out with significant participation by those most directly affected, namely employees and communities. Federal assistance, such as directing non-military procurement contracts to defense-dependent communities, will play an important role in making conversion plans economically viable.

Chapter 1 Solar Job Skills and Employment

INTRODUCTION

Much has been written describing the social benefits of solar technology. As a renewable, nonpolluting source of energy, well matched to human end-use requirements for heating, solar energy represents an attractive alternative to conventional energy sources.

Solar technologies vary both in their usefulness and their employment potential. In this report we investigate four solar technologies. Two of these are available now: active solar space and water heating (flat plate collectors), and passive solar space heating (direct use of the sun's energy). The other two solar technologies may be available in the next decade or two, and they have generated great interest in California. These are photovoltaic (solar) cells and wind energy conversion systems. For each of these four technologies we explain the operation, discuss current and future market conditions and cost compared with existing energy sources, describe skills required for production and installation, and review existing employment impact studies.

We also look briefly at solar as an energy source for industrial process heat. This useful and important application will probably also be proved within the next decade, but currently, little descriptive information exists.

Several other solar technologies which we did not have time to investigate are:

- **Biomass**: wood or other organic material (including municipal waste) converted to liquid or gaseous fuels such as methane, or burned directly to provide heat or to drive a steam-electric power plant.
- **Low-head Hydropower**: a small, low-head dam (less than 12 feet) feeds a small turbine-generator, or, a small amount of water is diverted into a pipe which follows the river and then drops into a water turbine downstream (run-of-the-river system).

Other solar technologies produce electricity and are large, centralized, expensive, and have unresolved social problems. Because they are undeveloped, high technologies, they will not be available for at least a decade or two. These technologies include:

- **Solar-thermal Central Power Plant**: hundreds of small, sun-tracking mirrors focus sunlight onto a tall tower (power tower) where steam is boiled and fed into a turbine-generator. A 10 MWe pilot plant built by McDonnell Douglas has recently been completed near Barstow, California.
- **Ocean Thermal-electric Conversion (OTEC)**: warm ocean water in the Gulf Stream boils freon which then drives a turbine-generator. Other schemes involve capturing the energy of tides, waves, ocean currents or salinity gradients.
- **Satellite Solar Power Stations (SSPS)**: large satellites covered with solar cells generate electricity which is then beamed down to Earth via microwaves and put into the electrical transmission grid.

ACTIVE SOLAR HEATING

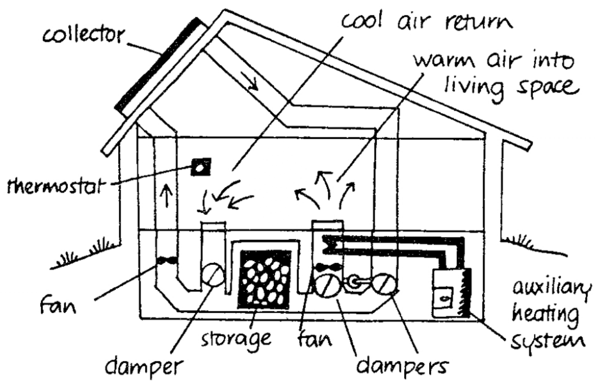
When people discuss solar energy they usually refer to active solar heating. This technology consists of solar collectors (panels) mounted on the roof of a building. The collector is blackened to absorb the sun's energy and a glass or clear plastic cover reduces heat loss. A working fluid, usually water or air,* is circulated through the collector and picks up heat from the black surface.

In an air collector, the heated air is blown directly into the building, or if the building is already warm it is blown through a heat storage bin filled with rocks. Later, when the sun is no longer shining, air blown through the rock bed picks up the heat stored there. The warmed air is then circulated through the building.

In a water collector, the heated water passes through a heat exchanger where its heat is transferred to air that is then circulated through the building. Excess hot water is stored in a large water tank for use at night and on cloudy days.

* Technically, air is classified as a fluid, as are all gases.

Solar heating systems are usually designed to supply 70–80% of the heating requirements of the building. A back-up heating system is therefore required to supplement the solar system. Solar hot water for showers and washing machines is usually produced as an extra benefit. In an air collector system, a heat exchanger is required to make domestic hot water. Small systems that only produce domestic hot water are more common than complete solar heating systems because they are presently cheaper and more cost effective.



Typical Active Heater with Air Solar Collectors

Currently, space and water heating represents 50% of the total thermal energy used in California and 17% of all energy used in the state. [1]

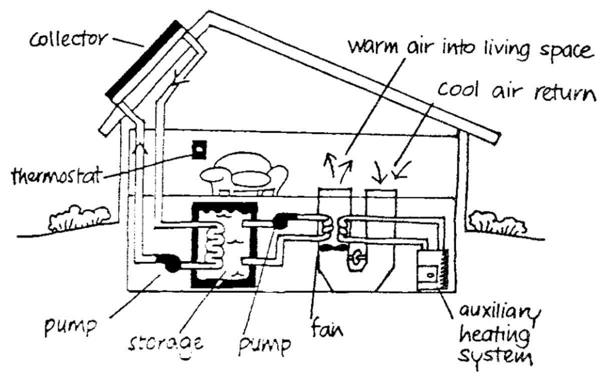
Other systems. Currently the mainstay of many solar firms are swimming pool heating systems which are much cheaper than conventional solar systems since they do not require insulation or glazing. Though swimming pools are common in California, we chose not to investigate this field because of its limited applicability.

For industry, active solar collectors can provide low-temperature process heat or pre-heat water or air for high-temperature applications. Potentially, concentrating solar collectors (parabolic trough or some other configuration) could generate high temperature air or steam for industrial processes. Farther in the future are hybrid (total energy) systems that combine high and low temperature solar collectors, wind turbines, and photovoltaic cells in some combination to extract the maximum amount of energy from the sun and wind. Because they are far in the future, there is little descriptive information on these systems.

Current Market Conditions

We conclude, as detailed below, that active space and water heating systems would be cost-competitive if subsidies for conventional sources were matched by similar subsidies for solar (or by eliminating subsidies for conventional energy sources). Even given the current market conditions, solar heating is competitive with electric heating. With subsidies, solar heating may be competitive with natural gas depending on fuel price escalation and interest rates.

Size of the industry. The solar industry is growing rapidly in both California and the country as a whole. The California Energy Commission estimated that in January 1978 there were 5,000 to 10,000 solar hot water and pool heaters, and 500 to 1,000 solar space heating systems operating in California. [2]



Typical Active Heater with Water Solar Collector

New solar manufacturing and installation firms are springing up each month. But solar still is not a “boom” market. The major reasons that solar systems have not been more widely installed are:

- High purchase cost of solar heating systems.
- Consumer ignorance and caution concerning this very young industry.
- Problems of capital procurement and financing.
- Lack of consumer information concerning life-cycle cost comparisons.
- High turnover of house ownership so that an owner does not want to spend a large amount of capital for a solar system.

Table 1.1 The Cost of Active Solar Heater Systems (Installed) in California [3]

	New Buildings	Retrofit Applications
Water Heating only	$1,400 – 2,000	$1,700 – 2,300
Space and Water Heating Single family homes	$6,000 – 10,000	$7,000 – 11,000
Space and Water Heating Multi-family homes, apartments (per unit)	$3,000 – 7,000	$4,000 – 8,000
Space and Water Heating Single family, heat pump assist (a)	$6,000 – 11,000	$7,000 – 12,000

(a) A heat pump is basically an air-conditioner run backwards. Heat is pumped into the house rather than out. A solar water heater can supply a warm reservoir of water from which to pump the heat.

- Allocation of solar benefits to renters and costs to the property owner.
- Outdated building codes and uncertainty concerning "sun rights" (access to the sun).

As the solar industry matures and solar installations become more commonplace and accepted, many of these problems will recede. Consumer confidence will grow and laws will be amended to alleviate the institutional barriers.

Solar costs. Active solar systems can either be designed and constructed as an integral part of a new building or retrofit to existing buildings. The current initial purchase price (completely installed) of solar heating systems in California are listed in Table 1.1.

At these costs of about $20 to $30 per square foot (installed), active solar is close in cost to conventional water and space heating systems. A 1976 Energy Research and Development Administration (ERDA) study, using a solar cost of $20/sq ft and assuming conventional fuel escalation of 4% per year above inflation, found that in all 13 cities studied except Seattle,* solar was cost-competitive with both electric resistance space and water heating.† [4]

A Congressional report prepared in 1977 again found that solar water heaters are cost-effective compared with electric water heaters everywhere except Washington state (and it will be cost-effective there in 1983). This study also concludes that new active solar heating is competitive with electric resistance space heating in two-thirds of the continental U.S., mostly in northern and eastern states where electricity is most expensive. Compared with natural gas, solar was found to be competitive in only a few states by 1980. [5]

Conclusions from both of these reports must be considered tentative because they are influenced greatly by the expected interest and fuel price escalation rates. Given the uncertainties of OPEC oil, natural gas deregulation, nucl ear power development, and safety and environmental restrictions on coal, no one can predict accurately how fuel prices will rise. Interest rates may change considerably depending on the state of the economy and federal policy.

The solar-cost situation improves markedly when solar is subsidized. With the new tax credits (55% in California and a similar amount for the whole nation), solar has a life-cycle cost under or close to all conventional energy sources, even though conventional sources are very heavily subsidized. Duane Chapman, Associate Professor of Resource Economics at Cornell University, demonstrates the effect of subsidies by comparing the annual cost to heat a

* Electric rates in Washington state are extremely low due to the abundance of cheap hydroelectric power from dams built by the federal government.

† On a life-cycle cost basis.

Table 1.2 The Effect of Subsidies on the Annual Cost of Heating a Home in Los Angeles in 1985 (1975 Dollars) [6]

	Solar	Alaskan Gas	Nuclear Power
Unsubsidized Cost	$725	$775	$1325
Market Cost (a)	$500	$350	$750
Percent Subsidy Overall	31 %	55%	43%

(a) This is the cost given present tax and pricing subsidies including the California 55% solar tax credit, various personal income tax deductions as appropriate, and the corporate tax subsidies of accelerated depreciation, investment tax credit, and interest expense deductions. [7]

home in Los Angeles in 1985 from various energy sources (see Table 1.2).

Chapman's analysis does not consider other important subsidies including the resource depletion allowance and price regulation of natural gas and oil, uranium enrichment, insurance waivers for nuclear power plants, and heavy federal funding of research and development for all conventional energy technologies.* [8] Total subsidies for conventional energy sources were estimated in 1976 to be $10 billion per year in the United States. California's share of this would be about $1 billion per year. [13]

Recent studies in California find solar water heating to be competitive with natural gas as well as electricity if the solar tax credit is considered. The California Energy Commission, Solar Division found solar water heating to be cost-effective comparing solar, electricity, and natural gas in a life-cycle cost/benefit analysis of water heaters. This comprehensive analysis considers 17 factors including federal and state tax credits, fuel price escalation, solar system salvage value at the end of its "life," annual maintenance costs, periodic component replacement costs, and' insurance costs. They conclude that if the tax credit is in effect and "if solar systems on the market today have system lifetimes greater than 20 years, then solar water-heating is without question a viable alternative to both gas and electricity." [14]

Figures generated by two local solar firms basing costs on California's 55% tax subsidy demonstrate that the "payback period" for solar heating systems — the time required to recover the cost based on saving conventional fuel in Northern California — is less than 20 years. Their calculations are shown in Table 1.3.

Job Skills Required

The active heater industry requires a broad range of skills, from laborers to engineers. The industry can be divided into two main sections: solar firms that actually manufacture and install solar systems (direct solar) and companies that supply the materials and common components used in solar collectors (indirect solar). Our data regarding employment in the indirect solar industry is sketchy. Material on direct jobs was collected through interviews and tours of manufacturing facilities. We identified seven sectors in the active solar industry; four indirect and three direct (see Figure 1.A).

The indirect sectors include conventional industries which will expand to accommodate the increased demand for solar.

- **Raw materials mining and processing**. Iron, bauxite, copper ore, and sand are mined and processed into the steel, aluminum, copper, and

* "From 1953 to 1973 the U.S. government spent some $5 billion on research and development in nuclear energy, but less than a million on solar technologies." [9] Batelle Labs recently reported that, "over the past 30 years, we estimate that between $15.3 billion and $17.1 billion has been spent by the federal government to assist the development of commercial nuclear power… The total does not take into account several non-quantifiable incentives." [10] They estimate that since 1918 the federal government has spent as much as $134 billion to stimulate oil, gas, coal, and nuclear energy production. [11] Some estimates put the figure at close to $500 billion. [12]

Table 1.3 Payback Periods of Active Solar Heaters in Northern California (a) [15]

Compared to:	Electricity	Natural Gas
Water Heating	3 – 5 years	6 – 13 years
Space and Water Heating	7 – 9 years	17 – 19 years

(a) These estimates assume the California tax credit is in effect and fuel escalation rates are 0–10% greater than the interest rate obtainable for a loan to purchase the solar system.

glass that will be used in solar collectors and components.

- **Solar collector materials manufacturing**. Materials that are used by solar collector manufacturers (aluminum extrusions, copper tubing, insulation, metal backing plate, plastic or glass glazing, paint, etc.) are made from the raw materials.
- **Solar system component manufacturing**. This sector involves the manufacture of solar systems components such as pumps, blowers, electronic controls, storage tanks, heat exchangers, expansion tanks, antifreeze, pipe, ducting, and valves.
- **Distribution and warehousing**. Solar collectors, components, and materials must be distributed and stored.

People and Energy

As more solar systems are installed, Anaconda copper, Grundfos pumps, Corning glass, and O-N-C freight can be expected to expand production to meet demand generated by solar production.

The direct sectors of the active solar heater industry are under the purview of the actual "solar companies." Solar businesses frequently cover two or all three of these sectors.

- **Solar collector manufacturing**. Collector manufacture* requires the following steps:

1. Receiving — raw materials are unloaded and stored.

2. Cutting and forming — the copper tubing, insulation, and box materials (often an aluminum extrusion for the side pieces and metal sheet for the bottom) are cut to size and formed into the proper shape.

3. Soldering/brazing — the copper tubing is soldered together and attached to the absorber plate.

4. Testing and inspection — the finished collector must be tested for leaks.

5. Finishing — the absorber plate is painted black so it will absorb the sun's heat.

6. Screwing/riveting — the collector box, insulation, glazing, and absorber plate are assembled into a collector by screwing and riveting them together.

7. Storage and shipping of the finished collector.

Figure 1.B shows the typical plant layout of a solar collector manufacturer. All of the tasks represented in this figure are semi-skilled and can be

* This description is for a liquid collector. Assembly of an air collector is very similar.

learned in a few weeks. Supervisors and inspectors, of course, must have more manufacturing experience.

Designing and testing new solar collector models requires mechanical engineers, technicians, and drafters. The engineers and technicians may need a few months of on-the-job training to learn the specifics of solar system sizing and design.

- **Solar system assembly**. The components of a solar heating system are sometimes pre-packaged into a module that can be easily installed. Systems include storage tanks, heat exchangers, pumps, and controllers. Pre-packaging is a simple operation which involves welding and screwing components together, both semi-skilled tasks.

- **Solar system installation**. Companies that install solar systems usually calculate the proper number of collectors and the size of components (pumps, blowers, pipes, ductwork) appropriate to the particular building. This requires mechanical engineers, technicians, architects, drafters, and sometimes building contractors. Installers then must attach the collectors to the roof, install the components (pre-packaged or separate) in place, connect the appropriate piping and ducting, and wire the controls. This requires the skills of carpenters, electricians, sheetmetal workers, plumbers, and sometimes roofers, concrete workers, and crane operators. The basic aspects of these trades can be learned on-the-job in a few months, but the more difficult parts may require more professional skill.

All solar businesses, of course, need a full com-

Figure 1.A The Seven Sectors of the Active Solar Heater Industry

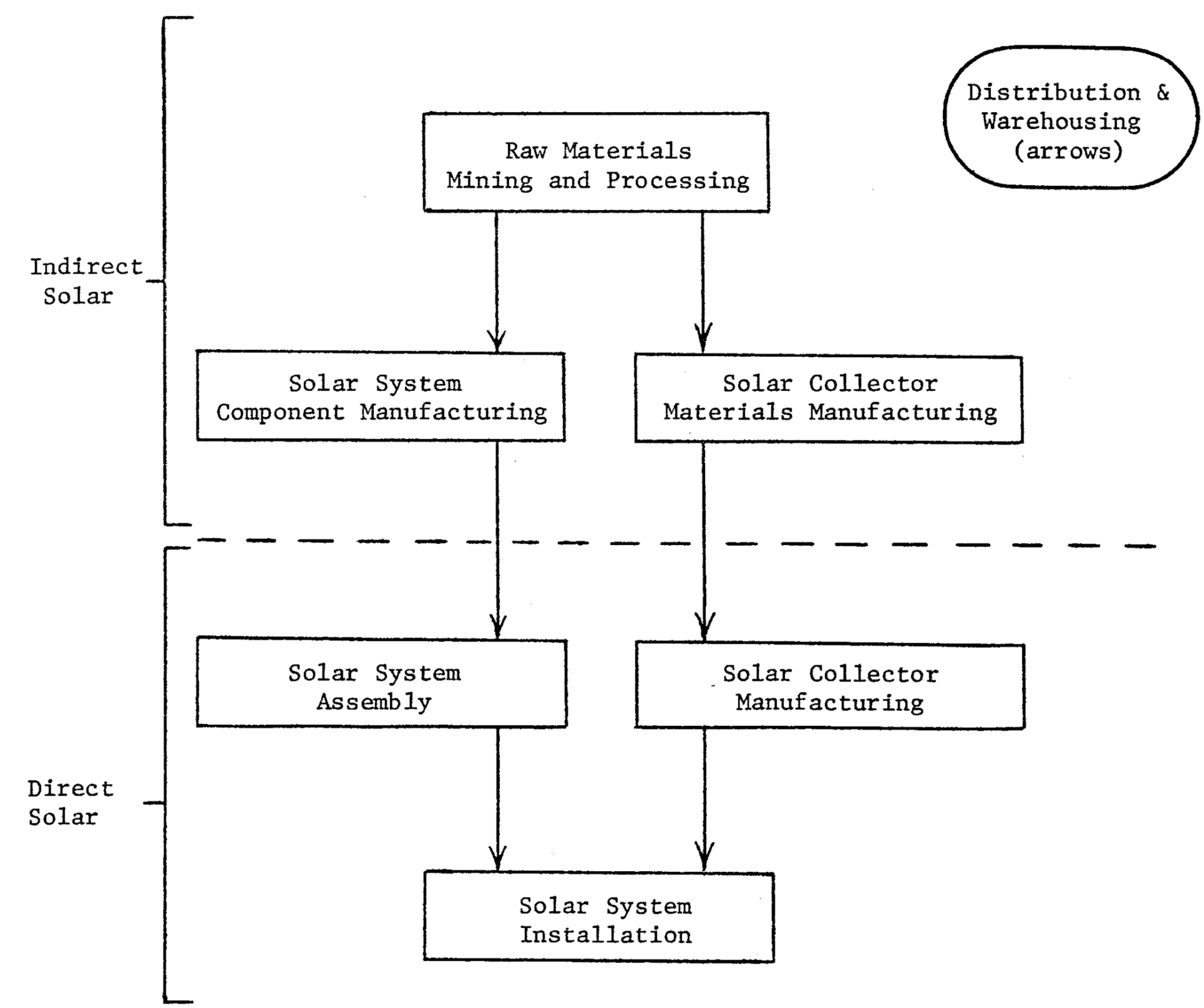
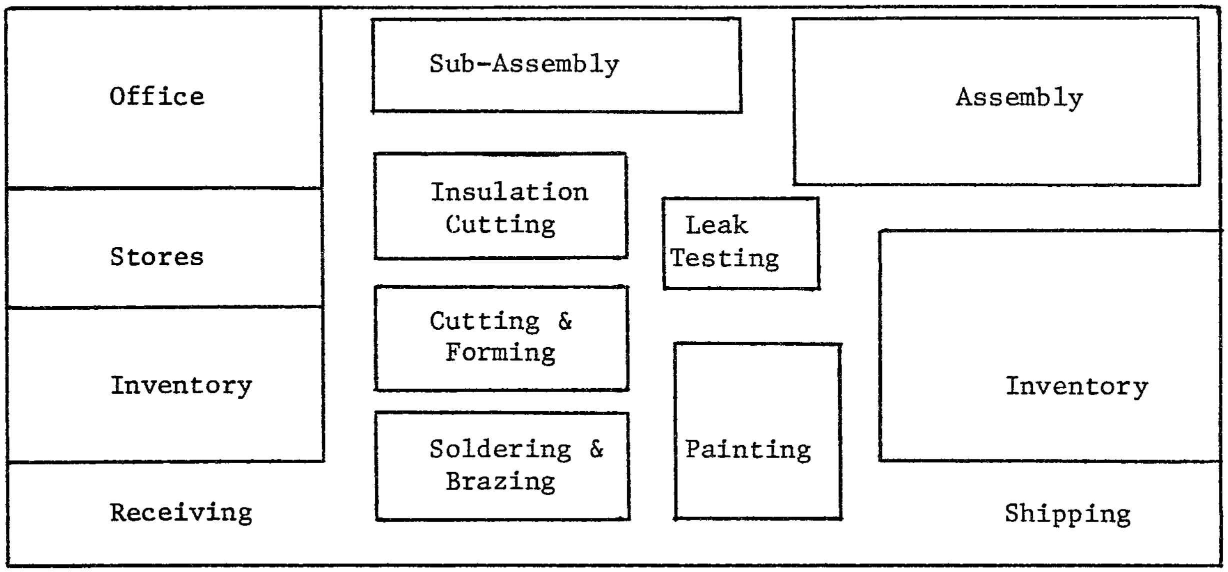


Figure 1.B Typical Layout of an Active Solar Collector Assembly Plant



plement of salespeople, managers, accountants, secretaries, and typists.

Number of Jobs

Several recent studies have attempted to quantify the number of jobs produced by the growing active solar heating field, particularly as compared to other energy sources. In general, these studies indicate that to produce the same amount of energy, active solar heating systems create 2 to 8 times more direct jobs than conventional oil-, coal-, or nuclear-fired power plants at equivalent or lower cost. To provide space and water heat for the same number of homes, solar creates 55 to 80 times as many direct California jobs as liquified natural gas (LNG) at a much lower cost. Unfortunately, none of these studies deals comprehensively with the whole employment impact situation.*

Below, we present an overview of a few of these studies.

In the extensive report, *Jobs from the Sun*, the California Public Policy Center (CPPC) found that to "solarize" California, that is, to install solar collectors essentially wherever practical, would require 103,000 direct jobs (as defined above) for the 10-year period 1981–1990, or a total of 1,030,000 job-years. [17] There would be 20,500 jobs in collector manufacture and 82,300 in installation. Comparing these 103,000 jobs to the 302,000 California electric and electronic equipment and instruments manufacturing jobs in 1976 [18] or the 388,000 California current construction jobs [19], it is obvious that the solar industry could be a large employer. These 103,000 jobs represent about 1% of the 10,000,000-person workforce in California.

CPPC also calculated the number of jobs required in indirect manufacturing (as defined above) and employment resulting from the increased purchase of goods and services by those employed directly and indirectly in the solar industry (induced jobs).†

* Recently the Exploratory Project for Economic Alternatives (EPEA) extensively reviewed most of these job studies. In a draft report supplied by Meg Schacter, they identify many shortcomings of the various analyses: no comparison of the qualitative aspects of jobs created or social costs, different time periods used for different options, cost discount rates set implicitly at zero, omission of all but initial capital costs, cost of back-up power neglected, and energy conversion and transmission losses neglected. [16]

† Calculation of these numbers of jobs is a difficult process requiring a detailed analysis. CPPC unfortunately uses a very simplified technique, and performed it incorrectly. They employed a simple 2.2 multiplier that should be used to calculate the total number of jobs from the direct

Table 1.4 Direct Solar Jobs Projected in 1985 [22]

	California Region	Nationwide
Collector Manufacture		
Manual	2,420	9,400
Supervisory	240	900
Administrative	350	1,400
System Design		
Contractor	1,240	5,000
Professional	1,110	4,500
System Installation		
Manual	7,970	31,500
Supervisory	1,500	5,900
Professional	1,910	7,600
Total	**16,740**	**66,300**

We prefer examining only the number of direct jobs because it is difficult to adequately calculate indirect/induced jobs and identify the social benefits of this employment (as compared to the more obvious benefits or lack of benefits of a particular direct job).

The full CPPC solarization process would be a very large undertaking. It would require that 75% of all existing homes and 95% of all existing multifamily residences (apartments, etc.) be retrofit with active solar heating systems, and 100% of all new housing units be built with solar. Large amounts of commercial and industrial space would similarly be solar heated. This is such a large task that the CPPC job estimate, it would seem, must be regarded as an upper limit.

Another more probable estimate of number of solar jobs is contained in a draft report prepared by the MITRE Corporation. MITRE concludes that in order to meet the stated goal of 2.5 million solar heating, cooling, and hot water systems in 1985 as set forth in the President's April 1977 energy program, there will be 66,300 direct solar jobs in the United States in 1985. The California-Southern Oregon Region will have 16,700 of these. [22] A summary list of these jobs is shown in Table 1.4.

The CPPC solarization discussed above involves the installation of 3.98 billion square feet of solar collectors. [23] At $ 25 per square foot installed,* this would total $100 billion, a seemingly large cost. But it must be compared with the cost of other energy sources producing equivalent quantities of energy.

The CPPC assumes that solar collectors will mostly displace natural gas and that as U.S. supplies run out, liquified natural gas (LNG) from Indonesia and Alaska will be solar energy's main competitor. With these assumptions and cost estimates generated by the Jet Propulsion Laboratory (JPL), they came up with the comparison shown in Table 1.5. [24]

As the table shows, to produce the same amount of energy, LNG will cost 1.5 times as much and generate 55 to 80 times fewer California jobs than the solar equivalent.

As natural gas supplies dwindle, electric resistance heat or heat pumps may become the dominant

jobs. But they used this multiplier to calculate indirect/induced jobs and *added* that figure to the direct jobs. Then they calculated distribution jobs as 25% of the direct jobs and added that in. This raised the direct-to-total jobs multiplier to 3.45 — not as conservative an estimate as projected. [20]

The exact magnitude is unknown, but it can be safely assumed that the number of indirect and induced jobs will be large, perhaps 2 to 5 times the total number of direct jobs. [21]

* Approximately today's costs.

Table 1.5 Direct Labor Requirements in California for Solar and Liquified Natural Gas Facilities — Construction and Operation [24]

Source	LNG (a)	Solar (equivalent energy)
Energy Delivered (Billion cubic feet of natural gas or equivalent annually)	474.5	474.5
Total Cost (billions of dollars)	$42.7	$ 27.9 (b)
California Employment (Direct job-years over a 20-year period)	7,600	420,000 – 600,000 (c)

(a) This analysis excludes jobs created at gas fields and LNG ports overseas and those involved in shipbuilding and shipping.

(b) This figure was calculated from CPPC's assumption of $20 billion for 340 billion cubic feet of natural gas equivalent. It assumes a rather low installed collector cost of $10 per square foot. [25]

(c) These numbers were generated by EPEA, based on a similar calculation by CPPC, but corrected. [26]

heating source. In fact, already in California, about 30% of new housing units are electrically heated, and most of these electric units are resistance heaters (a small proportion are heat pumps). [27] In the U.S. as a whole, the figure is even higher with 47% of all new dwellings having electric heat (in 1974). [28] The labor requirements of solar heating and electricity generation/electric heat are compared in many studies.

A recent report prepared by the Congressional Office of Technology Assessment (OTA) compared the direct labor needed in various solar energy systems with those for a coal-fired electricity generating plant. [29] The labor requirements for the coal plant included all labor to construct the plant, to build the 800 MWe turbine-generator in a factory, to operate the generating facility at an average of 57 per cent full capacity for its 30-year life, to strip mine enough western coal to support the plant, to transport the 2.5 million tons of coal per year needed to operate the plant, and to construct and maintain an electricity and distribution network. The labor requirements for the solar systems included those for manufacturing and installing the collectors, routine operation and maintenance, and conventional back-up over their 20-year lives. The results are listed in Table 1.6 and indicate that solar is 1.4 to 2.2 times more labor intensive.

Analyzing the employment impact of solar, the OTA concludes that: "A large fraction of the value of solar equipment is attributable to direct labor costs. The high labor intensity of solar equipment is not surprising. Most devices can be constructed from relatively inexpensive material, and the small

Table 1.6 Direct Labor Requirements for a Coal-Fired Power Plant and Solar — Construction and Operation [30]

Project	Job-hours per MW-year
Conventional 800 MWe Coal-fired Power Plant	2,348
Solar Hot Water System	3,200 – 4,900
Solar Hot Water System with Backup	3,540 – 5,240

Table 1.7 Direct Labor Requirements for Nuclear Power Plants and Solar — Construction and Operation [31]

Project	Conservation/Solar (a)	Nuclear (b)
Details	963,000 'packages' of conservation and solar measures	Two 1,150 MWe pressurized water nuclear reactors
Job Requirements (Job-Years)		
On site	75,120	27,880
Direct manufacture	36,350	11,030
Operation and Maintenance	66,880	27,700
Total	**178,350**	**66,610**
Energy Output (10^{15} BTUs) (over 30 years)	1.8	0.88 (at end use)
Total Costs (billion 1976 dollars) (over 30 years)	$ 5.9 (c)	$ 6.8
Cost / Job- Y ea r	$ 33,000	$102,000
Cost / 10^6 BTU	$3.28	$ 7.73
Jobs / 10^{12} BTU	99	76

(a) Conservation/Solar includes installation and materials.

(b) Nuclear includes construction, reserve, transmission, and distribution.

(c) The solar systems are assumed to cost $45 per square foot installed.

equipment examined here would not require extensive capital-carrying charges during construction."

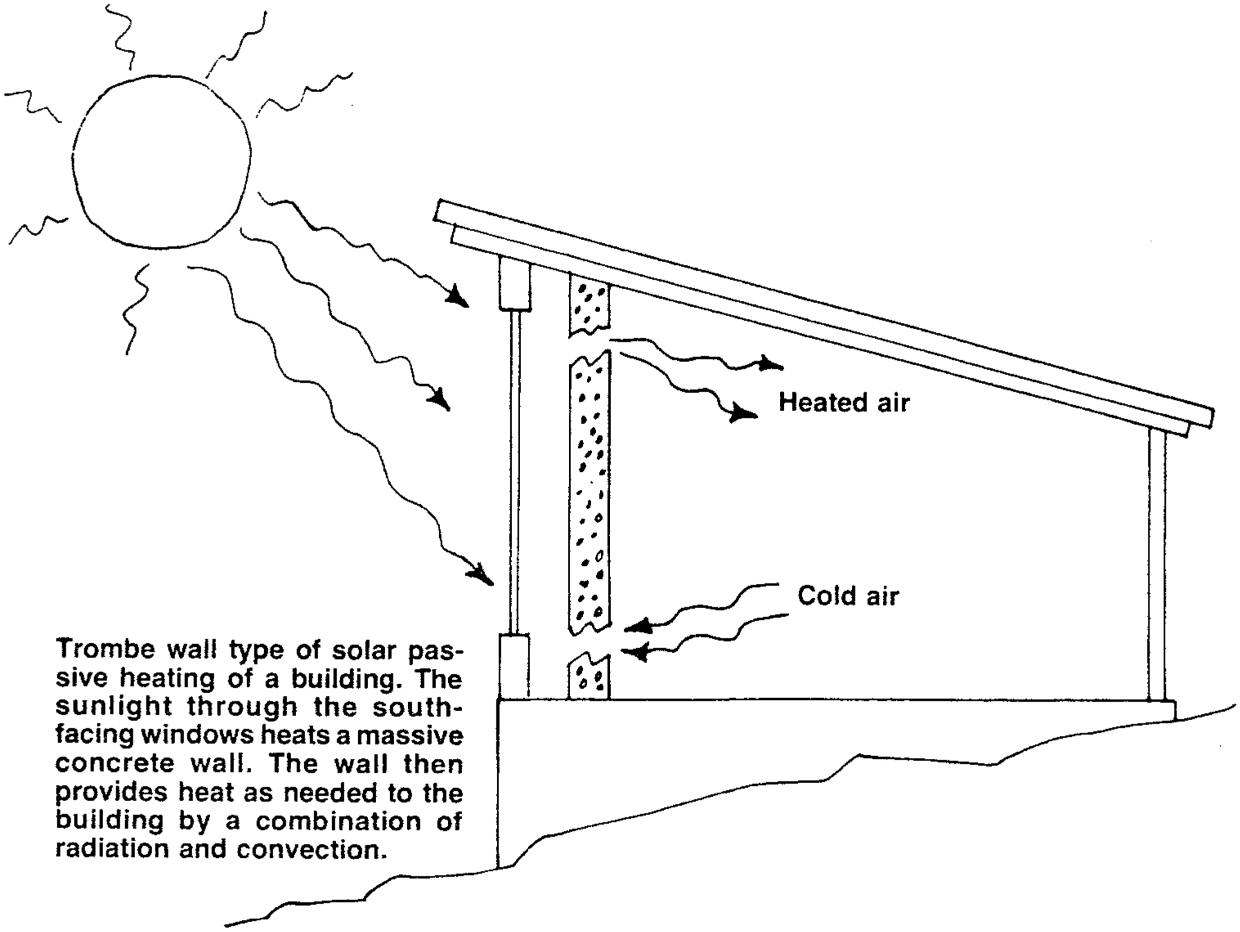
The most comprehensive job-energy-cost analysis is currently being conducted by the Council on Economic Priorities (CEP). They are investigating the potential for conservation/solar space and water heating as an alternative to two proposed nuclear power plants on Long Island, New York. [31] James Benson, in testimony before the Congressional Joint Economic Committee on March 15, 1978, presented the data listed in Table 1.7. This study indicates that the conservation/solar option provides 2.7 times as many jobs and 2.0 times as much energy at a cost only 87% as much as the nuclear option. Solar/conservation is clearly the better option on all counts.

These studies assume many factors that cannot easily be assessed; still they all indicate that to heat buildings or water, solar energy is cost-effective and provides many more jobs than conventional energy sources. These jobs, involving manufacture and installation of active solar heating equipment, are similar to those in appliance manufacturing and conventional building trades construction.

PASSIVE (DIRECT) SOLAR HEATING

In contrast to buildings that use special solar collectors and complex pump systems, a passively heated building is designed so that the building itself is the solar collector and the storage tank. Large south-facing windows admit the winter sun to warm the building naturally. Concrete, brick, or rock comprise part of the building's structure, or are specially added, to store the heat for nighttime and cloudy days. Steel drums set in the south side of the building can act as a thermal reservoir. Overhangs and deciduous trees shade the windows during the summer. Large quantities of insulation in the building's walls and roof keep the heat of the building from leaking out (and heat from leaking in during the summer).

Most passive solar heating systems are designed into new homes and buildings, but special add-ons can be used to retrofit existing buildings. Greenhouses attached to the south side of a house can



Trombe wall type of solar passive heating of a building. The sunlight through the south-facing windows heats a massive concrete wall. The wall then provides heat as needed to the building by a combination of radiation and convection.

collect solar heat that can be admitted to the house through windows or doors. And solar window box heaters, special air collectors that fit right into the windows, can be used to warm a room in a house.

Current Market Conditions

Passive solar heating seems to be the cheapest way to heat buildings. But since the heating system is usually an integral part of the building, it is difficult to accurately determine the additional cost of the heating system. This dual function of the structural components of the building accounts for the low cost of passive heating.

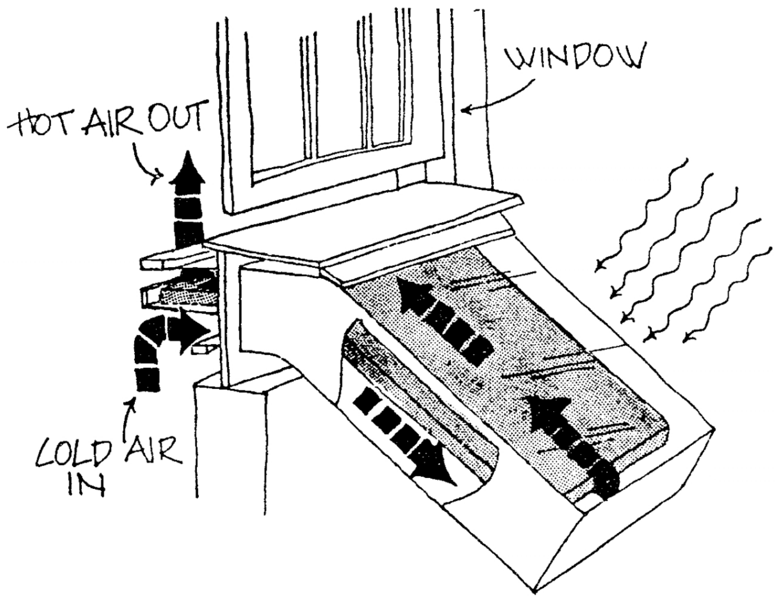
A typical passively heated home should only cost more than a non-passively heated home by the amounts shown in Table 1.8.*

* The added cost above that for a conventional house goes to pay the designers and builders of the passive solar heater components. This added value is the source of the additional jobs provided by this industry.

For new buildings, some passive design techniques cost essentially nothing; for example, the orientation of the building and the window sizing and spacing can play important roles in utilizing solar energy. Depending on climate, passive solar heat should be able to supply 40% to 100% of the heat required for new homes and perhaps 20% to 50% of the heat for a retrofit. [33] James Benson, director of the CEP study, notes that, "Passive heating and cooling costs little or nothing in new buildings. It is as close as one can come to a free lunch." [34]

Passive solar heating is necessarily decentralized since each building must heat itself. Passive systems are particularly convenient because they have few or no parts that need maintenance or can wear out. Once the building has been designed and built, it continues to provide heat as needed as long as the building exists.

Passive heating is the easiest way to provide heat for a home, but its widespread use is hindered by many institutional barriers such as building codes



A window box heater for warming a single room. Cool air flows down through the bottom passageway and is warmed by the sun on its return flow above a blackened partition. Glass or plastic covers the window box surface. At night the box is sealed off from the room.

(often obsolete), an innovation-reluctant building industry, and inherent misallocation of the costs and benefits (builders versus buyers, landlords versus tenants, etc.). Furthermore, there are no large companies or other powerful constituencies who stand to gain significantly from passive design, and many who stand to lose if it is widely adopted. Since there are no easily packaged products to promote and market, most consumers are unaware of the contribution that passive solar could make. Still, given its many advantages, passive should grow rapidly. In testimony before the California Energy Commission, the Natural Resources Defense Council concluded: "It is clear that passive design offers the most immediate hope of cost-effective utilization of solar energy for space heating." [35]

Types of Jobs

The components of a passive solar heating system are, in general, conventional building materials: glass, building block, concrete, wood, tile, insulation, ductwork, and fans. As passive solar heating becomes more widespread, jobs will be created for building trades people who will install these components, and there will be more jobs in the industries that produce these building materials. Carpenters, glaziers, sheetmetal workers, brick layers, and laborers will be required for passive installations. To design, size, and specify passive systems will involve engineering consultants, technicians, architects, and drafters. And, of course, there will be a need for salespeople, secretaries, typists, and accountants to provide support functions for this new industry.

Table 1.8 The Cost of Passive Heating Systems (Installed) in California [32]

	New Building	Retrofit Application
Space Heating (1-4 rooms)	—	$200 – 1,000
Space Heating (single-family home)	$1,000 – 5,000	$2,000 – 5,000
Space Heating (multi-family home, apartment)	$1,500 – 3,000	—

Table 1.9 Calculation of Direct and Indirect Labor Requirements for Passive Solar Retrofit Construction — 1981–1985 in California [36]

	Low Estimate	High Estimate
Current single-family homes	5,300,000	5,300,000
Percent that could be retrofit with passive heating	10%	20%
Current multi-family homes	2,800,000	2,800,000
Percent that could be retrofit with passive heating	5%	5%
Total passive heating installations	670,000	1,340,000
Cost per installation	$ 2,000	$ 5,000
Amount of cost that goes for wages (direct and indirect)	50%	50%
Typical wage	$20,000	$20,000
Number of job-years required (direct and indirect)	33,500	167,500
Number of jobs per year for 5 years, 1981–1985 (direct and indirect)	6,700	33,500
Direct construction trades jobs (1/2 of above)	3,400	16,800
Total cost (billions of dollars)	$1.3	$6.7

Number of Jobs

To our knowledge, there are no studies predicting the number of jobs created by installing passive solar heating systems. But some ballpark numbers can be generated by making a few simple assumptions. We found that about 4,500 to 17,900 construction jobs could be created in California by building and retrofitting passive houses. Our calculations are explained below.

There are approximately 5,300,000 single-family homes in California and about 2,800,000 multi-family units. [36] We can assume conservatively that 10% to 20% of the single-family homes and 5% to 10% of the multi-family homes could be retrofitted by 1985 with a south-facing greenhouse or solar wall. Many homes would, of course, be unsuitable for passive systems because they are shaded by trees or other buildings or they do not have a large south-facing exterior.

The typical installation, we can assume, would cost approximately $2,000 to $5,000, half of this cost going for materials and the other half paying for construction, design, and administration. Assuming the typical construction worker, designer, or administrator earns $20,000 per year, the number of direct and indirect job-years created would be 33,500 to 167,500. Over the 5-year period of 1981–198 5, this would be 6,700 to 33,500 jobs each year. At least half of these would be trades jobs in construction and installation. These 3,400 to 16,800 construction jobs represent 1 to 4% of the total California construction work force of about 388,000. [37] A summary of these calculations is shown in Table 1.9.

About the same number of jobs would be required to incorporate passive heating on new homes as shown in Table 1.10. A similar number of jobs would be created by installing passive heaters on commercial and industrial buildings.

Passive heat is the cheapest, most environmentally benign, decentralized, renewable way to heat buildings, and it also has the potential to provide many jobs in industries and crafts. These jobs would

Table 1.10 Calculation of Direct and Indirect Labor Requirements for Passive Solar Construction on New Homes — 1981–1985 in California

	Low Estimate	High Estimate
Total new single-family homes built 1981–1985 (JPL estimate)	280,000	280,000
Percent that could be passively heated	40%	70%
Total new multi-family homes built 1981–1985 (JPL estimate)	550,000	550,000
Percent that could be passively heated	40%	60%
Total passive heating installations	332,000	526,000
Cost per installation	$ 1,500	$ 5,000
Amount of cost that goes for wages (direct and indirect)	50%	50%
Typical wage	$ 20,000	$ 20,000
Number of job-years required (direct and indirect)	12,450	65,750
Number of jobs per year for 5 years, 1981–1985 (direct and indirect)	2,490	13,150
Direct construction trades jobs (% of above)	1,250	6,580
Total cost (billions of dollars)	$ 0.5	$ 2.6

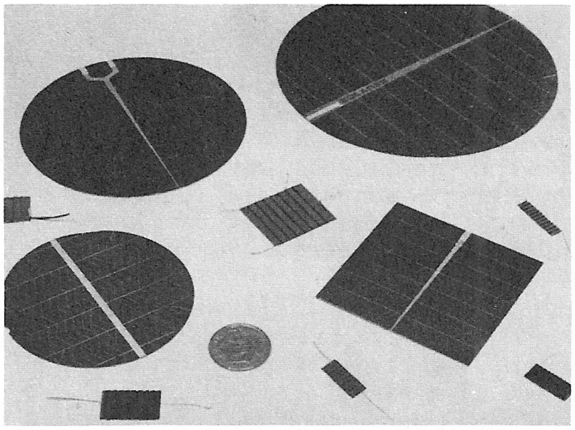
require virtually no skills retraining because the tasks performed are traditional construction jobs. More should be done to explore the potential of this technology.

PHOTOVOLTAIC CELLS

Photovoltaic (solar) cells are the simplest and cleanest operating devices known to produce electricity. They have no moving parts and are consequently quiet, pollution free, extremely reliable, and easy to operate.

Certain specially constructed semi-conductor materials, similar to the silicon chips produced by the electronics industry, when exposed to sunlight, develop an electrical voltage potential. This potential can be tapped just like the voltage of a flashlight battery. These "solar cells" or "photovoltaic cells" are interconnected in series/parallel fashion to provide the required voltage and amperage. The DC power generated can be changed to AC with an inverter. A collection of these solar cells, referred to as solar arrays, could be mounted on the roof to supply the electrical needs of a building.

The manufacture of solar cells is currently similar to the manufacture of electronic integrated circuits (ICs): large single-crystal silicon boules are grown and sliced into thin wafers. The wafers are doped with a small amount of boron or phosphorous to give them their special electrical characteristics. Electrodes are then deposited on the wafer surface for electrical contacts. Next, the cell is coated with an anti-reflective coating to reduce losses due to reflection. These wafers are subsequently sandwiched between layers of glass or plastic (to protect them from the elements), and formed into flat array panels 3 to 10 square feet in size.


Solarex Corporation

Current Market Conditions

Current solar cell prices of about $15 per peak watt (Wp)* are 30 to 100 times that of electricity produced in conventional power plants. As explained below, refinements of existing technologies and expanded production capacity will probably lead to photovoltaic prices in the $1–2 Wp range by the mid-1980s — making them competitive with diesel generators. Major technological advancement, required for price reductions allowing broad commercial applications, may not occur until the 1990s or later. [38]

Photovoltaic development will probably not be accomplished by small business. Because of the technological complexity and capital required for research and development, large high-technology firms like Motorola and Exxon have come to dominate the market.

Supporting these conclusions is the work of Gnostic Concepts, a market research firm in Menlo Park, California. Gnostic completed, in December 1977, a comprehensive project examining photovoltaic market opportunities. Although Gnostic's 18-month study is proprietary to their clients, we gained a general picture of their projections through interviewing Douglas L. Finch, Project Director. [39] We drew two important findings from Gnostic's research. First, to remain competitive, photovoltaic firms will probably experience two major turnovers of capital equipment and technology before photovoltaics penetrate bulk energy markets in the U.S. in the 1990s. Second, firms best suited for entry into the market are large, diversified, high-technology companies with international marketing capabilities and revenue exceeding one billion dollars per year. We discuss this latter point fully in Chapter 3.

Photovoltaic prices and technologies. Finch discussed three phases that are likely to characterize photovoltaic markets before 1990 — the short-run, medium-term, and bulk energy phases. In the short run, photovoltaic firms must depend upon government development and demonstration contracts and applications in remote areas far from transmission lines. Within 4 to 6 years, during the medium-term phase, present technologies will be refined enough for broader use in remote areas including third world nations. Purchasing this updated equipment will require a massive capital outlay. If the price falls to between $1–2/Wp, photovoltaics could compete domestically with electricity produced by diesel generators. In the third world, irrigation water pumping and communications will become attractive markets. Yet Finch stressed the need to develop a new, highly automated technology — such as thin film — in order to reach bulk energy markets (widespread commercial and residential use). Thus, firms which pursue a strong market position in photovoltaic development must be prepared for possibly two complete turnovers of capital equipment inside 15 years.

These projections are confirmed by other information we collected. Solar cells have been used in terrestrial (earth) applications for many years and as the cost has dropped, many additional applications have been found. In 1977, about 900 kilowatts of solar cells were installed, twice the 1976 volume. [40] Some of these were purchased as part of the federal government demonstration program, but most of them were for power supply applications on oil rigs, signal buoys, satellites, remote communication systems, and corrosion protection devices for pipelines.

In the medium-term, prices should drop about 10-fold. Scientists at the Jet Propulsion Laboratory in Pasadena, who are overseeing the flat plate photovoltaic federal research and development program, hope to see the price drop to $0.50/Wp by 1986 (see

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* Peak power is the amount of electricity produced by a solar cell on a sunny day at noon (sun-light intensity = 100 mW/sq cm).

Figure 1.C Jet Propulsion Laboratory Price Goals for Flat-Plate Solar Cells [41]

Low-Cost Silicon Solar Array Project

Price Goals – Achievements

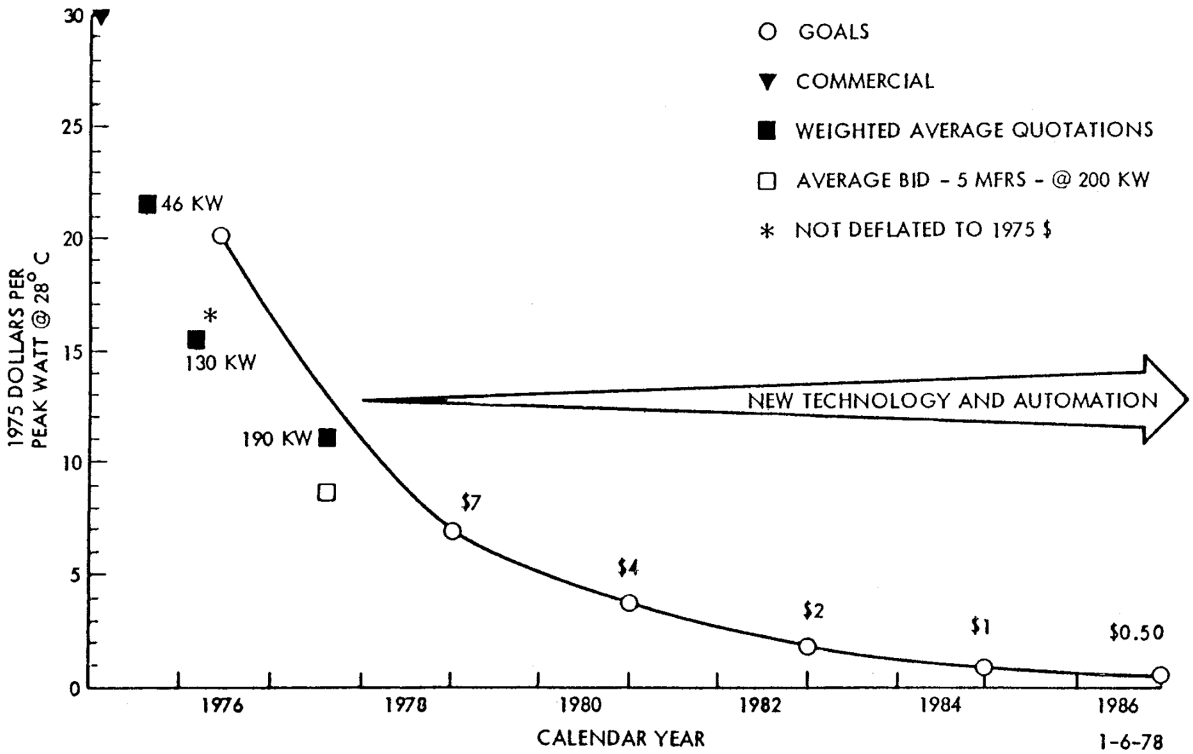


Figure 1.C). [41] So far, the cost goals have been met by increasing the demand for cells and by technical improvements in existing technologies. Some photovoltaic manufacturers we interviewed believed this trend would continue, but most were skeptical that price reductions using present technology would allow photovoltaics to penetrate mass energy markets.

A report prepared by the Federal Energy Administration in 1977 also predicts major price reductions, but this prediction is based primarily on a false comparison with other semiconductor devices. [42] Citing the rapid cost decreases in semiconductor technology, they conclude that if the Department of Defense bought 152 megawatts (peak) of solar cell remote generators instead of conventional gasoline or diesel generators over the period 1979–1983, solar cell prices would drop enough by 1983 that DoD's net outlay would be less than for the conventional equipment. Further, the cost of electricity produced at the end of the 5-year period would be competitive with commercial electricity supplied to numerous remote locations, such as reconnaissance stations in Alaska and Greenland.*

However, this analysis is faulty because the cost reductions achieved in the electronics field due to the miniaturization (photo-reduction etching) of components are not applicable to solar cells. The semiconductor industry has reduced costs by developing the means to deposit more electronic components on each wafer of silicon so that now several thousand transistors, diodes, capacitors, and resistors can be etched onto each small, electronic chip. This is accomplished by employing etching masks that have been photographically reduced in size several thousand-fold. Solar cells, on the other hand, consist

* They predicted a $0.75/Wp solar cell cost in 1983.

of just one electronic component — a photo-diode. Development of component miniaturization techniques does nothing to reduce costs of solar cells.

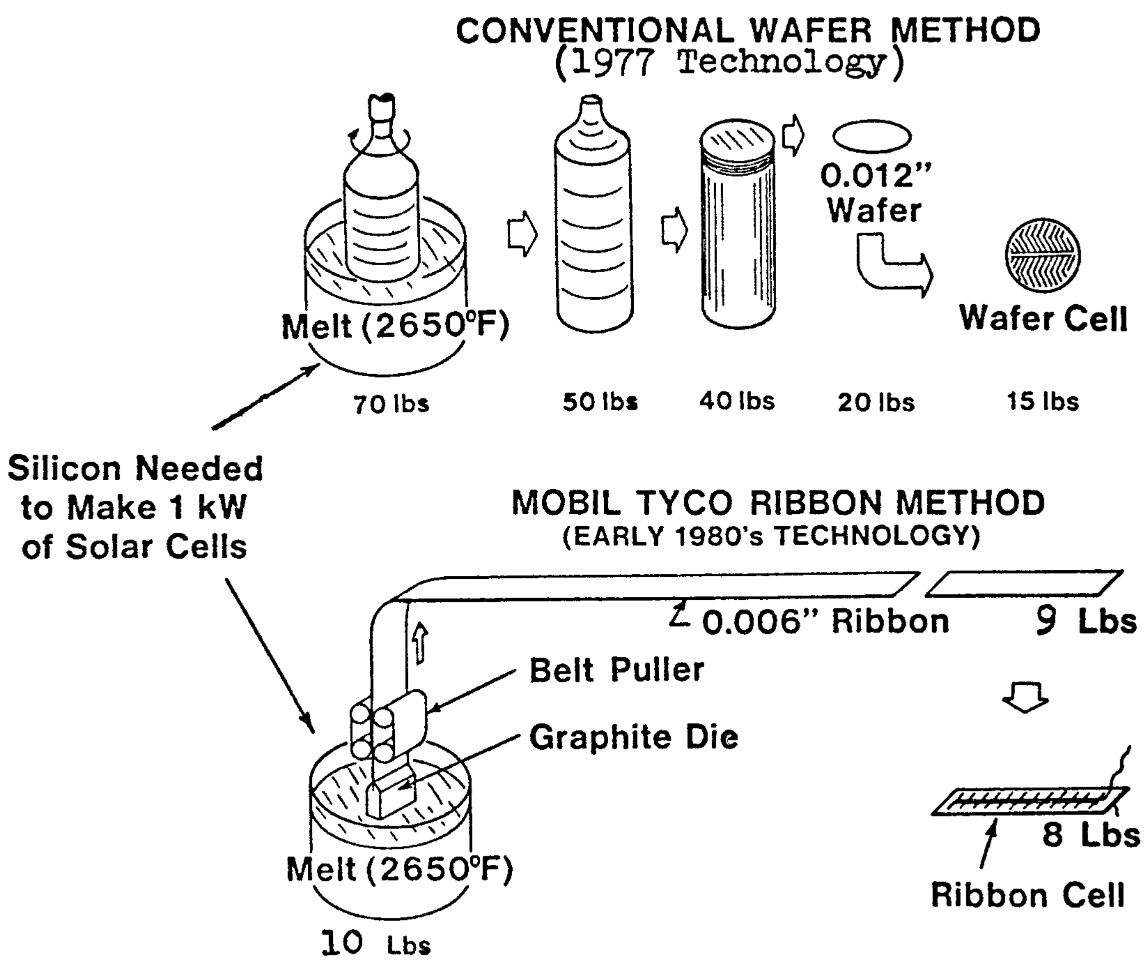
In the long term, cost reduction goals will require major technological innovations. Three general approaches are being pursued to achieve these goals:

• **Material Cost Reductions**. A large part of the current cost of solar cells is attributable to the extremely pure semiconductor-grade silicon that is used. This material currently costs about $60 per kilogram ($30/pound). [43] Moreover, it has been estimated that cells made with present techniques would have to operate between 6 and 12 years to recoup the energy expended in their manufacture. [44] In the medium-term, lower grade (less pure) silicon may be used or better crystal growing or wafer slicing techniques may be developed that waste less silicon. However, long-term cost reductions will probably result from a new silicon growth technology such as thin film. Mobil-Tyco, IBM, and Westinghouse Electric are working on a process for growing thin continuous ribbons of crystalline silicon. Mobil-Tyco's "edge-defined, film-fed growth" process (see Figure 1.D) has produced a ribbon 100 feet long, 1 inch wide, and 0.008 inch thick, pulled at a rate of about one inch per minute. [45] Using this technology, eventually photovoltaic cell factories may be as automated as paper mills.

Costs may also be cut by using materials cheaper than silicon. Cadmium sulfide, for example, offers the potential of equal efficiency, but at substantially lower cost.

• **More Efficient Materials**. Some materials like gallium arsenide are inherently more efficient than

Figure 1.D A Comparison of Two Methods of Producing Solar Cells [45]



silicon in converting sunlight to electricity. But these materials have prices even higher than silicon. Major cost reductions can be achieved, however, by using these cells in concentrator systems (see below). Another possibility that Varian Associates and others are pursuing involves layering various solar cell materials that are sensitive to different parts of the solar spectrum so that more of the incident sunlight is utilized.

• **Development of Concentrator Systems**. Because each solar cell is so expensive, costs can be cut by producing more electricity with each one. This is accomplished through the use of mirrors or lenses that direct more sunlight onto each cell. Silicon cells lose their efficiency at concentrations greater than 200 times, but other materials, such as gallium arsenide, maintain their performance up to 1,000 suns. Concentrating systems usually track the sun across the sky, requiring mechanical positioning equipment which adds costs and decreases reliability. Cells in concentrator systems must also be cooled since their performance will degrade significantly at high temperatures. These systems can, however, be engineered to use the heat extracted in the cell cooling process to provide hot water in addition to the electricity produced by the solar cells.

Skills and Number of Jobs

Currently about 1,000 people are employed in the photovoltaic industry. [46] These jobs are very similar to those in the electronics industry, but exclude those associated with circuit design, photoreduction, and mask-etching. The same types of health and safety problems common in the electronics industry — silicosis and handling strong acids and harsh chemicals are also endemic to the photovoltaic industry.

Because the manufacturing process will probably change considerably in the next 10 to 15 years, most of the new jobs created in this industry will involve research, prototype development, and pilot plant production. Varian Associates, for example, is developing its gallium arsenide cells just as it develops other new products with physicists, chemists, laboratory technicians, and prototype design engineers carrying out most of the work.

WIND ENERGY

Wind results from the uneven heating of the earth's surface by the sun. Thus it is an indirect form of solar energy. Wind power can pump water, as did the windmills that were once so common in the Midwest, or drive an electrical generator. Modern 2- or 3-bladed wind generators are sophisticated machines, aerodynamically-designed to convert the maximum amount of wind energy to electricity.

The power generated by a wind machine is directly proportional to the area swept out by the blades. So it is usually cheaper to build one large wind generator than many small ones to produce the same power. Also, the power generated is proportional to the cube of the wind velocity, so each additional mile per hour of average wind speed increases the power output greatly. These physical factors give large wind generators, located in windy (usually remote) places, an edge over smaller generators located at the point of end-use. However, smaller machines, 1 to 50 kilowatts (kW) in size, being simpler and more easily mass-produced, and not requiring extensive transmission lines, may be more economical overall.

In addition to the conventional horizontal-axis wind machines with the generator mounted on top of a tower, several designs have horizontal axes with the generator mounted at ground level. One such design, known as the Darrieus rotor, looks like a giant two-bladed eggbeater. A vertical machine has three big advantages over a horizontal-axis machine:

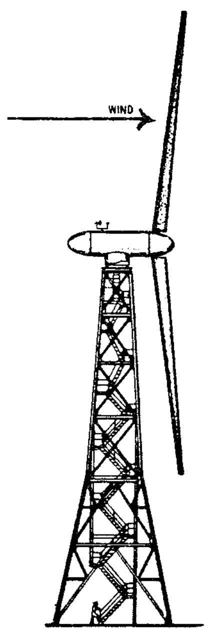
- It can accept wind from any direction and winds that shift direction rapidly.
- The generator is at the bottom so it is not as top-heavy and is more stable in high winds.
- It does not require a tall (expensive and ugly) tower.

Because of these advantages, the Darrieus rotor or some other innovative configuration may eventually become a commonly employed design.

Market Conditions

Both large and small wind generators appear to have great potential within the next decade. Since the mid-1800s, 6 million small windmills have been sold in the U.S. Electricity generating wind machines were first built on a large scale in the 1930s. These machines lost their popularity only when cheap natural gas and rural electrification became widespread. Now that these other energy supplies are growing expensive, wind power may become commonplace again.

One of the machines that powered many farmhouses in the 1930s, the Jacobs Wind Electric plant is being sold in reconditioned units for $1,000 to $1,800 per kilowatt in Vermont. [47] The Jacobs machines are sized at 2 and 3 kW. The Grumman Corporation has sold five prototypes of its new 15 kW wind turbine for about $1,300/kW. [48] A study prepared by JBF Corporation concludes that a 10 kW machine presently available (without electricity storage) could produce electricity at 15 cents/kW in 12 mile-per-hour average winds. [49] Electricity from a utility costs about 4 to 4.5 cents/kWh, but in remote locations, where new transmission lines must be installed, this high cost is competitive.



For large wind generators (0.5–2.0 MW), estimates of $400 to $800/kW have been made. Machines of this size are expected to be available in the early 1980s. "For the purpose of comparison, a wind turbine costing $600/kW and producing rated power 40–50% of the time can produce electricity at a cost roughly comparable to the cost of electricity from a coal- or oil-fired plant which costs about $1000/kW with pollution abatement equipment, and produces power about 67% of the time." [50] The problem of intermittent operation due to wind speed fluctuations can be compensated by tying several dispersed wind machines together or by coupling a wind machine to a hydroelectric project so that when the wind is generating power, water is held back.

The California Energy Commission staff has expressed interest in encouraging utilities to use wind energy. In a draft report they recommend that the state spend $13.25 million over the next five years to spur the commercialization of wind power by field testing available machines and prospecting for suitable windy locations. [51] California has many windy areas along the coast and in mountain passes in which to locate large numbers of wind machines. Many of these locations have average wind speeds of 13 miles per hour or more.

The federal government has an extensive wind energy program that coordinates and funds research, development, and demonstration projects at the small-scale, 100 kW-scale, and megawatt-scale. So far, they have built and installed a 200 kW experimental wind turbine generator in Clayton, New Mexico and a 100 kW machine in Plum Brook Station, Ohio. [52]

Skills and Number of Jobs

It is possible that thousands of large wind-generators will be installed by the late 1980s. Many jobs in the manufacturing and heavy construction industry would then open in this field.

For example, Lockheed predicts that when production and installation of wind generators rises to 8,000 a year, each 1 to 4 MW in size (which they feel could happen as soon as 1986), the direct labor required would consist of 645,900 people. Of these, 89.4% would work in the wind generator heavy manufacturing industry and 10.6% would work in heavy construction. [53] The manufacturing jobs would be equivalent to those in other heavy manufacturing or aerospace firms.

The Exploratory Project for Economic Alternatives, using MITRE Corporation data, estimates the number of 1.5 MW windmills produced and the number of manufacturing jobs that could be created with a $15 billion investment (see Table 1.11) [54]. This estimate is only for windmill manufacture and does not include site preparation, installation, operation, or maintenance. The cost/job-year figure indicates that wind generator production is more capital-intensive than flat-plate active solar heater production. But this production could still create substantial numbers of jobs.

Wind technology would require mechanical design and production engineers, technicians, inspectors, machinists, assemblers, electricians, and precision machine operators. These skills are very similar to those employed by a company like Lockheed or

Table 1.11 Direct Labor Requirements for Wind Generation (Manufacture only) [54]

Total Costs (billion 1976 dollars)	$15.0
Number of 1.5 MW Wind Generators Manufactured	13,400 – 20,400
Job Requirements for Manufacture (Job-Years)	147,000 – 223,000
Cost / Job- Year	$102,000 – $67,000

Boeing in aerospace. The construction jobs would consist of preparing the site by excavation and road building, constructing concrete foundations, and then erecting the tower and installing the wind generator.

SOLAR INDUSTRIAL PROCESS HEAT

Steam, hot water, and hot air are needed for many purposes in the industrial, commercial, and agricultural sectors for everything from paper manufacturing to food drying. Currently in California, approximately 14% of total thermal energy is utilized at temperatures below 350°F. [55] Somewhat less than half of this energy is utilized at temperatures below 212°F, and could be supplied by active solar collectors similar to those employed for space heating. Higher temperatures require more complex concentrating collectors.

General Electric and Owens-Illinois offer evacuated-tube collectors in which concentric glass tubes are separated by a vacuum. The inner tube is blackened to absorb solar radiation and the vacuum, being a very good insulator, prevents the heat from escaping. A painted white board behind the tubes reflects sunlight onto the receiver.

Several firms, including Acurex of Mountain View, California, build collectors in which a trough-shaped mirror reflects sunlight onto a blackened pipe. A control mechanism adjusts these collectors to track the sun as it moves across the sky, so that the sunlight is always focused on the receiver pipe. The tracking gear is unfortunately complex, expensive, and subject to failure. Furthermore, these collectors work well only on sunny days because they cannot focus diffuse light. These problems are not insurmountable though, and a well-designed system can provide a substantial amount of process heat at reasonable cost.

Right now, solar industrial heat is more expensive than conventional energy sources. But with development and with subsidies similar to those for other energy supplies, it will soon be cost-competitive. Environmental restrictions on fossil fuel combustion may also accelerate implementation of these systems.

Department of Energy Secretary Schlesinger recently stated in a Business Week interview, "Where solar technology can be most effectively applied is for low- and medium-grade heat requirements. We should put a great deal of emphasis behind an industrial process heat program. There is substantial potential demand, a substantial market, and by golly, it's nearly here, or should be nearly here." [56]

Skills and Number of Jobs

High-temperature solar collectors and equipment for process heat are similar in complexity to household appliances such as dishwashers and air conditioners. Their manufacture requires a wide-range of skills: engineers with design, structures, thermodynamics, heating, ventilating, and cooling (HVAC), and materials science backgrounds; technicians; inspectors; machinists; semi-skilled machine operators; and operatives. Installation would be similar to that for industrial air conditioners and would require HVAC engineers, crane operators, plumbers, welders, and unskilled workers. The number of jobs created should be substantial, but unfortunately, no studies have yet been conducted to verify the employment impact.

Chapter 2 Options for Military Workers

INTRODUCTION

One of the greatest assets of defense industry are the millions of military workers and their skills. Much can be done with the plants, equipment, companies and communities now reliant on defense production once a meaningful way is found to shift the skills of the workforce. This section discusses conditions necessary for shifting workers now engaged in military industry into solar production. Specifically, we examine the skill *transferability* of military workers to solar development, production, and installation. Broader questions of occupational conversion, such as wage differential, numbers and availability of jobs, and relocation are touched on but not analyzed in depth. It is beyond the scope of this study to consider two important aspects of the conversion question directly: the convertibility of plants and equipment, and national and community planning for economic adjustment.

In analyzing the jobs found in defense industry, and considering their transferability to solar technologies, we found the following:

- Clerical and support workers can move into solar work with little or no retraining.
- Semi-skilled assembly workers have highly transferable skills, and can move immediately to solar assembly.
- Skilled craft workers and machinists can move readily into solar technologies, although certain highly skilled workers will need retraining.
- Technicians, many of whose skills are highly specific to defense work, will have difficulty matching their exact jobs in solar work, but minimal retraining will fit them for solar jobs.
- Engineers and managers will require major reorientation to the civilian marketplace.
- Wind energy systems offer the clearest job skill matchup for aerospace workers of any solar technology surveyed.
- Numbers of job transfers from military to solar will depend on the magnitude of commitment on the part of government and industry to solar development.

Since the largest number of military workers are in production, we examine various production jobs in solar technologies and compare them, category by category, with jobs in military industry. In considering the special problems of defense engineers in research and development, we compiled case studies of two Santa Clara County military firms which have diversified into solar development: Acurex Corporation and Varian Associates. Finally, we explore the ways that military workers can participate in the process of planning for conversion by examining conversion planning at Lucas Aerospace in Britain.

TRANSFERABILITY OF DEFENSE INDUSTRY JOBS

Jobs in military industry break down into four basic categories (in descending order of numbers of workers): (1) production workers, both skilled and semiskilled; (2) engineers, scientists, and highly skilled technicians; (3) clerical and unskilled support staff; and (4) management and administration.

The majority of defense workers are blue collar (production) workers, or clerical and support staff, occupations which might be found in any industry. About 20% to 30% of the workers, however, have occupations specific to defense work. [1] Certain defense firms have even higher percentages of scientific, engineering, and specialized technical staff, particularly those engaged in a significant amount of research and development work.* [2]

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* Some 35% of military workers are organized in trade unions. Most of these workers are organized by the International Association of Machinists and Aerospace Workers (IAM) and the United Automobile, Aerospace, and Agricultural Implement Workers (UAW). In addition, several other unions have workers employed in military work, including the United Steel Workers, the International Union of Steel Workers, the Oil, Chemical, and Atomic Workers (OCAW), the United Electrical Workers (UE), the International Union of Electrical Workers (IUE), the International Brotherhood of Electrical Workers (IBEW), and the Communication Workers of America (CWA).

All told, approximately 350,000 military production

Transferring Clerical and Support Staff

Nearly all clerical and support staff can transfer from military to civilian work since their skills are not military-specific. A clerk-typist can easily change from being a clerk-typist for Grumman Aerospace to being a clerk-typist for Grumman Energy Systems. The only exceptions are a few highly trained clerical personnel and unusual defense firm support jobs which are rarely found in civilian industry.

Transferring Managers and Administrators

Management personnel of military corporations cannot easily transfer to civilian work for two major reasons: (1) they deal with the U.S. government almost exclusively and are therefore inexperienced in working in a commercial market, and (2) there are far more of them at higher rates of pay in military companies than in civilian firms. [3]

Managers (division, department, sales, marketing, and personnel) of prime military contractors and subcontractors do their business with one customer, the Department of Defense. Normal marketing skills are not as necessary. Instead, managers in military plants and divisions learn, in exhaustive detail, the procurement practices of the U.S. Army, Air Force, and Navy, and the details of regulations involved in foreign military sales. [4]

As a result, many military industry managers are not oriented to managing for the lowest possible costs. Instead, many have worked on contracts for the military which have operated on cost-plus principles. In these contracts, all the company's costs are paid, plus a guaranteed profit margin. Companies are often rewarded with higher total profits if the product is completed at the highest possible cost. This is not the same as in civilian industry, where it is important to reduce costs. [5]

Secondly, there are more managers per worker in defense companies than in civilian firms. No commercial firm could employ the full number of managers left idle by a defense close-down. [6]

workers are organized into unions, out of a total national labor force of nearly 1 million production workers. [3] The other 65% of military workers are not organized. These include not only engineers, managers, and technicians, but also production and assembly workers in the military-electronics industry that is largely unorganized, especially in the South and West.

Conversion of military management will require major reorientation from government to civilian work, and from cost escalation to cost reduction. Some managers will in all likelihood have to relocate and take jobs in other industries.

Skill Transfer of Production Workers

Skilled and semi-skilled production workers remain the heart of military industry. The higher their level of skill and the narrower their specialization, the more difficult is the problem of skill transfer and conversion to civilian jobs.

The government has not closely studied the impact on individual workers when firms lose military contracts, and only occasionally has analyzed the convertibility of various job skills. The only detailed studies of job skill transfer of military production workers were commissioned by the Arms Control and Disarmament Agency (ACDA) in the late 1960s. These included studies of three major layoffs which took place immediately prior to the Viet Nam buildup at Boeing in Seattle, Martin-Marietta in Denver, and Republic Aviation on Long Island. [7] The Boeing and Martin Marietta studies dealt with worker experience in transferring from defense to non-defense industry, and their attitudes toward such a shift, but did not analyze in detail the job skill transferability of production workers. The Republic study dealt only briefly with job transferability.

To our knowledge, only one study has been done which analyzes in great detail the job skill transferability of a sample of military production workers.* This study, *The Potential Transfer of Industrial Skills from Defense to Non-Defense Industries*, was completed in 1968 by the California Department of Labor for the ACDA. The study found that almost all jobs examined were transferable. [8]

Using 1966 data, *Potential Transfer* analyzed 127 occupations in which 5,600 workers were employed at two missile manufacturing plants: Aerojet General in Sacramento, which produces rocket engines and missile parts; and Lockheed Missiles and Space Company in Sunnyvale, which manufactures missile air frames, re-entry systems, and space vehicles. The study focused on technical and production occupations such as fabrication, assembly, testing, and in-

* A non-government study of transfer problems of production workers at Hughes Aircraft was completed by Trevor Bain for the University of Arizona in 1968. [9]

spection, but did not deal with engineers and scientists.

The first stage of the study was a detailed job analysis of 99 occupations, which were specifically related to missile work, to determine counterpart occupations in other industries. This analysis included an assessment of the machines, tools, equipment, and work aids involved, as well as basic knowledge, skill, and training required of the worker. This was and remains necessary because there are no standardized job titles in the defense industry, making it difficult to correlate them with job classifications in other industries. As the 1968 study indicated, "most defense jobs, which appear to be unique, can be related to counterparts in other industries, if they are broken down into their component duties."* [10]

All but six of the 127 occupations examined could be matched with at least one non-defense occupation. The only occupations not found to be transferable without major retraining (more than 6 months), were the six dealing with missile propulsion systems. [11]

The second phase of the study examined the long-run market outlook for the counterpart occupation. Employers in civilian industry were surveyed, asked about job openings for the counterpart occupations, and queried concerning employment prospects for defense workers. About half the occupations (47%) were found to have good or fair employment prospects, and 62% had no apparent barriers to transfer. One barrier to transfer to civilian jobs is the wage differential between military and civilian industry. Most wages for non-defense occupations were found to be below those for similar defense occupations.† [12] In spite of these salary differentials, however, the ACDA studies have found that defense workers have shown wage flexibility in seeking and accepting other employment.

The basic results of the 1968 study — that production workers' skills are readily transferable to civilian occupations, but that salary, mobility, and to some degree, specialization create barriers to conversion for these workers — were confirmed in the recent experience of laid-off B-1 workers in Southern California. The B-1 workers conform to the Lockheed and Aerojet General samples of 1968. They are predominantly technical (54.2%) and bench-machinist (39.4%) in skill composition, with the remainder in clerical and support services. The bench-machinist production workers include such jobs as mechanic, milling machine operator, electronic assembler, structures mechanic, and tool and die maker. These skills are found readily in civilian industry. It is more difficult to find counterparts for the technical-engineering jobs in civilian industry (see below). [14]

Unfortunately, we do not know the outcome of the B-1 workers' involuntary search for civilian jobs. The two studies of the B-1 economic impact (one by the Department of Defense Office of Economic Adjustment and the other by the State of California's Business and Transportation Agency) were completed in September and November of 1977, while workers were still being laid off.‡ The studies' conclusions are necessarily tentative, since no one is tracking the workers, and it takes up to two years for some workers to find new jobs. In addition, we are hampered in analyzing the data and experience of the B-1 workers by the unequal character of the data of the two studies.§ [15]

Production Worker Job Skill Matching. As one example of the job skill transferability of mili-

* "There were a number of seemingly defense-unique occupations which turned out to be otherwise. The 'Planetary Cable Stranding Machine Operator,' for example, operates a machine that fabricates wire rope or electric cable. Aside from adhering to the rigid standards set by the defense plant, his duties are the same whether the fabricated wire is used in an automobile, missile, ship, or as an electrical component of other devices." [10]

† "A much heavier concentration of scientific, engineering, and technical skills exist among defense workers, and their concomitant higher salaries tend to raise the wages of production and other lower-skilled workers in the defense industry." [13]

‡ Another, much more exhaustive study was originally commissioned by ACDA to the Council on Economic Priorities, but was canceled before formal contract signing. [15]

§ The Business and Transportation Agency study was published in December 1977 based on September 10 layoff total of 6,037 workers, but without a detailed analysis of the jobs skills of the workers affected. The OEA study, published in September 1977 analyzed 4,532 laid-off workers as of August 10, but occupational breakdowns obtained separately from Rockwell International, UAW local 887, and California Employment Development Department (EDD) did not mesh, and no attempt was made to correlate the findings.

Table 2.1 Military/Solar Job Creation at Lockheed Missiles and Space [16]

Prime Military Contracts, FY 1977	$918 million
Employment, 1977	16,000
Job-Years, 30-year period	480,000
Job- Years, 30-year equivalent solar commitment	446,000 – 840,000 (a)

(a) Calculated on the basis of a combined wind and active/industrial systems approach, using figures from California Public Policy Center and the Exploratory Project for Economic Alternatives use of MITRE data. [16]

tary production workers, we examined skilled and semi-skilled job categories of the International Association of Machinists and Aerospace Workers (IAM) at Lockheed Missiles and Space Company (LMSC) in Sunnyvale, California. We compared these categories to job skills in the solar industry. We found, in general, that skilled machinists and craft workers are easily matched, and that semi-skilled operatives are matched almost as easily. Military technicians, although readily trained for solar technicians' jobs, had few ready avenues for their specific skills in solar industry as it has developed to date.

Our work in matching existing job skills found in military-aerospace industry with jobs found in an emerging solar industry has been handicapped by the lack of development and experience in the solar industry. It is also difficult to assess the potential numbers of certain jobs available in solar work without a sense of the magnitude of commitment on the part of government and industry to the solar field. For the purposes of this study, we have assumed a major, thirty-year commitment to solar development in the four technologies outlined (active, passive, photovoltaics, and wind) on the part of state and federal government and private industry.

Lockheed Sunnyvale received $918 million in 1977 in prime contracts for the production of Trident and Polaris missiles, satellites, and reconnaissance systems. This $918 million employed 16,000 workers at the Sunnyvale plant. An equivalent commitment of $918 million per year for 30 years to solar energy technologies would provide from 446,000 to 840,000 job-years, compared to 480,000 for military systems over the same period of time (see Table 2.1). [16]

Comparing military jobs only to solar jobs leaves out a vast array of other job matches in such areas as transportation, medical equipment, heavy industry, shipbuilding, housing, or electronics. Consideration of all these fields is beyond the scope of this study, but such consideration would be essential to providing jobs for all Lockheed workers.* [17]

We assessed 162 skilled and semi-skilled job categories covering 2,115 members of the IAM at LMSC in Sunnyvale, California. Job categories were grouped into three broad areas: operatives (semi-skilled), skilled, and technicians. Not included were another 2,500 jobs in clerical/administrative support and plant support, most of which are readily transferable. Also not included were engineers, managers, and other non-IAM workers at Lockheed, on which no data were available. [18]

For solar matches, we look at the four solar technologies surveyed in this report: active, passive, photovoltaic, and wind, as well as solar industrial applications, to determine what corresponding job fits the description of the military job, with a minimum of retraining. Not included in this consideration of solar technologies and potential jobs are several high technology areas such as Ocean Thermal Energy Conversion (OTEC), Satellite Solar Power Station (SSPS), and Solar-thermal Central Power

* For a more complete description of other options, see Philip Webre's new study for the Exploratory Project for Economic Alternatives, *Jobs to People: Planning for Conversion to New Industries*. [17]

Plant ("power tower"). Aerospace firms employing many military workers are exploring these technologies, and some offer easier job transitions than active, passive, or photovoltaics. There are major problems with these technologies, however, and job impact studies have not been made. The clearest solar technology match for aerospace workers we found to be wind energy systems.

Our findings are necessarily quite tentative. We did not interview individual workers, supervisors, or IAM officials. Nor did we do an exhaustive analysis of the job skill components. We examined a listing of IAM job categories and numbers, analyzed them with the help of a local machinist, and compared them, job by job, with what is currently known about job skills in the solar industry (see Table 2.2). [19]

- **Operatives (semi-skilled)**. With a minimum of retraining, nearly all the semi-skilled operatives are transferable to assembly and sub-assembly jobs in the solar industry. Some assembly jobs will be readily available, particularly structural assembly for the solar collector and wind machine parts of the industry. Processors, molders, and electroplaters will be used least. Electronic, mechanical, and hybrid assembly jobs are available in active solar heating components assembly and wind systems assembly, and machine operators can be used wherever there are machines in a factory.
- **Skilled**. Every skilled job category has its counterparts in solar industry. Some craft jobs (carpenters, plumbers, sheet metal workers, electricians) will be heavily demanded in solar development. Others, particularly machinists, mechanics, and grinders, will have fewer applications. These will be in machining parts for wind electric and industrial solar systems. Skilled machinists remain in short supply throughout U.S. industry. Other sectors of industry should be able to utilize their talents. They are readily transferable because they work from blueprints, turning out small numbers of specific parts.
- **Technicians**. Most technicians have two years training at a technical school or junior college, and then learn their specific tasks in on-the-job training at the plant. Except for the very specialized defense technicians, most are readily transferable to other kinds of technicians' jobs in the solar industry. For most of the categories of technicians surveyed at LMSC (all members of the IAM), corresponding jobs exist in solar. Several categories of specialized technicians: space lab technicians, weapons effect technicians, and electronic product assurance technicians, have no corresponding jobs available in solar industry at this time.

The skilled and semi-skilled operatives in military industry, as represented by the IAM job categories at Lockheed, will have the easiest time transferring to solar work. The major barrier remaining is the number of available jobs, which will be a function of the commitment and creativity of government and industry in developing alternative energy systems. Technicians are hardest to place, because of the specificity of their military-related skills, as well as the large employment aerospace work provides.

Transferring Military Engineers

A much heavier concentration of scientific, engineering, and technical skills exists among defense workers than among other industries. This is especially true among engineers. For example, at the B-l facility in Los Angeles, before President Carter's cancellation of the B-1 Bomber contract, there were 5,000 engineers and 5,000 production workers, a one-to-one ratio.* [20]

Engineers have a harder time transferring their skills to civilian industry than any other category of workers for two major reasons. First, they have become extremely specialized, designing systems which have no counterparts in civilian industry. Military applications require extreme specificity of design to meet military requirements, instead of the broader perspective required in engineering for the civilian marketplace. Secondly, large numbers of engineers have been required in defense industry, with a greater ratio to production personnel than in civilian industry.

To our knowledge, there has been only one detailed study of the transferability and conversion of defense engineers, which was conducted by Stanford Research Institute (SRI) for the Arms Control and Disarmament Agency in 1967. [21] The SRI study

* It should be noted, however, that the B-1 facility was in an advanced research and development phase with limited, rather than full-scale, production which accentuates the engineering/production ratio.

Table 2.2 International Association of Machinists (IAM) Jobs at Lockheed Missiles and Space Company (LMSC) Compared with Solar Jobs [19]

IAM Job Category	Number at LMSC	Comparable Solar Job Description	Sector*	Solar Job Outlook†
Operatives (semi-skilled)				
Electronic/Mechanical Assembly	207	Component Assembly	W	Moderate
Hybrid Assembly	27	Assembly of solar systems	A, W	Moderate
Structure Assembly	59	Assembly of solar collectors and wind machines	A, W	Large
Machine Operators	19	Machine operation in solar plants	A, W, PV	Moderate
Fabricators/Heat treaters	8	Large industrial systems and solar concentrators	A, W, PV	Small
Processors/Molders/ Electroplaters	49	None	—	—
Plant Services and Unskilled	143	Plant Services	All	Large
Total Operatives	**512**			
Skilled				
Machinists	289	Wind machines, materials production for solar components, aluminum extrusion, pumps, controls, parts	A, PV, W	Moderate
Developmental Mechanic	116	Fabricating propellers for wind machines	W	Small
Missile Electronics Development Mechanic	47	Wind systems controllers	W	Small
Mechanic	58	Fix all factory machines	A, PV, W	Moderate
Plumber	28	Install active systems	A	Large
Air Conditioning Mechanic	28	Design and install solar cooling systems	A	Moderate
Receiving Inspector	35	Precision factory inspection	A, PV, W	Small
Carpenter	26	Installation of active/passive systems	A, P	Large
Painter	16	Passive systems installation	P	Small
Electrician	54	Installation of various systems	A, PV, W	Large
Fleet and Ground Support Mechanic	38	Ground support for solar factories	A, W	Small
Grinder	9	Production of wind machines	W	Small
Total Skilled	**744**			

IAM Job Category	Number at LMSC	Comparable Solar Job Description	Sector*	Solar Job Outlook†
Technicians				
Missile System Inspector	118	Inspector of industrial solar systems	A, PV, W	Small
Space Lab Technicians	123	No direct applications	—	—
Weapons Effect Technician	20	No direct applications	—	—
Control System Technician	18	Controls for solar industrial systems	A, PV, W	Moderate
Electronic Equipment Technician	18	Wind and hybrid industrial systems	A, PV, W	Moderate
Data Reduction Equipment Operator/Technician	117	Designing hybrid industrial systems	A, PV, W	Small
Machine Technician and Inspector	196	Checking/metering precision wind turbines	W	Moderate
Test Lab Structure Technicians	70	None	—	—
Electronic Assembly Inspector	82	Assembly controls for hybrid systems	A, PV, W	Small
Function Test Equipment Technician	40	Unknown		Unknown
Electronic Products Assurance Technician	30	Highly specific tasks not applicable		Unknown
Electromagnetic Technicians	22	Hybrid energy systems	A, PV, W	Small
Photo Instrument Technician	5	None		—
Total Technicians	**859**			
Grand Total	**2,115**			

* A – active P – passive PV – photovoltaic W – wind

† Job Opportunities in 30-year Solar Commitment at LMSC

found that there are no insuperable barriers to transferring and reorienting individual engineers, but there are major problems when groups of engineers or whole sections of companies attempt to make the transition to commercial work. Defense engineers are best suited to research and development, systems design and analysis work, and team approaches to major problems. [22]

The study surveyed 2,100 engineers and 100 managers at 14 aerospace and commercial companies throughout the U.S., focusing on questions of the transferability of engineers from defense to commercial work. The engineers surveyed included those who were working in commercial and defense work, who had transferred from one to another, or who had worked in only one or the other. The sample surveyed four broad categories of engineers: electrical, electronic, mechanical, and aeronautical, encompassing 80% of all engineers employed in primary defense industries. In the sample, 14% were aeronautical, 20% mechanical, and 40% electric or electrical. [23]

The study focused on barriers to transfer from military to civilian work, as well as aids to transfer. It also assessed the general potential for conversion of defense engineers to civilian work.

Barriers to transferability included the following:

- Defense engineers are extremely specialized, to a degree not found in commercial areas. Commercial engineers are product oriented, while defense engineers tend to specialize in more narrow technical fields and do not usually follow a product through from start to finish.
- Defense engineers design for maximum performance, regardless of cost, while cost is a major factor in commercial design.
- There are more electronic and aeronautic engineers in defense industry by far than in commercial industry. In general, there are more engineers per sales dollar in defense than in civilian work. This creates a structural problem of lack of available jobs in the commercial sector.
- Most defense engineers are more highly paid than their commercial engineering counterparts and are thus reluctant to transfer to lower-salaried commercial jobs.
- Defense industry makes more extensive use of engineers in systems analysis and system design.
- Certain defense engineers, such as aeronautical and documentation engineers, do not perform conventional engineering functions but are employed to meet military requirements for reports and specifications. They have major problems transferring because of the lack of comparable jobs in civilian industry. [24]

Aids to transferability included the following:

- Most defense engineers are willing to transfer, even those employed in defense who are satisfied with their work. There is an overall preference for civilian work in terms of job satisfaction, contrary to common public perception.
- There is a larger proportion of mechanical engineers in the commercial workforce than in defense, facilitating easy job transfer.
- Technical skill levels are generally higher in defense industry than in commercial work. Upgrading of skills or retraining would not be required for transfer to civilian industry.

The results of the SRI study, despite the obstacles cited, are encouraging. Of those interviewed, the general attitude toward the transferability problem is one of "cautious optimism" if certain difficulties are recognized and steps taken to overcome them. Most important is the basic conclusion that "individuals are transferable, particularly if they can be brought gradually into a functioning commercial unit so that they can learn on the job by absorption. Organizations are not transferable." [25] New work teams are best assembled by drawing from engineers accustomed to working in the commercial sector and then adding specific defense engineers, as needed, by function.* By far the best kind of retraining and reorientation involved moving engineers, one by one, into the new operation or division and helping them to learn their new tasks on-the-job.

In terms of type of work, defense engineers were found to be best suited to designing integrated systems, advanced engineering, and analytical design.

* This finding is contradicted, however, by the recent experience of Boeing-Vertol in Philadelphia. There, in a conversion from Chinook helicopters to light rail transit vehicles (trolley cars), all but one of the 80 engineers now designing trolley cars transferred from aerospace work at Boeing. [26]

At the time of the study, systems approaches to engineering problems were being pursued only in certain sectors of civilian industry, and to an even lesser degree in non-defense government programs. Since that time, however, the systems approach is being used more in commercial industry and by state and local government as well as by major federal programs such as the Environmental Protection Agency, the Department of Transportation, and the Department of Energy. It is here that the greatest potential for use of engineers in civilian work lies. [27]

Engineers in Solar Technologies. Most military engineers, as we have seen, fall into four broad categories: electrical, electronic, mechanical, and aeronautical. There are also smaller numbers of other engineers, including systems engineers and engineering managers.

Solar technologies, including active and passive heating systems, photovoltaic development, wind energy systems, and advanced hybrid and industrial systems, will utilize fewer engineers by far than the present aerospace industry. Solar industry will make the widest use of mechanical engineers of several types and will also absorb some systems engineers, engineering managers, and a few aerodynamic engineers, electrical engineers, and electronic engineers. The engineers and their projected functions in the solar industry are listed below. [28]

Mechanical Engineers

Design engineers. Design everything mechanical and electro-mechanical, such as solar collector boxes, all solar system components, wind systems components, photovoltaic encapsulation, and all factory machinery.

Thermodynamics engineers. Deal with problems of heat transfer and fluid mechanics, such as solar collector heat transfer, flow through the collectors (pressure loss), concentrator solar cell cooling systems, and environmental temperature fluctuations of active, solar cell, and wind machines.

Heating, Ventilating, and Cooling (HVAC) engineers. Specify heating and cooling equipment needed, and arrange for its proper installation (some systems design) for active and passive solar heating and cooling systems.

Systems Engineers

Design systems necessary in active solar applications for entire buildings or factories, large photovoltaic or wind applications, and electrical grid systems. Also design hybrid advanced energy systems for industrial use.

Aerodynamic Engineers

Design airframe surfaces and helicopter blades. Design wind turbine blades.

Electrical and Electronic Engineers

Design electrical systems and circuits for control devices in all four fields.

Engineering Management

Oversees groups of engineers working together, needed for large and complex projects and advanced research and development.

To explore further two particular uses of defense-aerospace engineers in the developing solar field, we have taken a look at two firms in the Santa Clara Valley, Acurex and Varian, each of which has taken a different path to the utilization of engineering talent. At Acurex, the systems approach to advanced energy and environmental work has been developed with striking success, while at Varian, very specialized work with gallium arsenide has been shifted from military to solar applications.

SANTA CLARA COUNTY CASE STUDIES

Acurex

Acurex Corporation in Mountain View, California has applied its systems engineering skills to advanced large-scale solar industrial applications. They have developed a parabolic concentrator collector for supplying solar process heat and electricity to industry. They are also working on large-scale industrial applications of solar technology. These projects, described in more detail below, utilize a full range of engineering talent: thermodynamics, fluid mechanics, aerodynamics, heat transfer, and systems engineering.

Acurex began in 1965 as a group of engineers who advised the Department of Defense (DoD) on missile nose tip heat and stress problems and helped NASA control the extreme environments that space vehicles encounter orbiting the earth and moon. Early in its career, Acurex management faced the problems of declining U.S. defense and space expenditures. For a firm with "growth ambitions", it was clear that DoD and NASA contracting was not sufficient.

Diversification: During the late 1960s, Acurex' current president, Noel J. Fenton, was hired to develop a commercial sales base. [29]. Acurex, which began as Aerotherm Corporation with 100% military and space government sales, first diversified by adding two groups through acquisition: Icore, which offers food processing equipment, and Autodata, which produces data acquisition and control equipment. Aerotherm became a group within Acurex which has three divisions: Aerospace, Energy and Environment, and Alternative Energy Systems.

The company identified environmental and energy markets as areas of growth potential in 1968. Attempting to diversify into pollution measurement and control, Acurex began responding to Environmental Protection Agency (EPA) requests for proposals. While not immediately successful, Acurex finally received "problem definition" contracts from the EPA. [30]

As Acurex increased its non-aerospace contracting, the management developed a unique business style. "We view ourselves as offering the whole range of engineering services, from feasibility studies to implementation", explains Carl Moyer, Engineering and Construction Manager for the Energy and Environment Division. For example, in the pollution control field, Acurex studies nitrogen oxide emissions for the EPA on the one hand and offers industry products and services that can measure and control pollution on the other. [31]

They also help solve industry's pollution problems by designing furnaces which conserve fuel and burn efficiently. In one instance, Acurex developed a system for a brick factory to recover exhaust heat from their kiln for a pre-heating process. [32] Because, as Moyer points out, "the government supports an awful lot of engineering talent," Acurex often secures government contracts to solve industrial problems. [33] For example, a recent Acurex project funded by the Energy Research and Development Administration (ERDA) demonstrated the use of a coal-oil slurry fuel in the company's existing oil-fired boilers. [34]

Acurex's aerospace work has declined substantially from 100% of total sales in 1965 to 16% in 1977 although its actual volume of defense contracts has risen. In the next five years Acurex foresees shifting its energy research from 21% to 39% of total revenues. [35] Through acquisitions and expansion, Acurex has grown from $7.5 million revenue in 1972 to $30.8 million in 1977. [36] Moyer feels their success in building non-defense markets has resulted from the flexibility and diversity of Acurex's engineering talent. [37]

Management has facilitated Acurex's flexibility by creating an environment which encourages communication and participation. Management by objectives, strategic planning, and retaining a small business atmosphere encourage accountability and productivity. Regular evaluation and review play a key role. As President Noel J. Fenton explains, "When you devote more time to the front end, that is, the process, the talking and listening, you find the back end, the implementation, gets done a lot faster." [38] As part of this consulting process, Acurex produces a five year strategic plan each year that clarifies their objectives.

Solar Energy Experience: Acurex became involved with solar energy development in 1975 by producing, through in-house research and development, a high-temperature parabolic trough concentrator collector. This collector was then used as the basis for obtaining ERDA and DOE contracts subsidizing demonstration projects which provide solar process heat and electricity to industry. [39]

Their first installed system, finished in the spring of 1977, employs 6,720 square feet of collector to pump water for a shallow-well irrigation system outside Albuquerque, New Mexico. These collectors heat an oil-like substance which, through a heat exchanger, turns freon into a high pressure gas. This gas then drives an organic rankine cycle turbine that pumps 830 gallons of well water per minute. [40]

In their other major project completed in the spring of 1978, an Acurex solar system provides industrial process hot water for a Campbell soup can pre-rinse line in Sacramento, California. This solar system is the first to be installed at a food processing plant in the United States. Cold water is run through a series of conventional flat-plate collectors to raise its temperature to 140°F before circulating through the concentrator collectors. This system supplies an average of 12,000 gallons of hot water daily at 180°F for the pre-rinse process, about 75% of the requirements for one wash line. [41]

From these projects, Acurex's solar energy development has grown into a $6 million business (in 1978), necessitating the creation of an Alternative Energy Division within the Aerotherm group. They have opened a collector manufacturing facility capable of producing 13,000 square feet of collector a month (currently Acurex has a backlog of 100,000 square feet). The operation will employ about two dozen metal workers, pipe benders, and painters. [42]

Other Acurex solar projects in progress include:

- A deep-well solar irrigation system employing 48,960 square feet of collector to produce 150 kWe of electricity using a rankine cycle turbine.
- An industrial process steam solar system for gauze-bleaching at a Johnson & Johnson plant in Sherman, Texas.
- Design of a large-scale, solar total energy system. The design provides for four needs: electricity, process steam, space cooling, and space heating at a Georgia manufacturing plant.
- Development of a low-cost non-concentrating solar collector using printing press and plastics technologies.
- A novel low-cost photovoltaic concentrator. Acurex was awarded a contract to use existing seal beam automobile technology to develop a photovoltaic concentrator. The lens glass is aluminized and a cell is mounted where the lamp is usually located. [43]

These projects amply demonstrate the diverse talents of Acurex's engineering staff — which includes expertise in thermodynamics, fluid mechanics, aerodynamics, heat transfer, and systems engineering. [44]

Acurex depends upon federal demonstration contracts to make their projects attractive to industry. While thermal and photovoltaic technologies are not commercially feasible given present technologies and energy prices, even cost-effective process heating systems have marketing problems. As Ed Rossiter, Business Manager for the Alternative Energy Division explained, "a process heating system cannot be sold off the shelf, it has to integrate into someone's system." [45] Even then, process heat systems "pay-back" in about 10 to 15 years, while industry wants 2 to 4 year pay-backs. [46]

During our interview, Rossiter stressed the need for government incentives, including accelerated write-offs and tax credits, to make solar energy attractive to industry. "The government has been subsidizing the oil business for the last 35 years; there is no reason why they can't subsidize solar," noted Rossiter. [47J

Varian Associates

Varian Associates of Palo Alto, California has also diversified into the energy field. By redirecting its scientific and engineering talent and using its 30 years of experience in advanced electronic devices, Varian has produced efficient photovoltaic cells for converting sunlight into electricity.

Varian has invested approximately one million dollars in the research, development, and manufacture of gallium arsenide (GaAs) photovoltaic cells which can generate electricity more efficiently than conventional silicon cells. Varian's cells have achieved 21% average efficiencies at sunlight concentrations of 1,000 to 1. This compares to about 14 to 16% efficiency for conventional silicon cells that must be operated at much lower concentrations because at high concentrations their efficiency drops drastically. [48]

Varian Associates was formed in 1948, initially to research and then manufacture klystron tubes, the essential microwave tube component of radar and advanced communication and satellite systems. The firm began as an exclusive defense contractor but has diversified greatly in the 30 years since that time. In 1977, total sales were $352 million of which $34 million, or less than 10%, were prime military contracts. [49]

According to John M. Heldack, Corporate Director of Marketing, interest in developing solar energy grew in the late 1960s, as Varian began searching for a niche from which it could make a positive contribution. [50] A photovoltaic concentrating system was chosen because many fewer cells are required, reducing the most costly element of solar electricity. The company pursued research in gallium arsenide solar cells with the hope that higher efficiencies would offset the higher material costs. [51]

Varian draws on many related technologies to develop their solar cell devices. Their Central Research Laboratory has long worked with gallium. It is used in light emitting diodes and night vision devices by the military and for rescue missions. Varian equipment is used to grow, slice, and process silicon crystals into solar cells. Varian's wafering machine, used by other photovoltaic cell manufacturers like Spectrolab, cuts thinner wafers with less material loss than other techniques currently employed. [52]

Varian recently announced receipt of two new research contracts from the Department of Energy (DOE), one to improve the efficiency of their photovoltaic cells; the other to design and build an experimental photovoltaic generating unit for utility use in conjunction with Pacific Gas and Electric Company. [53]

Varian solar energy research and development has been carried out by their Central Research Laboratory and, except for the semiconductor wafer processing equipment, it remains financed by Varian expenditures and government contracts. [54] While their photovoltaics cannot compete against present electrical prices, Heldack believes that their research can establish a base for a commercial business. [55]

The significance of the Varian experience for engineering and scientific talent is the flexibility which a high technology firm can have in exploring R&D problems. The same scientists who developed gallium arsenide for military purposes are now exploring its use in solar cells. Although Varian's military work has not declined absolutely, and its solar work is dependent on government contracts, its technical talent has creatively moved into solar work.

Planning For Conversion: The Lucas Experience

Over a period of two years, substantial numbers of workers at all skill levels at Lucas Aerospace in Britain have been involved in detailed planning for alternative uses for their skills and equipment. Their experience is the first time that workers in a major military industry have linked their demands for work security to a comprehensive plan for alternative production. [56]

The focus of planning for conversion should be to create jobs for affected military workers in their own communities, utilizing their skills and producing goods needed by the community and the society at large. The most comprehensive program of government relocation, retraining, supplemental assistance, and economic planning cannot replace the need for specific planning and the creation of jobs for displaced workers.

We cannot deal in this limited study with the varied tasks which must be involved in comprehensive community planning for conversion and economic development. We are convinced, however, in keeping with our emphasis on the transferability of military workers' skills, that a key component in any planning is the involvement of the military workforce and communities in the planning.* Here, the experience of Lucas Aerospace shop stewards is informative.

The Lucas Combine Shop Stewards Committee is the major active example of the comprehensive involvement of the workforce of a major defense plant in planning for alternate uses for their skills and the equipment of their plant. This Combine Committee at Lucas Aerospace, Britain's largest military firm, has drawn up a detailed plan for converting jobs from military to socially useful production.

The Combine Committee developed slowly, over a period of nearly five years, as a response to continued layoffs at Lucas, reduced over a period of 15 years from 20,000 to 11,000 workers. The Combine developed as the shop stewards of the different unions came together, overcoming geographical and craft divisions. At first, the Combine took only defensive actions designed to fight against layoffs. In 1975, a science and technology consultancy service was set up to provide technical support to members who faced new machinery which might threaten their jobs. Gradually this evolved into the idea of an "alternate corporate plan" to use in bargaining with management.† [57] Today, the Combine represents workers at all 17 plants and 13 unions of Lucas, from crafts to semi-skilled, clerical, and white collar technicians and engineers. Thus it is in a good position for assessment of the entire work force and the entire equipment at Lucas.

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* It is important to realize that planning is essential whether or not the military budget is cut, because of the shifting nature of Department of Defense needs, from one weapon system to another and one force level or emphasis to another. There will be changes in demand in geographic or skill areas regardless of the overall level of the military budget.

† "Their idea was to devise a complete programme of alternative technological development which they would present to government, hoping to attract financial support for its implementation. The Plan would then be negotiated with management through conventional collective bargaining." [57]

Figure 2.A Lucas Shop Stewards Corporate Plan Questionnaire [58]

Factory

A. (1) Size: square feet of floor space
 (2) Other space: car parks, perimeters, land, etc.
 (3) Total space

B. (1) Age and condition of buildings
 (2) Suitability of buildings for modern production

C. (1) Location and access, e.g., near motorway, main road or railway link
 (2) Other services, e.g. Telex, computer, gas, etc.

Workforce

A. Total number employed

B. (1) Total number hourly paid
 (2) Number skilled
 (3) Number semi-skilled
 (4) Number unskilled

C. (1) Total number of staff
 (2) Number of design, development, etc.
 (3) Number of other technical staff, e.g., production engineering, contracts, technical sales
 (4) Number of administrative staff
 (5) Number of supervisory staff

D. (1) General availability of labour
 (2) Availability of skilled labour
 (3) Availability of design and other technical staff

Equipment

A. (1) Total number of machine tools
 (2) Breakdown into groups, e.g., lathes, mills, N.C. machines, etc.

B. Other production facilities, e.g., heat treatment, plating, welding, etc.

C. Details of equipment, e.g. age, value, condition

Products

A. (1) List present product range
 (2) List subcontract work out and number of hours
 (3) List subcontract work in and number of hours
 (4) Hourly rate for manufacturers

B. List new products made in past

C. (1) List new products under development
 (2) Any other new products outside aircraft work which your plant could design, develop, and manufacture
 (3) Any socially useful products which your plant could design, develop, and manufacture

Running the Plant

A. (1) How could the plant be run by the workforce?
 (2) Could existing 'line' managers still be used?
 (3) Have you got a joint staff/works Committee?
 (4) Have you set up a local Corporate Planning Committee?

Early in 1975, the Combine Committee began an intensive process for the development of the Corporate Plan. They set up a corporate planning committee at each of the 17 plants to make a detailed analysis of the design, development, and production capabilities and facilities of their plant. A questionnaire (see Figure 2.A) was sent to all 13,000 Lucas workers, asking them to analyze their own skills and their machinery as well as to propose alternative products. Mass meetings and smaller committee meetings were held for discussion. As a result, a vast amount of information was collected and analyzed in a year.

The complete plan, announced in January 1976, with parts updated since that time, contain detailed proposals for 150 new products and a number of proposals for completely reorganizing Lucas production.

By working on the corporate plan, the Combine Committee developed new clarity about their objectives. The plan has two major aims: protecting members' jobs by proposing alternative products whenever further cutbacks are proposed and assuring that these alternative products are useful to the wider community.

Alternative Products

Among the 150 alternative products in the Combine Committee Corporate Plan are a number of products already produced in small volume by Lucas, and some totally new products. These products include such diverse devices as retarders or secondary braking systems for buses and other heavy vehicles, combination electric-diesel engines, solar heating components, fuel cell technology, medical devices such as kidney machines and pacemakers, and industrial ball screws (see Figure 2.B). In each case the proposal is carefully outlined, showing how the present work force and machinery at Lucas can be used to produce the product. The Combine would rather work on large-scale systems that are useful to the community, such as braking systems and advanced rail transport, than with isolated, individualized products for domestic use.

Of the 150 products proposed, twelve were selected by the Shop Stewards for extensive development and presentation in six areas: oceanics, telechiric devices, transport systems, braking systems, alternate energy, and medical equipment. Because of the potential for the company to take the best ideas without negotiating the entire plan, the Combine has only released to the public and the company an extensive outline of the plan, plus a complete section on alternate energy. This section is particularly interesting because of our focus on solar systems. At a high technology aerospace firm like Lucas (with about 3,000 engineers), it is especially exciting to see the range of products and systems proposed in the alternate energy areas. There are six major areas of products outlined in the 200-page section of the Corporate Plan's section on alternate energy: (1) electronic systems and components for integrated solar heating and cooling systems (like switching circuits and pumping components), (2) solar heating and cooling panels, (3) wind power systems, (4) fuel cell technologies, (5) solar electric technologies, and (6) energy conversion and storage technologies such as batteries, heat pumps and pipes. The Shop Stewards are particularly interested in those technologies which provide a combination approach which they feel is not only the best use of the skills and equipment at Lucas, but is also necessary for the best utilization of the various alternate technologies.* [59]

Figure 2.B Lucas Alternative Product Proposals [61]

The product proposals

1. Oceanic equipment — for use in the exploration and extraction of natural gas, collection of mineral-bearing nodules from the sea bed, and submarine agriculture.

2. Telecheiric machines — electro-mechanical extensions to the human body, remotely controlled by the operator, for use in dangerous environments.

3. Transport systems — lightweight road/rail vehicles; hybrid internal combustion/ battery-powered vehicles, combining the best characteristics of both; airships.

4. Braking systems — safe systems for both road and rail vehicles.

5. Alternative energy sources — wind generators; solar collectors, producing electrical output or direct heating; tidally-driven turbines.

6. Medical equipment — portable life support systems for ambulances; kidney machines; aids for the disabled; sight-substituting aids for the blind.

7. Auxiliary power units — interchangeably driven by petrol, diesel, or methane, and able to operate as a pump, compressor, or generator.

8. Micro-processors — electronic devices for continuously monitoring and controlling the operation of large machines.

9. Ballscrews — used for converting rotating to linear motion, or vice versa, with wide applications to machine tools and other products in the plan.

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* "In general what is required is not so much basic R&D into particular components as the integration of existing components into visible systems — for example hybrid solar cell/flat plate systems; solar cell/electrolysis/fuel cell systems." [60]

Lucas skills and experience seem particularly suitable for advanced research and development in wind power systems and solar electric technologies. With electric wind machines, the main problem has not been in aerofoil design, according to the Shop Stewards, but in mechanical to electrical energy conversion. Lucas' work with transport, braking systems, energy transfer, and energy storage may be particularly helpful in raising the efficiency of wind machines to make them usable on a much wider scale. Research could usefully be focused on dynamos, alternators, and associated electrical gear, gearing systems, transmission units, and clutches.

Solar technologies: The Shop Stewards mention five separate ways of converting solar energy into electricity: (l) direct conversion via solar (photovoltaic) cells, (2) indirect conversion through steam turbines, (3) thermionic generation where electrons are released when certain materials are heated, (4) thermoelectric generation, (5) streams of hot gas where ions are stripped through some form of magnetohydrodynamic process (MHD). In both solar cells and steam plants, related systems are needed for maximization of heat and energy. The Shop Stewards saw four areas in which Lucas skills and equipment would be particularly useful: (1) investigation of fluid flow behavior, pumping problems and control systems for flat plate collectors; (2) feasibility studies of large and small-scale solar steam systems; (3) further refinement and development of solar cells, particularly study of other techniques than the "silicon crystal method" (now the most common but also expensive); (4) production of ancillary equipment for heat transfer (heat pipes, heat pumps, heat exchangers).

Solar cells, heat pumps, and wind electric machines are now, or have been, produced in small, experimental ways by different sections of Lucas Aerospace. [62]

Ways of Working

The Shop Stewards' Corporate Plan deals not only with alternative products, but it also describes how the work is to be done. It describes "ways in which the skill and ability of our manual and staff workers are continuously used in closely integrated production teams, where all the experience and common sense of the shop floor workers would be directly linked to the scientific knowledge of the technical staff." [63] This includes specific proposals for the establishment of integrated product teams, job redesign, more autonomous control by work groups, and retraining and education programs necessary during any transition. The Combine Committee is acutely aware, that "it is pointless to produce environmentally appropriate products in a way that is socially alienating and environmentally damaging." [64]

Negotiating for Implementation

The Shop Stewards' Committee has been working over the last two years to persuade both the government and Lucas management to accept the plan. On the government level this has entailed a wide-ranging public education and lobbying effort to convince the British government to adopt the plan. Although it has been endorsed by numerous Members of Parliament and some sectors of the government and the Labour Party, it has not been pursued vigorously at the government level. At the company level, the Combine has been pressing for consideration of the plan within the context of annual collective bargaining negotiations carried out by individual unions. So far the negotiations have been unsuccessful. The Committee has agreed to wait for a heavy push on Lucas until there is a further threat of layoffs, when the workforce would be more likely to support industrial action such as work stoppage or strikes. The Lucas management has made only one formal response to the plan, flatly rejecting it in May 1976. There has been no real negotiation since.

For over two years, from January 1976 to February 1978, Lucas announced no further layoffs. Then in February, another 2,000 layoffs over a two-year period were announced. As of this writing, none of these layoffs has actually taken place. The Lucas Stewards are determined to begin industrial action (work slowdowns, strikes, etc.) in the event of further layoffs, this time demanding implementation of the corporate plan. Although the various unions involved in the combine are supportive in the local plants, the national union leadership feels threatened by the Shop Stewards going outside the traditional union structure. But if industrial action comes, it is thought likely that the unions will rally to the Combine's support. A fascinating prospect is in store if a sit-in comes: the Shop Stewards could actually begin work on the alternative products. As one Shop Steward, Mike Cooney, commented to the *New Scientist* (16 February 1978), "Either you can sit in "til the grass grows out of the machines, or you can start work on new products." [65]

In fact, local Shop Stewards Committees have managed to negotiate a couple of products into production on a small scale. At Burnley, for example, the Burnley Shop Stewards Committee negotiated with the local plant manager for a small-scale production of heat pumps. Lucas' own marketing survey showed that the heat pump had a potential market of 255 million pounds by 1985. [66]

The Lucas Shop Stewards Combine Committee is under no illusions about the difficulties it faces, but it is determined to press on, step by step, to resist layoffs and cutbacks and demand the right to work on socially-useful products. It sees the corporate plan as "a humble start to make a small contribution to demonstrating that workers are prepared to press for the right to work on products which actually help solve human problems rather than create them." [67]

Spread of Lucas Style Efforts

The significance of the Shop Stewards Combine effort clearly reaches beyond the ultimate success or failure at Lucas. Already in Britain, shop stewards at Chrysler, Parsons (Newcastle), GEC (manufacturers of generating turbines for nuclear power plants), Vickers (military ship building), Rolls Royce (jet engines), and British Aircraft Corporation at Preston have begun to develop alternate corporate plans or at least to develop product ideas and do shop-floor organizing along the same lines as at Lucas. In none of these campaigns has the work advanced to the point at Lucas, in large part because in none are the Shop Stewards Combine Committees as strong or as well organized. But at some, like Vickers, there is substantial technical support. [68]

In the United States, the struggle is at a much more rudimentary level. It is now being carried on in public forums, within the peace and environmental movements and to a small extent in the Congress. But it is not yet a significant factor within the trade unions or on the shop floor except for some national leadership of the United Auto Workers (UAW) and the International Association of Machinists and Aerospace Workers (IAM). No significant conversion related proposal has been introduced by a trade union since Walter Reuther's UAW proposal, *Swords to Plowshares*, in 1969. [69] Although both William Winpisinger of the IAM and Douglas Fraser of the UAW are supporting national conversion legislation proposals, they are not taking steps to raise these issues at the bargaining table, or to involve their unions in advance, alternative use planning.*

This must change if U.S. trade unionists are to follow the Lucas example and become involved in alternate use planning. As the Lucas Shop Stewards have commented,

> We trade unionists are attempting to transcend the narrow economism which has characterized trade union activity in the past and are extending our demands to the extent of questioning the products on which we work and the way we work on them. [71]

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* In fact, when Phil Asquith, a Lucas shop steward was in the U.S. and met with a number of Lockheed stewards and machinists in Sunnyvale in May of 1978, he was told that something similar to the Lucas initiative was impossible and possibly illegal in the United States, because of the "rights of management" clause in all contracts. As Asquith quickly pointed out, nothing is impossible if it becomes an issue and is won through collective bargaining. After all, the Lucas proposals have not yet been accepted by management either. [70]

Chapter 3 Community Solar Development

Introduction

Solar energy can be more than an abundant source of clean and safe energy. Solar has the potential to slow inflation, create jobs in times of high unemployment, encourage local energy self-sufficiency, and promote community economic development.*

Through our analysis of the economic trends in the solar energy industry, we conclude that the degree to which these benefits will be realized is directly dependent on the structure of control in the industry. Examining different solar technologies, we found that:

- Major corporations with assets over $100 million may well dominate the solar energy industry, particularly in photovoltaic cells and active systems production. This control would negate many of the potential benefits of solar energy, but is not yet solidified or finalized.
- In order to establish an appropriately scaled solar industry which maximizes social benefits, a coalition of small solar businesses, minority and low-income communities, labor unions, and environmentalists must form to insure that no small group of firms control the industry.
- Alternative forms of business structure could increase community involvement and control, particularly in solar installation and active systems production. Community development projects can combine solar projects with housing rehabilitation and conservation programs.
- Existing and proposed financial incentives, regulatory measures and government procurement policies will play crucial roles in determining how soon solar energy is developed and in shaping who will control the industry.

* Community economic development refers to enterprises which are: owned locally for reinvestment in the community; controlled locally with some form of public accountability; located near where people live to minimize land-use problems (housing shortages, commuting, environmental pollution).

Big Business Control of the Solar Industry

The solar energy field is currently composed of several hundred firms researching, designing, manufacturing, and installing solar systems. According to a California Public Policy Center study analyzing active solar heating companies, these firms are predominantly small businesses employing an average of ten people each. [1]

Despite hopes that "no one can monopolize the sun," the prospect of energy firms and other large corporations entering the solar market may foreclose more diffused control over the developing industry. The ability of these firms to obtain capital, shield initially risky investments with the umbrella of huge assets, control markets and buy out promising small businesses make them tough competitors for capital-starved small solar enterprises.†

Based on the data presented below, we conclude that control of solar energy by large corporations would reduce its job creation potential, keep costs higher than would otherwise be possible, retain low public accountability, provide environmentally destructive energy, tie up massive amounts of capital, and suppress innovative programs capable of responding to community needs. From our analysis of the solar industry and the economic problems facing workers and communities today, it is clear that large-scale corporate control would not best serve our energy or economic needs.

The energy industry (oil, coal, gas and nuclear — often owned by the same company) and other strategic sectors of the US economy (aerospace, electron-

† In this study, we do not address the issue of medium-size firms (sales of $10 to $50 million) and their participation in the solar industry. It remains to be seen whether companies of this size will be able to compete with larger corporations. It is also unclear just what kind of solar path these companies will follow — whether they will be suppliers to larger firms pursuing high technology systems, or whether they will continue to concentrate on producing smaller-scale technologies. Their fate — in terms of survival and direction — may determine much of the future course of the solar industry.

ics, raw materials, and automobiles) are characterized by oligopoly, in which a small number of large firms dominate the market. [2]

Corporations in these industries are moving rapidly into the solar field. Exxon, General Electric, General Motors, Reynolds, and PPG Industries are all in the solar heating field. Grumman has two factories manufacturing solar heating systems. Twelve of the top 25 public solar companies have annual sales of greater than $1 billion (19 of 25 have sales greater than $50 million) (see Figure 3.A). [3]

Forbes magazine accurately summarized the consequences of this level of corporate involvement: "When companies like (these) dabble in those waters… they make waves big enough to swamp most of the little enterprises that to date have dominated the field." [4]

Anthony Adler, a leading solar investment analyst for Muller & Co., predicts that the number of solar manufacturers will shrink over the next ten years to "no more than 12 or 15 of any size. And I think the consumer will be looking for a reliable performer, favoring large, recognized firms like General Electric." [5]

Pressures Toward Centralization in the Photovoltaic Industry

Major industrial firms involved with photovoltaic development include Exxon, ARCO, Mobil, Shell, Texas Instruments, and Hughes Aircraft. Six of twelve firms producing solar cells have or are owned by a firm with annual revenue exceeding $1 billion (see Figure 3.B).

We have identified five factors encouraging entry by large corporations into the photovoltaic marketplace. These factors provide competitive advantages in developing solar cells and favor large systems-oriented companies and energy firms. Conclusions are based on interviews with Douglas Finch, director of Gnostic Concepts' photovoltaic market analysis, and with photovoltaic manufacturers:

- **Ability to make large capital outlays.** Photovoltaic manufacturers may have to update production twice before bulk energy markets are available (see Chapter 1). Additionally, a firm must have the capital to carry on a major research and development program. The company first able to develop a mass market photovoltaic technology would capture a substantial share. Finch felt firms under $1 billion in revenue (sales) per year would probably not meet this criterion. There are less than 250 industrial firms in the U.S. whose sales top $1 billion yearly. [6]
- **Systems manufacturer.** Vertically integrated firms which produce systems are also favored. For example, a firm which wins a contract to develop a communications system for a third world nation could build a photovoltaic power supply into their equipment. Photovoltaic systems which supply energy during peak demand periods might be integrated into household energy systems that monitor and control energy use.
- **Strong international and domestic marketing capabilities.** The short and medium term opportunities will require a strong marketing capacity-especially for developing third world markets.
- **Political influence.** Firms must be accustomed to operating within a marketplace which depends in the medium term upon government contracts and influence for survival. R&D and demonstration contracts will provide a major source of revenue for photovoltaic producers. The structure of foreign aid programs during the 1980s will influence U.S. corporations' capacity to build large markets for photovoltaics in the third world.
- **Strong technological base for research and development.** High technology firms with a systems approach could provide the base for the R&D projects necessary to develop a commercially feasible technology.

Flat Plate Production

While manufacturers need large capital outlays and extensive corporate resources for a high technology solar path like photovoltaics, active solar systems only require the capital and machinery of a light manufacturing plant. While we were not able to gather any conclusive data on economies of scale (optimal plant size for production efficiency) in the flat plate industry, discussions with manufacturers indicate that factories need not employ more than 50–100 workers and could be started with $100,000 –$300,000 initial investment. [7]

Relatively small firms should be as efficient as large corporations, making them effective competitors. Nonetheless, several factors enhance the position of large corporations. First, major corporations

Figure 3.A Solar's Top 25 Public Companies [3]

Company	Total 1977 Corporate sales Millions of dollars	Principal solar-related commercial activities
Aluminum Co. of America	$3,400	Coatings and aluminum for panels
American Heliothermal	0.8	Residential and industrial flat-plate collectors
American Smelting and Refining	1,000	Flat-plate collectors
ASG Industries	70	Glass for use in flat-plate collectors, concentrators, solar cells
Champion Home Builders	278	Heating systems
Columbia Chase	12	Flat-plate collectors
Exxon (Daystar Corp.)	48,600	Flat-plate collectors
General Electric	17,500	Evacuated-tube collectors
General Motors (Harrison Radiator Div.)	55,000	Flat-plate collectors, concentrators
Grumman (Grumman Energy Systems)	1,600	Flat-plate collectors, industrial and residential heating systems
Honeywell	2,900	Control devices and systems
InterTechnology /Solar	2	Flat-plate collectors
Johnson Controls	373	Control devices
Libbey-Owens-Ford	978	Flat-plate collectors
3M Co.	413	Window films and coatings
Mor-Flo Industries	87	Water heaters for solar systems
Olin	1,500	Flat-plate collectors
Owens-Illinois	2,800	Evacuated-tube collectors
PPG Industries	2,500	Flat-plate collectors
Raypak	14	Flat-plate collectors
Revere Copper and Brass	580	Flat-plate collectors
Reynolds Metals	2,400	Flat-plate collectors
Robertshaw Controls	270	Control devices, flat-plate collectors
Solaron	3	Flat-plate collector systems
Terra- Light	34	Copper absorber plates

Source: Anthony W. Adler of Muller and Co., *Business Week*, October 9, 1978.

Figure 3.B Survey of Photovoltaic Solar Cell Manufacturers

Company / Location	Type of Work (a)	Parent Firm (b)
ARCO Solar Chatsworth, CA	Production: 50-75 kW	Atlantic Richfield Revenue: $8.46 billion Oil, Gas, Chemicals
Columbia Chase Solar Holbrook, MA	Package cells (from Exxon)	Columbia Chase Sales range: $12–20 million Electrical
Mobil-Tyco Solar Waltham, MA	Research and development	Mobil Oil Corporation Revenue: $20.62 billion
McGraw-Edison Co., Power Systems Div. Bloomfield, NJ	Production	McGraw Edison Co. Sales: over $1.01 billion Electrical appliances
Motorola Semiconductor Phoenix, AZ	Production: 100–500 kW	Motorola, Inc. Revenue: $1.5 billion Communications
Optical Coating Labs, Inc. City of Industry, CA	Production: 75 kW	Optical Coating Labs, Inc. Revenue: $22.9 million Optical coating, photo sensors
Photon Power El Paso TX	Research and development	Owned by Campagnie Francaise des Petroles (51%), Libbey-Owens-Ford (39%), Baldwin Co. (10%)
Sensor Technology, Inc. Chatsworth, CA	Production: 500-700 kW Sales: $2 million	ASPRO, Inc. Revenue: $64.8 million Auto equipment, pulleys
Silicon Materials, Inc. Mountain View, CA	Production: small	Silicon Materials, Inc. Silicon wholesaler
Silicon Sensors, Inc.	Integrate solar cells into systems	Silicon Sensors, Inc. Sensing devices
SES, Inc. Newark, DE	Production: 500 kW	Shell Oil Company Revenue: $9.2 billion Oil, gas, chemicals
Solar Power Corporation North Billercia, MA	Production	Exxon Revenue: $48.6 billion Oil, gas, chemicals
Solarex Corp. Rockville, MD	Production: 500 kW	
Solec International Los Angeles, CA	Package OLCI Cells Consumer products	
Solenergy Corp. Wakefield, MA	New firm, Production: 250 kW	

Company / Location	Type of Work (a)	Parent Firm (b)
Sollos, Inc. Los Angeles, CA	Production: 10 kW	
Spectrolab Sylmar, CA	Sensing devices, space solar cells Sales: $10 million	Hughes Aircraft Company Aerospace
Spire Corp. Bedford, MA	Research and development; Thin film, automated process	
Sun Trac Corp. Wheeling, IL	Buy cells for packaging	Declined to state
Texas Instruments Solar Dallas, TX	Research and development	Texas Instruments, Inc. Sales: $1.7 billion Electronics

(a) Primary mission of firm. This list was compiled from phone interviews on June 28, 1978 and from *Solar Engineering*, November 1977, p. 14.

(b) Listed only if photovoltaic work is not the primary mission of the firm. Revenue or sales figures obtained from *Standard and Poor's Register*, 1978, Volume 1.

with substantial reserve assets will be able to weather hard times in the solar field more readily than smaller competitors. In the severe industry slump of the past year, about 75 solar businesses dropped out of the field. [8] Second, large firms can buy out successful or promising smaller companies. Third, if necessary, large firms have more leeway to lower prices temporarily to gain control over market shares.

Examining the trend toward larger manufacturing firms bears out these assumptions. In 1974, only one firm was producing more than 10,000 square feet of solar collectors. By 1977 there were 18 companies producing more than 50,000 square feet annually, accounting for 46% of the collector market. [9]

Centralized Solar Systems

Solar projects planned by large corporations tend toward large-scale, capital-intensive, high technology ventures. Two proposed projects which fit into the framework of centralized power generation and control are the Solar-thermal Central Power Plant (Power Tower) and the Satellite Solar Power Station (SSPS).

Solar Power Tower

McDonnell-Douglas is building a prototype 10 MW "power tower," consisting of two thousand sun-tracking mirrors which focus sunlight onto a twenty-five story tower. The heat boils water inside the tower, and the resulting steam drives a turbine generator.

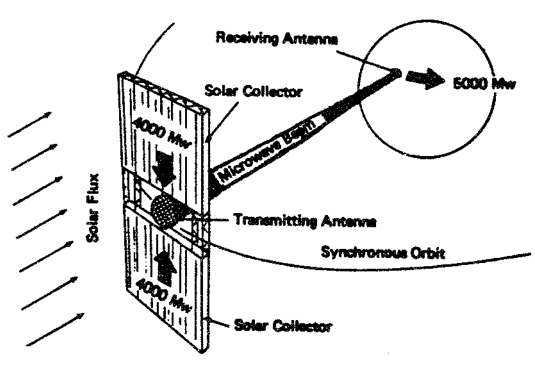
This system, located near Barstow, California, is expected to cost $123 million, or $12,000 per kW. A conventional coal-fired plant costs about $1,000 per kW to build. While this is only a pilot project, *Business Week* reports that the power tower "would generate base load electricity at a cost that apparently will be about ten times that of power from a conventional plant." [10]

This high technology project requires a very long development process (20 years or more). Other solar electric options such as wind and photovoltaics could probably be cheaper, are more adaptable to plants of varying size, and can be used on an individual site. Moreover, planning, construction and material costs of the power tower may well exceed current estimates through the cost overruns normally experienced in high technology ventures. Despite this, the power tower is the single largest item in the federal solar energy budget, receiving 25% of solar research funds.

Aside from the questions of cost and centralized control, thermal electric plants produce large amounts of waste heat, equal to about two thirds of the electricity produced. Disposing of the waste heat is a major environmental problem. Centralized power systems, particularly those in remote locations, lose a large percentage of their electricity in transmission, further reducing the efficiency of the power tower. Nonetheless, the Department of Energy plans to follow this pilot project with a 100 MW tower by the 1990s, covering 400 acres with a 735-foot tower.

Satellite Solar Power Station

Since NASA's manned lunar program ended early this decade, U.S. aerospace industry has been searching for projects which would employ its excess capacity. Their most recent proposal, developing a massive Satellite Solar Power Station (SSPS), opens the door to a multi-billion dollar market by capitalizing on solar energy's new-found popularity. They envision assembling a rectangular photovoltaic grid covering 36 square miles in stationary space orbit. The idea's originator, Peter Glaser of Arthur D. Little, predicts that two microwave transmitters could beam between 5 and 10 gigawatts of power (comparable to 5–10 large nuclear power plants) to a 5 by 7 square mile earth antenna. [11] The microwave would then be converted back to electricity and put into the electrical transmission grid.



Satellite Solar Power Station

Powerful support for the solar power satellite concept, which fits nicely into NASA's hope for an expanded space shuttle program, has been mobilized by the newly formed Sunsat Energy Council. This lobby, consisting of more than 25 of the largest aerospace, utility, and electronics firms, is asking Congress for a $200 million research and development program, and they have already received an initial grant of $25 million. [12] According to investigative journalist Adam Hochschild, four Sunsat firms stand to gain the most by developing SSPS: "Raytheon, which makes microwave equipment; Grumman, which has worked on techniques for fastening together the huge array of 'Solar Dam' cells to catch the sun's rays; and Boeing and Rockwell, which are both involved with assembly techniques and eyeing the contract for the Super Shuttle, which will have to shoot all the stuff up there."* [13]

The solar power satellite has also excited utility executives desiring a way to fit solar into their centralized power-generating framework. "The problem utilities have had in the past with solar energy projects is that they've been highly decentralized," says James Moyer, a Southern California Edison Company official who has been actively supporting the SSPS. [14]

Representative Richard L. Ottinger (D-NY) characterizes the SSPS as "a perversion of the potential of solar energy." [15] He views the Sunsat Energy Council as "the collusion of the high technology space/industrial complex [to] assure full corporate socialism for the next 20 years, much like that which the American taxpayers have provided for the last 20 years…" [16]

In addition to the irresponsibility of continuing government subsidies for corporate giants, solar power satellite opponents cite environmental dangers and exorbitant costs as bankrupting the concept. The microwave beam will heat up a column of the ionosphere with unknown effects on atmospheric conditions and radio reception. [17] Critic Dr. Aden Meinel, Professor of Optical Sciences at the University of Arizona, compares the beam to a "giant microwave oven cooking all people, plants and animals caught by the wandering beam." [18] If the beam were focused, an easy system modification, the solar satellite would become a potent weapon capable of destroying major cities. The satellite's potential as a weapon motivated its inventor to advocate international cooperation in the satellite's development. [19]

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* Sunsat also includes other firms which stand to gain greatly from the project: Lockheed Missiles and Space, General Electric, Southern California Edison, Westinghouse, IBM, McDonnell Douglas, Hughes, Garrett, General Dynamics, Varian Associates, and Martin Marietta among others.

Costs of the solar power satellite are staggering. Comparing the investment required for the 36 square mile satellite with a similar investment in flat plate solar heating equipment clearly demonstrates how unsound the solar power satellite concept is. It is reasonable to compare these two technologies because, as Amory Lovins demonstrates, we do not need more electric power generation.* Let us compare a few key issues:

- A flat-plate solar heating investment would create over twice as much energy as the solar power satellite. Capital cost estimates for the first SSPS range from $40 to $80 billion — not accounting for cost overruns often encountered in these massive high technology projects. If high and low cost estimates correspond to the high and low energy production projects, a $40 billion investment will create 0.15 quads (1,015 BTUs) each year and $80 billion, 0.299 quads each year. If we assume solar heating collectors cost $25 per square foot installed (today's average price) and they produce 200,000 BTU per square foot each year (California Energy Commission's lowest estimate), a $40 billion solar heating investment (1.6 billion square feet) will produce 0.32 quads per year and an $80 billion (3.2 billion square feet), 0.64 quads per year. [21]
- A solar satellite investment would consume 7 to 10 times more energy to build than would the solar heating investment. And the satellite would not contribute net energy for 21 years.

The SSPS may consume as much energy in sending equipment into space and assembling it as it will produce for the first 7 to 10 years of operation. [22] The SSPS would not come on-line until after all construction was completed. If, as estimated, building requires 14 years, there will be no net energy gain from the satellite for at least 21 years. [23] SSPS energy consumption for construction will exacerbate the fuel shortage during the critical period of the next two decades. Solar heating systems can provide needed energy almost immediately. According to the California Energy Commission, solar heating systems should pay back the energy used to produce and install them in less than one year. [24] While it may take up to 20 years to produce and install the approximately 8 million† average solar home heating systems purchased by an $80 billion investment, each would begin producing net energy soon after it came on line.

While these are preliminary calculations, many assumptions SSPS proponents make still need examination. For example, Glaser believes the SSPS can remain in orbit for a century, yet Sky lab has had difficulty remaining in orbit for less than five years. How easily could the satellite be put out of service by a meteor or sabotage? How much operation and maintenance work will be required? Have transmission and distribution costs been factored in? Finally, the $1,700/kW cost of the satellite amortized over 30 years is higher than any large commercial power plant ever constructed. [26] We have shown that solar heating can compete with current prices for electric resistance space and water heating throughout the country. We find it unthinkable that the U.S. government would invest taxpayers' money in an unsound technology that has value simply because it fits the needs of giant corporations.

Employment Impact

Projects such as the solar satellite and the power tower will tend to reduce the employment impact of solar energy. While these technologies will of course create jobs, a decentralized, smaller scale industry could employ more people, because government policies and industry practices encourage the use of capital over labor. Capital tax credits, accelerated depreciation, and other energy subsidies make it cheaper for businesses to build centralized plants which use machinery extensively and consume large quantities of energy, both as substitutes for human labor.

These policies have had a direct impact on unemployment and have meant job losses in many of our major manufacturing industries. From mid-1973 to mid-1977, employment losses were concentrated in energy-intensive activities: manufacturing production (particularly metals, automobile/transportation

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* Only 8% of the energy used in this country requires electricity. [20] Much of our current electrical capacity is used to heat water and buildings, applications that solar flat-plate heaters are much better suited to.

† This could be accomplished if 400,000 systems (160 million square feet, assuming an average system of 400 square feet) were installed per year over the 20-year term. "In 1976, more than 1.5 million square feet were sold across the nation… [and] According to Federal Energy Administration (FEA) statistics, the market for 'flat-plate' solar collectors — the type that generally is used on houses — is doubling every 6 months." [25]

equipment, textiles, and electrical equipment), agriculture, and construction. [27]

For example, in the steel industry from 1949 to 1969, the number of production jobs decreased by 20%, while steel output increased by 45%. [28) In the coal industry, production output remained stable between 1947 and 1976, but employment has been nearly halved, from 419,000 to 216,000 workers. [29]

As Duane Chapman, Associate Professor of Resource Economic at Cornell argues, government subsidies result in “an inefficient use of excessive capital and energy and insufficient levels of employment.” [30] While production requires capital and energy inputs, studies examining the economics of scale for manufacturing industries indicate that there is not necessarily an intrinsic value derived from centralization. Chapman found in comparing two methods of production, one capital intensive, the other labor intensive, that without capital subsidies or employment taxes the capital intensive process is 9% more costly. With the present tax system, however, the labor-intensive process becomes 31% more expensive. [30]

TOWARD COALITION

Major corporations have not yet solidified control of the solar industry. Advocates of decentralized and publicly accountable energy systems still have the opportunity to build the support needed to change the trend toward centralization.

While the corporations eyeing solar, like those of the Sunsat Energy Council, are well organized and financed and have powerful political connections, only a disparate group of environmentalists, small businesses, a few government agencies, and activist organizations are fighting for small scale solar. At their current level of organization, they do not pose a major national challenge to corporate control.

If community solar advocates do not locate and work with other groups who stand to gain from their energy programs, big business and utilities will be able to develop solar satellites and solar power towers. The two most important groups who have considerable national political clout and are directly affected by energy policies are labor unions and the minority community.

Currently unions are the only body that effectively represent working peoples’ interests. They have been instrumental in securing important benefits for workers, including:

- Collective bargaining processes so workers do not face employers on an individualized basis;
- Increased job security;
- Wage levels which keep up with inflation and the cost of living;
- A means for redressing grievances without fear of job loss;
- Occupational health and safety protection.

Nationally, several major unions have publicly expressed interest in solar energy. The Sheetmetal Workers commissioned two solar employment impact studies, while leaders of the United Auto Workers (UAW) and International Association of Machinists (IAM) have spoken out for solar projects. [31] Labor unions in the Santa Clara Valley, including the UAW, IAM, the Central Labor Council (AFL-CIO), and the Santa Clara Building Trades Council, are investigating possible involvement in the solar industry.

The need to organize an industry in its early stages is particularly clear to unions in Santa Clara County. The region’s dominant business, the high technology electronics industry, employs 60,000 to 70,000 low-paid production workers, few of whom are organized. [32] Had unions made an earlier and more substantial organizing commitment, they might have avoided facing what is now one of the largest open shops anywhere in the United States.

A solar path of satellites and power towers would make the solar industry more centralized, automated, and capital-intensive. This will increase a company’s productivity (total output per worker) and allow higher wages. However, substituting energy and machinery for labor could reduce the employment potential of solar. As William W. Winpisinger, President of the IAM, noted in hearings before the Joint Economic Committee of the Congress:

> Indeed, productivity is linked directly to industrial energy consumption. Energy displaces labor. And, herein lies the dilemma of IAM members and working people in general. As the productivity index goes up, jobs and job opportunities appear to decline. [33]

In the past, some unions have acquiesced to a business structure which created fewer jobs at higher pay. [34] Furthermore, labor has sometimes encouraged greater mechanization where jobs are tedious, difficult, or dangerous. Workers displaced by machines and those entering the market usually found jobs in expanding sectors of the economy. Yet in today's economy with rising prices due to dwindling energy supplies and a capital scarcity, the development of new jobs has not kept pace with losses resulting from mechanization. Since a smaller scale industry could create more jobs, organized labor needs to re-examine this trade-off, especially in the face of high and seemingly permanent unemployment.

For their part, small businesses are more likely to create jobs near where people live. When workers earn and consumers spend money locally, and businesses buy supplies and services in the community and bank through local financial institutions, they increase the neighborhood cash flow, community economic development, and jobs. Also, local merchants and businesses directly benefit from an economically thriving community.

Small businesses offer other potential advantages in terms of job creation and the quality of work. Smaller firms can be less bureaucratic, hierarchical, and specialized. Though certainly not always, this can lead to more responsible and interesting work for employees, with less of the routinized, overspecialized low-skill work which characterizes mass production assembly line work today.

Minority and lower income communities are another major constituency vital to a successful solar coalition. Two major considerations will promote their participation. First, while rising energy costs hurt everyone, they impose a disproportionate burden on the poor. The average American household spends 7.4% of its budget on energy, but this figure is nearly 30% for the poorest 10% of the population. [35] Locally, the Santa Clara County Energy Task Force reported that by 1985, energy costs will take twice as much out of the average county resident's budget, with energy costs for low-income people equal to their rent. [36]

Second, communities with high unemployment stand to gain the most from an alternative energy path which maximizes jobs and community economic development. If neighborhoods could start both private and community-owned energy businesses, this could reduce living costs, provide jobs, improve housing, and increase neighborhood cash flow and development.

Alternative energy policies, however, have not yet focused on the needs of lower income and minority communities. Tax incentives mean little to a family with little taxable income, and access to bank loans and grants are limited. Energy conservation measures focus on single family owner-occupied homes, excluding rented homes and multi-family units. In addition, alternative energy strategies often do not stress the need for jobs and economic development.

If labor unions, minority, and low-income communities can be brought into a coalition with environmentalists, small solar businesses, and urban leaders interested in community development, we might see the beginnings of a movement with sufficient political strength to challenge centralized control of the industry and help create a democratic industry genuinely responsive to community energy needs.

Surmounting Obstacles

This solar coalition faces several problems which currently mitigate against joint action. Coalition participants must formulate alternative energy policies to overcome apparent conflicts of group interest.

The tenuous position of small solar businesses (especially with severe recent setbacks), creates problems for unions and communities desiring stable employment. The solar residential market dropped by 50% in the first half of 1978 compared to the previous six months. [37] While long term market growth seems assured, small firms face increasing risks, particularly as large corporations enter the field. The key problem is acquiring capital, since banks and other lending institutions channel investments and loans into safer ventures or more established firms. Hearings before the California legislature confirmed that small alternative energy firms would be forced out of business unless the government mandated new lending practices or institutions. [38]

Larry Newton, the President of Sunburst, a small solar manufacturing firm, explained the pressures to standardize production: "There is no other way to get capitalization if you don't standardize and consolidate production and plug into the national distribution pipeline." Sunburst's assembly line is not basically different from Ford's auto line in Milpitas, according to Newton. Sunburst's present labor costs represent 40 percent of total production outlays.

Eventually, through automation, Newton hopes to trim that figure to 25 percent. [39]

Unions are leery of allying with small businesses which might not be around in a year or two, and correctly note that environmentalists sometimes do not adequately assess the job impact of ecological policies.

Many people active in the solar field raise serious objections to unionizing solar jobs. Some environmentalists, noting that the AFL-CIO ardently supports nuclear power, contend that union scale wages would drive up the cost of solar energy. Wages for solar workers currently average $3 to $4 per hour. [40] This is at the low end of industrial union wages, where workers make anywhere from $3 (in smaller shops, according to a UAW representative) to $8 or $9. [41] Most military workers, for example, are at the upper end of this spectrum. Most skilled positions in the building trades average over $10 per hour. [42] Solar manufacturers and installers cannot presently match this scale. If they did and remained solvent, wage costs would drive the price of solar too high, and retard the introduction of alternative energy.

Traditionally, small business has employed the marginal labor force and sought to prevent unionization to remain competitive with larger companies. This trend appears in the solar industry partly because many manufacturing solar jobs require few skills. And solar installation jobs, while requiring plumbing, electrical, and carpentry skills, are unique and need to be learned even by tradespeople. Small business distributors train their workforce in the specifics of solar installation on-the-job and often hire the cheapest labor available.

Similarly, small businesses fear that higher labor costs would hurt their markets and competitive position. Wages are lower in solar production relative to normal union shops because small businesses substitute labor for capital. Since productivity is lower in small, labor-intensive operations, they must undercut labor costs to compete. In order for solar to be competitive, the cost of installation of solar systems must be held down.

Minorities and low-income people, often the victim of both corporate and union discrimination, complain that higher solar costs would make alternative energy unaffordable in their communities.

We will suggest several plans which might circumvent some of these problems. The coalition will have to work for a solar industry which creates large numbers of jobs with decent pay and working conditions. Unions will have to be sensitive to cost problems and not make demands which will cripple the fledgling solar industry.

We can already point to signs of progress. Several unions, including the Mineworkers, Steelworkers, and the Oil, Chemical, and Atomic Workers (OCAW) have publicly opposed the nuclear breeder reactor. Led by the Machinists' Bill Winpisinger, unions have allied with community groups to form the national Citizen Labor Energy Coalition. [43] And Environmentalists for Full Employment has been successful in gathering environmentalists' support for labor law reform and has stressed that pollution hits workers hardest in the form of dangerous working conditions. [44]

Coalition Programs

The first step for the solar coalition is to assemble sufficient political power on both a local and national level. This must be combined with developing a concrete program detailing the mechanics of an alternative solar industry developing community and small business participation, and planning a well-integrated national energy strategy. Below we explore some specific options for small businesses and municipal institutions for planning and support. At the end of this section we outline financial and regulatory measures which would help this solar industry.

We recognize that we do not present a complete blueprint for alternative businesses and a national solar energy program. Nonetheless, we try to point to certain useful programs and policies in the hope that others will follow our work with more detailed planning and implementation.

The most comprehensive and ambitious solar proposal is the SolarCal legislative package sponsored by the Campaign for Economic Democracy (CED) in California. Divided into twelve bills in the California legislature, SolarCal measures include loans to consumers, proscriptions against utility and energy company involvement, job training programs, and small business loans. Many of the bills are included in the final section of this chapter, and SolarCal as a whole is an important model for solar programs in other states. Because of the momentum generated by these proposals, California Governor Jerry Brown established a SolarCal Council headed by CED leader Tom Hayden to formulate plans to proceed with "maximum feasible solarization" in California.

Avram Bendavid-Val of the Institute for Local Self-Reliance has detailed criteria for community economic enterprises. These include:

- Local ownership, control, and location;
- Business viable with small-scale market area;
- Low capital requirements for entry;
- Production of goods or services which can viably serve lower income communities;
- Jobs which do not require extensive knowledge or high level skills (though training programs are needed to improve skill levels);
- Work that is not dull, repetitive, or unstimulating;
- Low capital/labor ratio to maximize employment. [45]

The coalition should consider ways of helping selected businesses (marketing, access to technical assistance), as well as developing institutional alternatives for planning and providing energy needs.

In addition to existing, privately owned small businesses, we can identify three major types of potential community enterprises: community development corporations, cooperatives (or worker-owned enterprises) and public enterprises.

Community Development Corporations

Community Development Corporations (CDCs) are community owned and controlled businesses and industries in low-income neighborhoods. To help local residents gain control over economic conditions and improve the quality of life, CDCs are set up to provide job opportunities, improve skill and income levels, reinvest capital in neighborhood projects, and provide needed services as determined by the community. [46]

CDCs are generally started by a local community group, often growing out of civil rights, welfare organizing, or housing movements. CDCs can start neighborhood businesses and construction projects, help attract outside private investment, set up local financial institutions to increase access to capital, provide services (health, day care, housing, legal), or push government agencies to expand the local economic infrastructure.

The structure of a CDC can be flexible and varied. There is an endless set of possible arrangements: a nonprofit umbrella with for-profit subsidiaries, equity investments made in business ventures, setting up the entire CDC as a profit making venture, or establishing a trust or holding company to buffer ventures. These choices will be contingent upon local needs, but also upon detailed consideration of tax laws (non-profit corporations will not have to pay income tax, for-profits cannot hold tax-exempt real estate) and funding sources (some foundations will give only to non-profits; the Small Business Administration only to profit making business ventures.)

While the CDC board of directors will often include outside technical people (legal, financial), community people usually compose more than half the board. It is difficult to overstress the need for genuine community involvement, particularly in setting goals, establishing policy directions, and evaluating results. Day-to-day operations and administration are generally left to the staff. One method of representation is to have the board composed wholly or in part of representatives from community organizations (ethnic associations, church groups, tenants' unions, welfare rights groups, etc.). The CDC should make continuing efforts to insure participation from members and constituent groups. This can be done through regular presentations to groups, followed by policy discussions which will then be carried out by staff.

Co-operatives*

The solar jobs coalition can encourage the formation of co-operatives producing or installing solar systems. [47] Members own all or at least hold a majority interest in most co-ops. Management structures vary, from co-ops which run entirely democratically (no hierarchy of authority), to those which work out a creative balance between some form of managerial authority and employee control. Workers

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* In the following pages, we will refer to three types of cooperatives: (1) cooperatives of *individuals* in a single business controlled by the employees; (2) cooperatives of *small firms* who market or purchase goods jointly; and (3) cooperatives of *consumers* who plan and purchase energy together. This section concerns the first.

usually have substantive power over production techniques, the division of labor, and sometimes hiring.

Co-ops can be part of a CDC enterprise, but more often exist on their own and are not tied to low-income neighborhoods. While CDCs are often multi-enterprise ventures, co-ops usually focus on a single business, which emphasizes the role of co-op members. To balance this with community needs, co-ops could have community representation on the board (1/3 or 1/2). Co-op and community members could have joint power over deciding how to reinvest business earnings.

Public Enterprises

Local government planning and control can reduce energy costs and flexibly plan alternatives in response to community needs. Municipal utilities, information and conservation services, and other public energy businesses can provide effective and accessible community energy programs.

Federal Power Commission studies have proven that municipal utilities deliver power which costs an average of 25-30% less than investor-owned utilities (IOUs). [48] Municipals are more efficient in production and distribution, funnel earnings directly into the city (IOUs pay state and federal taxes), and have less incentive to maximize capital costs. [49]

Most important, municipal utilities offer a chance for coordinated planning and citizen participation to structure energy policies. Less tied to large scale power systems, municipals can pursue alternative energy paths with greater flexibility and initiative. Where necessary, they can plug into the utility power grid, but are also free to utilize conservation, solar, biomass, and wind alternatives.

The Potential For Citizen Control

It is impossible to generalize about the potential for democratic and decentralized control of the solar industry. Each solar technology has different capital and plant requirements, while production and installation of the same technology will probably be performed by different enterprises.

We will consider the issue of control for three areas: (1) production of photovoltaic cells; (2) production of active systems (including solar window box heaters which, unlike other passive architectural and conservation measures, can be mass-produced similarly to flat plate collectors); and (3) installation of passive and active systems. We leave out wind, because the available literature provided no substantive data on the structure of the relatively unformed wind industry.

Photovoltaics

We have outlined the pressures toward centralization in the photovoltaic industry, emphasizing the extensive capital requirements, marketing capabilities, and government connections. Because photovoltaics will not achieve commercial feasibility for several years, the umbrella of large corporate assets will make near term losses easier to sustain.

We conclude that large high technology manufacturers will probably dominate the photovoltaic industry. However, it is conceivable that a major technological breakthrough in the production process could open the field to smaller firms. This quantum leap innovation such as cadmium sulfide photovoltaics in "spray on" form would have to vastly simplify the production process and capital costs, and be available through licensing and patent arrangements to firms not involved in making the breakthrough. Drastic price reductions could reduce the need for heavy government influence (less dependence on federal purchases) and extensive international marketing, since low cost would mean closer markets.

The issue of licensing raises a relevant issue of control in the solar industry. Under the current research and development program, the federal government, through Jet Propulsion Laboratory, is funding private corporate development of photovoltaic cells. Corporations will then presumably market this technology to gain a maximum return on their taxpayer-subsidized investment. However, since the federal government guarantees purchase of photovoltaic cells, manufacturers incur no risk, which is the normal justification for profit-taking in the market economy. Taxpayers who financed this technology deserve a say in the social impact of their investment.

The federal government could license out new patents on breakthrough photovoltaic technologies to give access to smaller firms. More generally, government sponsored research and development and procurement programs should not foster monopolistic industry patterns. For research and development, this would mean some form of open licensing arrangement to spread innovations even if they don't allow small business access. The government could spread procurement contracts to a diversity of firms, though this loses some meaning if all contractors are large corporations to begin with.

Alternative public policies could return the benefits of taxpayer supported innovations in other ways. For example, the government could require that photovoltaic manufacturers give discounts to future government purchases to install solar cells on public buildings.*

Active Systems Production

We previously noted the economic pressures which undermine the viability of small solar manufacturers. This competitive disadvantage can be traced to inadequate access to capital and large corporate advantages not directly related to production efficiencies.

We outline a variety of financial mechanisms and regulatory policies at the end of this chapter which could help small and community businesses gain capital grants, loans, and investments. However, it must be noted that the entire system of credit allocation is skewed to large manufacturers in direct relation to economic power. [50] This puts inherent limits on how much funding small businesses can expect to receive.

Assuming that relatively small production enterprises can achieve substantial economies of scale, local firms could still have a viable role within the industry. To encourage this participation, the solar coalition could help form a network of regional producer co-ops and small businesses. Eric Sableman of the Santa Clara Solar Power Research Institute has outlined some of the advantages which producer co-ops could provide: [51]

- Access to capital — perhaps by acting as a small business investment corporation (see financial incentives, below), or getting loans because of its larger size;
- Advertising and contact with purchasers — pooled assets could make conventional advertising cheaper for co-op members, while the co-op could sponsor trade fairs, exhibits, and informational publications to promote member products;
- Enforced quality standards and back-up guarantees — current solar legislation calls for the establishment of quality standards for solar products. The co-op should market tested products and be able to penalize members who produce consistently defective products and establish insurance policies to honor warranties and maintenance' contracts if co-op members go out of business;
- Bulk purchase of materials — providing lower prices for members;
- Soliciting large volume business — bidding on major contracts, with subcontracting to members;
- Pool research and development — particularly to establish efficient economies of scale and test innovative designs and production techniques;
- Lobbying — particularly to call for small business financing, and anti-trust activity against corporations, particularly energy companies who threaten to complete vertical integration of the industry.

Active and Passive Systems Installation

Installation is the best point of entry for solar CDCs, co-ops, and small businesses. First, installation and distribution account for the bulk of employment in the solar industry. A survey of 130 California solar businesses revealed that it takes four times the amount of labor to install a solar system than to manufacture it. [52]

Second, economies of scale are almost nonexistent in installation, so skilled small firms can be efficient at low levels of operation. Since installation requires many of the same skills and operations found in the construction industry, solar may well follow the small and decentralized pattern of this industry.

Third, capital requirements for installation are much lower than production. Bendavid-Val of the Institute for Local Self-Reliance estimates that a solar installation business would require approximately $30,000 to $60,000 in start up capital, at least $5,000 monthly to cover operating expenses, and about $30, 000 for a two-month cushion of working capital. [53] The reduced capital investment means less risk for the business, and also increases chances for getting financing.

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* This could be justified as giving taxpayers a return on *their* investment.

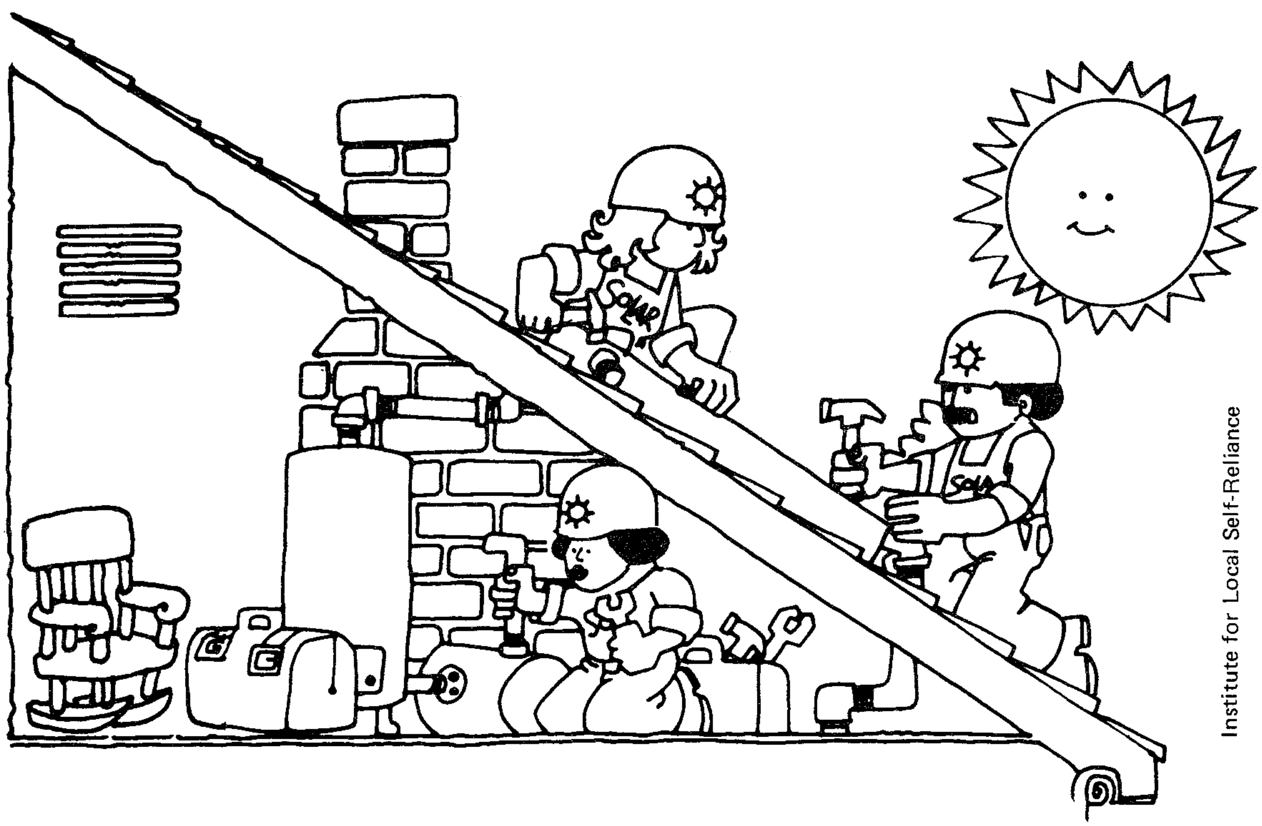
Finally, it is simply much easier and more realistic to enter a field in which you do not have to compete with large corporations. Once the business has established solid economic footing, stable marketing, and detailed knowledge about solar equipment, perhaps it can move with more ease into production.

Community businesses should consider entry into the solar field, particularly combining alternative energy with housing rehabilitation. Housing is seen as a more immediate need in low-income communities than energy, and the combination will strengthen both. The most feasible starting point here would be the installation of solar hot water heating systems or, based on feasibility, small passive retrofits such as window box heaters or solar greenhouses.

Bendavid-Val estimates that a workforce of seven people are needed to install solar water heating, including two office workers, four installers, and a supervising master plumber. [54] Workers need to be trained in plumbing, heating, and carpentry skills. Conversations with installers indicate that training should not take more than 6–8 weeks for basic skills. [55]

Solar projects combined with conservation would maximize energy savings. Insulation is the first step any energy project should take — it is quick, simple, cheap, and provides immediate energy savings. A community business could manufacture cellulose insulation made from recycled newspapers and then insulate homes in the community. Start-up costs for manufacturing are $300,000 to $500,000 which, as Bendavid-Val notes, may be too high for communities stressing job creation, or those with limited resources. [56] As with solar, a community can start with installation, and if successful in developing a viable business with adequate markets, can expand into manufacturing.

There are only a few existing community enterprises in the solar energy field. West Side Community Development Corporation (CDC) in San Bernardino, California grew out of a welfare rights group active in the 1960s, and began by getting money from the Department of Labor and CETA funds to do housing rehabilitation. In 1975, they moved into the solar field. With grants from HUD's Cycle II Solar R&D program, CETA job training, and Community Services Administration support for design and staff costs, they set up 72 collectors to provide water and space heating for ten newly rehabilitated units. (It is relevant to note that this CDC was a response to the high unemployment in the West Side area due in part to declines in the local aerospace industry and termination of an Air Force base. The houses were bought from the Veterans



Institute for Local Self-Reliance

Administration at a specially negotiated price. A Navy engineer designed the systems.)

West Side CDC has provided job training for over 500 low-income youths and visibly upgraded several neighborhoods' housing stock and environment. Future plans include additional rehabilitation, energy conservation, and solar projects. Also, West Side CDC has ambitious plans to set up an industrial park on nearby vacant land which among other things will manufacture solar collectors.

One problem is that grants for West Side's 10-unit solar system totaled over $437,000. [57] On the one hand, this was an experimental demonstration program which included rehabilitation work, but the high cost is still disturbing. Not many other groups will be able to afford such resources, and will need to reduce necessary costs drastically, with efficient management and operations. It would be a political and economic disaster to impose a non-cost-effective solar system on people, unless continuing grants (including on-going maintenance costs) can be guaranteed.

West Side CDC is also important for its focus on providing energy for several dwellings. Projects such as these can be expanded to provide the basis for a community energy system, bridging the gap between projects which focus only on individual homes and large scale energy generation. [58] Integrated systems, such as those which produce electricity and use waste heat for space and water heating, combined with wind energy could meet a substantial part of a neighborhood's energy needs (see discussion on Acurex in Chapter 2).

The Solar Center in San Francisco is another model for solar businesses. This small installation firm is a closed California corporation with all of its stock owned by employees and other active participants. In addition to employee investments, the Solar Center was capitalized through outside investments, which were in practice similar to a long-term bond arrangement. Investments are paid back at fixed rates of return and do not purchase ownership in the company. Internally, the Solar Center is officially run by a board of directors, which in practice is all or nearly all the workforce. Decisions are made collectively at weekly staff meetings, though there is a division of labor by field of expertise. [59]

The Santa Clara Solar Research Institute is a nonprofit corporation structured as a community business. SCSRI has spun off a company, Solpower Industries, which manufactures and installs solar equipment. To broaden community accountability, Solpower's board is composed of three employees, three consumers (customers), and three community residents who have authority to set general policy in their monthly meetings. The majority stock is held in trust for SCSRI, while the board has final authority. Business decisions are made at weekly meetings of all Solpower employees. Although they have different responsibilities (sales, design, construction, etc.) employees have equal voting power. [60]

Municipal Programs

There are also several examples of existing and proposed municipal programs to provide public planning and support for energy alternatives.

Seattle, for example, declined to participate in the regional utility's nuclear energy plan. Instead, the city initiated a study to assess energy needs and came up with a figure 50% lower than the utility's predictions. The study had a citizens' policy board with oversight authority, and formulated a comprehensive education and implementation campaign currently under way for conservation and renewable resource alternatives. [61]

Santa Clara, California is one of the few towns with a solar utility. Financed through an initial installation charge (dependent on the size of the solar collector) and payments on the monthly water bill, the city has installed 90 hot water heating systems since 1976. [62] However, the systems only provide heat for swimming pools. According to the utility, home water heating through the water department would cost 2 1/2 times the cost of gas and 30% more than electric heat. And space heating was seen as completely out of the question. The Santa Clara System also creates an interesting problem of union jurisdiction — the workers who install the units are public employees and therefore belong to the American Federation of State, County, and Municipal Employees (AFSCME).

Hartford, Connecticut has proposed a Citizen Energy Corporation (CEC) for local energy management. The CEC will conduct energy audits, beginning with public buildings, to determine how to improve heating and cooling systems and lower energy use. The CEC will also do the rehabilitative work (insulation, weather stripping, etc.) at the client's request. CEC will employ CETA workers assigned to community organizations, as well as skilled trades workers as monitoring inspectors. Hartford also requires that old buildings be brought up to energy efficient building codes before they can be sold. [63]

Other cities can undertake similar projects, beginning with municipal information services to perform cheap or free energy audits and give advice. Many towns have energy coordinators, and it would be useful to have a well-trained field staff for technical consulting requests from individuals and groups. Staff should deal with energy issues (conservation, solar) but also help with financing (grants, loans).

Neighborhood energy commissions could be a possible vehicle for an energy coalition strategy to formulate and communicate local needs to the city authority. These neighborhood associations could form a Neighborhood Energy Cooperative (NEC), proposed by the Appropriate Technology Action Coalition (ATAC) in New York. [64] The NEC is designed to meet the energy needs of low-income residents, as enabled by section 109 of the Energy Conservation Bill passed by Congress last year. This bill allows states to help set up consumer energy cooperatives for energy conservation measures and gives them mass purchasing power to reduce the cost of energy audits, purchase of materials, and installation of energy conservation equipment. [65] The NEC plans to undertake these activities as an organization of housing and tenants groups receiving funds from community development block grants and the National Co-op Bank.

Role of Labor Unions

These alternative business enterprises pose the same questions for labor unions as do existing businesses. If unions and their members are not involved, either directly or indirectly, in the creation of these new businesses, the coalition will be creating competing non-union jobs, a position unions will be hard put to support. Since labor support is a key to the political strength of a solar coalition, we must locate ways in which unions can participate in a decentralized solar path. Otherwise, we can expect that they will back corporate plans which seem to offer stable, though perhaps fewer total, union jobs at higher wages. IAM's William Winpisinger, for example, recently endorsed the Satellite Solar Power Station.

One possibility would be to combine CETA job training programs with labor unions. Generally, CETA workers are trained in non-union jobs. However, if a CDC got CETA money to train solar installers, Building Trades unions could set up and administer the job training program. This would give unions a stake in the CDC by creating jobs for union people. Moreover, after completing the program, which would be taught by skilled crafts workers and include extensive on-the-job training, workers would be eligible to become union members.

One question which comes up about this idea is whether unions need more jobs for members, or want to increase their total membership, which they often are reluctant to do in the face of high unemployment. However, since many unions (including locals in Santa Clara County and Bay Area Building Trades) are facing declining membership rolls, they might be open to such job creation plans. [66]

There is a danger that this plan could create a caste system within the building trades, where minority members are once again stuck in the lowest paying jobs. Plans must be made to give these participants access to higher skills and better paying jobs to avoid such a system of structural discrimination.

The key problem is wages, since, as we noted earlier, most union workers make considerably more than solar employees. Businesses could institute a pay-loan plan, where workers would be paid lower wages initially. This would be considered a loan to the enterprise to be repaid with interest once the business gets on its feet. The problem here is what if the business fails? Either the workers get stuck, or perhaps loan guarantees through financial institutions or state banks could be arranged. The pay loan plan is currently being negotiated with the San Francisco Carpenters Union for a union-owned corporation building low-income housing.

Another possibility would be to organize a state or federally supported wage package. This would provide a set of benefits, including health care provisions, compensation, unemployment, and perhaps pension fund support, combined with at least temporary acceptance of wages below union scale.

One of the most interesting examples of union participation in community economic development projects is the role of the UAW in creating two CDCs: the Watts Labor Action Committee and the East Los Angeles Community Union (TELACU). [67] For TELACU, begun in the late 1960s under

Walter Reuther's leadership, the UAW granted money to Chicano UAW members, and organized the sponsorship of other unions. TELACU has organized a major housing development project, has numerous construction projects both completed and underway, is creating a network of credit and financial assistance institutions for capital development, and provides extensive technical assistance for minority business people.

While UAW members still sit on TELACU's board, the CDC projects do not directly affect UAW workers and jobs. In its construction projects, TELACU consults closely with local building trade unions, negotiating compromises where projects adversely affect union jobs.

While the UAW has not initiated similar projects since TELACU, we can perhaps use this model to suggest a trade-off organizing strategy. The overall solar coalition would agree to support industrial union organizing in solar production (solidarity actions, fundraising aid, strike support, public education). In return, the union would agree to help finance, or organize another union financing consortium like TELACU, a solar installation community business. Hopefully, other coalition participants could help, either with organizational reserves or small stock offerings to individual members. Unions could even start up enterprises run by union members, like the carpenters' project mentioned above.

Although outside the traditional union role, financing community solar enterprises could be an aggressive step toward job creation and a strengthened trade union movement. Unions control vast sums of money through their pension funds. Randy Barber and Jeremy Rifkin of the People's Business Commission estimate union pension holdings at $125 billion. [68] Pension funds currently invested in non-union shops, and companies which run away overseas and at home to find cheap labor, could be used to reinvest in job creation and community economic development.

Union pension funds are controlled in one of two ways. Industries such as coal, construction, and textiles have multi-employer plans controlled by joint union-management committees. Single employer plans in industries like steel and automobiles are controlled entirely by the company's fiduciary agent — banks, insurance companies, or private fund managers. [69]

Changing this system requires a fight, challenging legislation which prohibits union control, and legal cases establishing precedents giving unions at least partial control. (In the past, union pension funds have sometimes been associated with corrupt practices. To avoid this, there should be some form of government oversight.) Given the magnitude of capital involved, however, we can expect stiff resistance, but union leaders such as William Winpisinger of the IAM have expressed interest in making union control of pension funds a major issue in the 1980s. Unions could combine working on legal and legislative changes to gain control of pension funds with the more immediate option of participating in financing local energy enterprises. These businesses could be capitalized by stock offerings to individual local and rank and file workers, as well as to community groups. This project would be greatly aided if an intermediary financial institution (private or state banks or some form of local development corporation) would guarantee loans and protect investments. [70]

Financing Mechanisms

Financial incentives applied by government and private institutions can rapidly accelerate the development of cost effective solar energy. These incentives currently promote six conventional energy sources, giving them an artificial cost advantage over solar. Since 1918, the federal government has spent at least $120 billion on energy subsidies for coal, oil, gas, and nuclear power. These subsidies include depletion allowances, tax exemptions or reductions, direct subsidies, and accelerated depreciation. [71] *Business Week* notes that this figure may be as high as $500 billion. [72]

Solar incentives would stimulate production and bring down costs. However, if applied without regard for the question of who controls the solar industry, many financial incentives will give advantages to large corporations able to make extensive capital outlays to maximize outside underwriting of their investment. Therefore, financial mechanisms should be designed to help promote a diversified and non-oligopolistic solar industry.

We will examine financing options to help alternative energy businesses, labor, and consumers, and where appropriate, discuss ways which these measures will affect the energy market and structure of the industry.

Aids to Business

Throughout this chapter we have emphasized that acquiring access to sufficient amounts of capital was the key problem for small solar businesses. A comprehensive program of grants, loans, and loan guarantees, and investment policies could greatly aid small businesses and promote their participation in the solar industry.

Grants. This applies primarily to community or cooperatively owned enterprises — CDCs, producer co-ops, etc., and will therefore help keep industry relatively small and decentralized. Grant subsidies will increase supply and, combined with consumer incentives, will speed the development of the solar market. Some grants to CDCs should allow for free installation in low-income communities, which are normally the last area to utilize new technologies.

Possible funding sources include:

- **Community Development Block Grants:** Housing and Urban Development (HUD) funds given to cities to aid low and moderate income neighborhoods. Legislative changes made in 1977 now allow CDBG money to be used for community economic development projects. CDBG grants can be used to provide small businesses and neighborhood non-profit businesses with working capital or operational funds, and with capital for fixed assets .
- **Community Services Administration (CSA):** a major funding source for large scale CDCs.
- **Economic Development Administration:** Title III, Section 301 provides direct grants to economically depressed areas to set up economic development programs. Title IX money can be used in areas facing severe unemployment for grants to businesses.
- **Department of Energy:** small scale projects, solar energy demonstration.
- **National Center for Appropriate Technology:** small grants for seed capital or feasibility studies for appropriate technology projects.
- **California Energy Commission:** small grants for demonstration projects.

Loans and loan guarantees. Unless targeted to small or community co-op projects, these could promote monopoly control given the current system of inequitable credit allocation. Loans should be financed on a sliding scale interest rate, with small firms required to pay lower rates. Or, the state could subsidize interest rates by several points. Possible sources include:

- **Private banks and savings and loans:** very difficult to get new enterprise loans, especially in high risk solar industry. It may be possible to use leverage of federal grants to get loans from private banks, who are generally more amenable to large established concerns. Loans might also be possible through a minority-owned bank in a local community.
- **Small Business Administration (SBA):** loans are difficult to get without a track record and have rarely gone to solar firms. Recently introduced legislation would provide $30 million in direct loans and $45 million in loan guarantees for alternative energy firms. This bill also eases track record requirements. SBA should reduce paperwork and application costs, and provide technical assistance to applicants.
- **California Regional Job Creation Corporation:** capitalized by the state, this corporation can offer up to 90% loan guarantees to get commercial bank financing.
- **Economic Development Administration:** Title II, Section 202 provides loans and loan guarantees for acquisition of fixed assets and working capital. These loans can specifically go to public corporations which because of high risk are unable to get other financing.
- **Business and Industrial Development Corporation (BIDCO):** enabling legislation recently passed in California to make loans to small (as yet undefined criteria) alternative energy businesses. BIDCO would be capitalized by a state appropriation leveraged at approximately ten to one by federal funds. These institutions could be funded on a county level to be more responsive to urgent local needs. [73]
- **Community Development Finance Corporation:** could be modeled after Massachusetts CDFC, set up to provide venture and equity capital to community-owned and controlled enterprises (i.e., CDCs). Mass-CDFC is designed to focus on economically underdeveloped areas. It could be funded with a pool composed of public funds (i.e., pensions) currently deposited in private institutions instead of with state appropriations. [74]

- **State Bank:** using state reserve funds, pensions, and local government money to finance projects neglected by private banking industry. It could be modeled after the Bank of North Dakota and participate in mortgage financing of loans originating with private banks; or, if political obstacles can be overcome, it could make direct loans to communities or small businesses. [75]
- **Equity Investments:** various institutions can invest money in community/ co-op projects, including CSA, CDFC, churches, and unions. One innovative proposal calls for the creation of a Small Business Investment Corporation for solar manufacturers. This corporation, called the Solar Underwriters Network, would be set up under guidelines from the Small Business Administration to invest in small solar manufacturers. Money obtained from private investors can be leveraged against federal money at a rate of $4 of federal funds to $1 of private investment. [76]
- **Investment Tax Credits:** there are two components to this mechanism: to provide tax credits to alternative energy businesses, and to repeal tax credits and other government subsidies for non-renewable energy sources. Tax credits to solar businesses would aid the developing industry, but unless targeted to small or alternative firms, would help large firms proportionately more. Repeal of conventional subsidies would speed the alternatives. However, this would also raise the cost of energy, which will disproportionately hurt lower income communities unless compensating rebates to low-income people are part of the package.
- **Employment Tax Credits:** give income tax breaks to corporations for each new employee hired in alternative energy businesses. A recently proposed bill (HR-3477) would credit 40% of the first $4,200 paid to new employees on corporate income taxes. However, since this subsidy cannot be used by a tax-exempt corporation, a nonprofit CDC should have a for-profit subsidiary do the new hiring.

Aids to Labor

Labor costs are the major component in keeping costs down for solar businesses, particularly for active and passive systems. In order that these costs not be held down at the price of low wages to solar employees, we list below several methods which can help underwrite labor costs and preserve the viability of small solar businesses.

- **CETA:** subsidized labor would help keep costs down. CETA gave $23 million to CDCs in 1977. CETA funds generally go to public/nonprofit agencies or community groups, so they help preserve a small-scale industry. The problem of competition with unions could be helped by bringing in unions for job training. [77]
- **Wage subsidies:** state payments to small alternative energy firms to raise wage levels to decent scale without driving up the cost.
- **Sweat equity:** community people contribute their own labor at little or no pay to implement a community energy project. This keeps costs down for low-income communities. [78]

Aids to Consumers

The high initial cost of active solar heating systems is currently a major barrier preventing consumers from utilizing solar energy. This is particularly true for low-income people who lack the extra capital to make an investment which will save them money in the long run. State and federal policies, combined with banking industry practices, can ease this barrier and promote consumer use of solar energy in communities of all income levels.

- **Grants:** state or federally supported grants to people installing solar systems. This should be done on a progressive basis, with larger grants for lower income people. Grants are necessary for people whom tax credits will not reach.
- **Loans:** should also be on a sliding scale with adjustable interest rates.
- **Tax incentives:** property tax credits along the lines of California's 55% credit for solar systems .
- **Sales Tax Relief:** exempt alternative energy purchases from sales tax.
- **Income Tax Credits:** for alternative energy purchases.

GOVERNMENT POLICIES AND REGULATORY MECHANISMS

Government energy policies encouraging solar energy can extend beyond financial incentives to include anti-trust and similar regulations to prevent centralization of the industry; regulatory mechanisms to bolster consumer confidence and minimize legal obstacles; and direct procurement policies to stimulate the solar industry and publicize solar feasibility.

Government procurement. Local, state, and federal governments should implement conservation programs and purchase solar systems where feasible for all municipal buildings. For example, the Department of Defense recently allocated $100 million to retrofit military buildings with solar energy systems. In addition, governments could pay institutions, such as schools, to install solar equipment.

Federal insurance for solar energy. The uncertainties of solar systems and businesses is a major barrier restricting consumer use. If government assumed the risk through insurance or indemnity incentives, consumers would be more willing to install solar systems. The Price-Anderson Act, whereby the federal government insures against accidents at nuclear power plants, is a precedent for similar solar incentives. [79]

Restrictions on energy company involvement. Modeled on California SB-1945, this prohibits energy companies from owning or controlling solar businesses. This is desirable to preserve decentralized solar industry, but difficult to implement politically (the above bill died in committee).

Restrictions on utilities. Could be modeled after California AB-2984, to prevent privately owned gas and utility companies from restricting competition or growth in solar industry. As long as utility and corporate prohibitions do not impede development of efficient economies of scale, these measures help keep costs lower by preventing monopoly price fixing.

Develop certification and warranty system. This would increase consumer confidence by setting quality standards and protecting purchasers' investments. This will help the solar market, but the government must be careful not to impose standards or regulations which will place small firms at a comparative disadvantage.

Develop building codes energy standards. Enact regulations regarding building design, orientation, windows, and insulation. Perform calculations on the basis of life-cycle costing to promote conservation and energy alternatives. Begin with public buildings, and target city projects to municipal enterprises or community/cooperative firms. Then the standards could be extended to city financed or assisted housing, new home construction, and sale of homes to new owners.

Sun rights legislation. To protect solar systems from being blocked by nearby buildings.

Conclusion

In this section, we have provided some of the steps we think could promote a solar energy program best suited to community development and control. On the one hand we speak to the need for a political coalition uniting now-separate factions which would have sufficient strength to challenge corporate control. On the other, we analyze specific options for alternative community businesses. Although many institutional and economic barriers currently block community solar development, significant although limited possibilities exist for establishing a democratic and decentralized industry.

This work is only the preliminary outline for an alternative solar industry. These ideas must be carried further to form a comprehensive, step-by-step strategy to follow up in areas most promising for citizen control. Community level action, although the backbone of our vision, will not be enough on its own. Because federal and state policies will be crucial in shaping the solar industry, the solar jobs coalition must develop a well-integrated and coordinated national plan for solar development. An effective campaign combining legislative and lobbying measures with well-organized local actions could provide realistic alternatives to the high technology projects of the large corporations.

In the final analysis, the real work remaining to be done is in the implementation of these ideas. While the proposals we have formulated seem logical and convincing on paper, we have no doubt that substantial revisions and new approaches will be necessary to put our ideas into practice. The process of working together with different constituencies in a coalition is a difficult and sometimes frustrating process. Moreover, actually starting alternative business enterprises can be a very risky economic venture. Nonetheless, these steps must be followed if a mass-based popular movement is to win control of the developing solar industry.

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79. Battelle, *Federal Incentives*, pp. 259–260.

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