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MASTER

SOLAR ENERGY POLICY REVIEW

SUBMITTED TO:

U.S. DEPARTMENT OF ENERGY

SUBMITTED BY:

DHR, INCORPORATED

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August 17, 1978

MEMORANDUM

TO: Allan R. Hoffman

FROM: James Just, Stephen Rattien, and David Staples

SUBJECT: Recommendations on the Findings, Problems and Issues in Strategy Sections of the DPR Status Document and Response Memorandum

A number of us have reviewed the Status Report and the first draft of the Response Memorandum with particular emphasis on the Findings, Issues and Problems, and Strategy chapters. This memorandum contains our major recommendations and is followed by a discussion of these recommendations and other observations. Two attachments are included. One describes several strategic concepts which could be used to organize the options. The other lists issues or options which are either buried or missing from the status report and which deserve somewhat more highlighting.

Our principle recommendations are (not in order of priority):

- (1) Derive the appropriate Federal role (and budget) for solar from a clear statement of the overall energy problem, how solar can help solve the problem and how this problem relates to other national needs. This should be as solid and quantified as possible.
- (2) Evaluate the options, especially with regard to the magnitude and timing of the energy impacts, of the dollar cost to the treasury and to the economy,

and the environmental impacts. This is the major hole in the study at the moment.

- (3) Relate the options and the problems to the National Energy Plan, as originally envisioned, and if necessary, to modifications made in Congress.
- (4) Include the role of higher energy prices, in particular the role of the crude oil equalization tax or oil import tariffs, in aiding the penetration of solar technologies.
- (5) Categorize the solar technologies into active vs. passive designs, central vs. decentralized technologies, and product type (thermal energy vs. electricity, vs. intermediate fuel). As an organizational theme for the discussion of issues and perhaps organizing the options, this would be useful to put up front and utilize in each chapter.
- (6) Include more of the sense of uncertainty about the performance/cost of solar, future fuel prices, resource base, etc.
- (7) Relate the individual options to the problems that have been identified which they are supposed to solve.
- (8) Provide a list of alternative strategic concepts which could serve as organizing themes for the options.
- (9) Describe the options as groups of option concepts, since they are not really fully described options.

(10) Categorize the option concepts into those with near-term, mid-term, or long-term impacts.

(11) Categorize the options by implementing mechanism: executive order, legislation, and redirection of existing funds, etc.

Findings, Problems and Issues

The NEA, as originally envisioned, provided significant support for solar energy directly through tax incentives and R&D and indirectly through a movement to incremental cost pricing of alternative fuels (very important). The problems and new options should be related to the NEA as obvious extensions resulting from our information.

There is no discussion of the relative importance or time frame of the issues and problems identified. This could be measured as the magnitude and timing of incremental solar energy that would result from removing the barrier, or solving the problem.

Since the price of alternative fuels is a major driving variable in determining relative solar economies and market penetration, pricing policies (like the President's ideas for COET, imported oil tariffs, gas deregulation) for non-solar fuels should be emphasized as important.

The issues need to be more closely tied to the options and strategies. The issues provide the questions which the strategies and options will address as well as the areas where major effort should be directed. The following are comments which may be helpful in further refining the stated issues.

- The issues must be tied to the options and strategies that have been developed in order to insure the proper questions and issues are answered and addressed.
- The issues should be prioritized. The key constraints to solar should be emphasized, especially in areas where the government clearly has the lead role (e.g. regulatory and institutional barriers, R&D, subsidies).
- The issues need better definition. For instance, the allocation and implementation issue groups are closely related, but the specific issues of concern will vary greatly depending upon the degree and intensity of Federal effort.
- Related to this the issues within each major grouping will not necessarily remain the same with varying degrees of Federal effort.
- The issues might be developed to incorporate various Federal government philosophies on how solar should be implemented. For instance, rather than supporting the supply side of the solar industry, perhaps the demand side should be supported.

Strategies and Options

The idea of integrated options is a useful one to compare the basic "building block" options according to quad impact, dollar impact, timing, type of implementation required, etc. but they do not represent strategies as such. A strategy represents a series of decisions about how the government should concentrate its resources, regulatory powers, R&D efforts, incentives, etc. on achieving a particular set of goals, i.e. maximize near-term decentralized solar impacts. Since the integrated option idea does not cull out any options or set priorities among them, it is most useful as a display option, but it does not represent a series of decisions. The options that are presented are not really options, they are groups of option concepts. They should be described as such.

It will be difficult to assess the extent and timing of energy and budget impacts of the option concepts but every attempt must be made to do so. This is the major hole in the study at the moment. There is no way at the moment to compare alternative strategies or groups of options other than a very crude, philosophical, non-quantitative basis. The DPR can do better than that.

There are too many strategic concepts which could be utilized to group sets of options into overall strategies. There is no unique nesting set of strategies that would be mutually exclusive and collectively exhaustive. Attachment II is a list of several interesting strategic concepts, but without quantitative information, and some decisions on the appropriate Federal role, it is

impossible to go further in developing alternative strategies. Once this data is available, the options could be grouped by clusters according to cost/benefit ratio, philosophical approach, etc. The structuring of the options is less important than getting the impact assessments of the options.

For the public document, the energy and dollar impacts of the options are not important but it would be useful to mention several alternative strategies that might be used and alternative federal roles. It is important in the public document to try to build a case for solar without prejudging any presidential decisions, but the case must be as solid quantitatively as possible and explicitly recognize the interaction between different fuel types.

Attachment I

Issues and Options Not Emphasized or Not Included in Current Draft

Biomass

- (1) Use of national forests as sources of fuel
 - a. clear cutting
 - b. fall wood
- (2) R&D into peripheral equipment--shippers and transport and delivery vehicles
- (3) Clean air problem relief for urban solid waste combustion

OTEC

- (1) Law of the Sea issue resolution--analogous to offshore nuclear powerplant issues

Passive Solar Heating

- (1) Non-architected building design--design competitions sponsored by DOE/HUD with NAHB/AIA
- (2) Use of EPCA/ECOA SIPs to modify state and local building codes and zoning ordinances
- (3) Building material R&D (water wall systems)

Active Solar Heating

- (1) Enlarged federal purchases (DOD, GSA) tied to an industry set standard
- (2) Maintenance contracts (TV used to have them air conditioners, etc. still do)--use EPCA

Low-Head Hydro and Small Windmills (Conserver-owned)

- (1) Buy back provision for excess power--state PUCs (through EPCA), required to set time-of-day electricity prices that the grid will pay to all marginal producers. Rate should be based on central power station marginal costs..

Attachment II

Sample Strategic Concepts for Organizing Options

- Maximize Near-Term Impacts
- Emphasize Technological Breakthrough (R&D)
- Keep Long-Term High Impact Option Open
- Keep early '90's Option Open
- National Energy Plan Extension
- Market Oriented Solar Parity
- Information Only Program
- Push Near-Term Decentralized Solar Technology
- Maximize off budget impact
- Meet 20 quad goal in 2000
- Maximize "bang for the buck"

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September 1, 1978

Memorandum

To: Jim Benson and Clark Bullard
From: Jim Just
Subject: Review of the CEP Job Study Draft Final Report

It is obvious that a tremendous amount of fine work has gone into this report in terms of data collection, analysis, etc. The report as stands does not do justice to the amount of work involved in the study. When an Executive Summary of the report is finally prepared it will do wonders for readability. However, to improve the body of the report, first off, the introduction needs a short summary of what was done, why it was done, what specific question were asked, how the answers may differ depending upon which questions were asked, which scenarios are run, an overview of the organization of the report, an overview of the logic flow, (not only for analyzing the impact of a particular conservation option but also for analyzing an overall scenario).

It is absolutely essential that there be a section that clearly describes the analytic problems associated with answering different types of questions. For example, under what circumstances is it

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appropriate to include multiplier or induced capital expansion effects in assessing the labor impact or total dollar impact of a measure. What are the differences between the results given by the RIMS local model and the national input-output model? Why are these differences important? What do they mean? This type of material is completely missing from the report and some of the analysis results may or may not be right depending upon which question is being asked. These differences make it important to separate direct labor impacts from the indirect labor and induced impacts of spending wages; from induced impacts resulting from capital expansion of the industry; and from impacts of spending increased disposable income resulting from any cost effective investment (e.g., net savings from upgrading attic insulation) in the labor analysis. No results from the national model have been included yet. I have recommended to Jim Benson that he include the national input/output model results and very carefully distinguish between the direct, the indirect, and the induced impacts that may result. With the RIMS model it is impossible to differentiate between indirect and induced impacts in the region.

So far the paper has wisely refrained from attempting to draw comparisons between the job impacts resulting from solar and

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conservation and those resulting from the nuclear scenarios. These scenarios are really not comparable. In order to properly analyze the relative job energy, or other impacts of a conservation/solar scenario vs. a nuclear scenario, the proper procedure would be to compare to extremely detailed scenarios over time that differ only in the amount of nuclear vs. conservation solar that are used to meet given energy service demands and GNP size and mix. Any claims for changes in the real GNP growth rate, aggregate employment, productivity growth could then be examined in detail with the scenarios context.

The probable areas in which the CEP job study will be attacked include the energy savings associated with each of the conservation solar investments; the rate of implementation of the technologies; the number of jobs required to perform the various conservation solar construction tasks; and whether double or triple counting is involved by focusing on the regional multiplier effects or the capital expansion effects on the national levels; and finally, on what questions have or have not been answered.

The most problematic area of the study, and I know this is one that Jim and his staff have wrestled with, is what are the implications of the study and the results so far. This is very

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difficult to deal with and I have made several suggestions to Jim over the phone and I will be glad to help with this in any other way possible.

Many assumptions have been used in this report which are alluded to or directly stated up front whose implications only become known much later in the study. For example, the assumption about fuel prices increasing at the effective rate of interest or the discount rate. This has tremendous implications for which conservation options are beginning to be economic but this is not made particularly clear at the time that the assumption is stated. This should be corrected.

The rest of my comments will refer to particular page numbers. The page numbers that I reference will be the handwritten page numbers in the report.

Page 1
Introduction

- A. The introduction needs a short summary of what was done, what questions were asked, what scenarios were run, etc.
- B. The first paragraph is very choppy, jumping from regional to national economy to employment, to capital investment. This should be a much grabbier paragraph. Incidentally, most studies that I know of do not consider capital availability to be a significant problem for the future.
- C. In the second paragraph it should be noted that there has been a long term historical decline in the energy to GNP ratio.
- D. In paragraph three, while energy efficiency is important, total factor productivity is more important.

Page 2

The methodology section badly needs an overview of what the study is trying to do, in addition, it needs a very clear statement of what the problem is and what questions specifically are being asked, and how the nature of the question being asked determines how the basic data are to be combined, analyzed, and implications incurred. In particular, the need for an overall national as well as local detailed scenario through time that differ only in the extent of their nuclear conservation and solar components must be emphasized.

Page 3

- A. At the top of page three, the question of to what extent multiplier effects are appropriate depends upon whether we are talking about incremental investments, at the national or regional level, or similar extraordinary absolute increases in income within a region.
- B. Second full paragraph. Given constant incomes and increase in demand for hot water systems creates a decrease in the demand for other products, be they electricity, aluminum siding or restaurants.
- C. It is important somewhere in this page to provide a simple but powerful description of the role of technology change in the sense that a shift from reliance on electric or gas hot water heating to solar hot water heating to solar hot water heating represents a technology change can result in real economic growth. Real economic growth occurs whenever the same sets of goods and services, at least measured in terms of attributes or delivered energy service, can be produced for with a smaller quantity of labor capital and other real resources. Thus the extent to which solar hot water heating represents a savings of aggregate resources over the next best alternative. A switch to solar hot water heaters can contribute to real economic growth.
- D. At some point the difference between purchaser prices and producer prices will have to be mentioned.

Page 4

Are the numbers in this table on purchaser prices or producer prices?

Page 5

I do not understand what these numbers mean. They are not particularly well-explained in the text. It would help understanding if an example were given of \$100 spent to purchase pumps and compressors in the Long Island area measured in purchaser prices. If this transaction could be translated into whatever the numbers of Table II mean, explained particularly with regard to what region is being discussed, and what set of dollars. Also, what is the role of the localization decision? The interaction between the localization analysis and these RIMS coefficient are still a mystery to me.

Page 6

A. First full paragraph.

Are the demands that are referred to in terms of deriving direct, indirect induced and total multiplier effects only on local industry? (i.e. in Nassau and Suffolk counties)

B. Second Full paragraph.

Is the requirement for more machinery from sector 35 a capital expansion or operating requirement?

Page 7

A. Second Full Paragraph

The phrase "for the study region" implies that the above calculations were for Nassau and Suffolk counties. Am I right here?

Page 6

A. We have a potentially serious problem here in the calculation of capital expansion required per dollar increase in sales. These capital investment impacts are only real if the growth rate of certain capital goods has accelerated. For example, if my business is manufacturing pumps, I may have a capacity sufficient to supply 10 nuclear plants or 10,000 solar water heaters per year. Consequently, I will only have to expand if I am asked to supply more than 10 nuclear plants or 10,000 solar heaters per year. Thus, we cannot tell whether new capital investment is required by analyzing just one piece in overall national or regional scenario. In other words, the nuclear analysis or conservation solar analysis by itself will not tell us whether new capital investment is required.

B. Second Full Paragraph

I think as you have discovered, the most difficult task in analyzing the employment impacts is what to do once you have compiled the bill of goods and collected the basic data.

Pages 26 and 27

The numbers that should be comparable between Tables 10 and 11 do not seem to be. For example, in page 10, the total escalated labor costs are 540,352 million dollars in Table 10, and 540,424,000 dollars in Table 11.

Page 29

In computing the distribution costs, we need some explanation as to why marginal investment was based on peak analysis rather than base load.

Page 34

It states at the top of the page that 11.7 mills/Kwh hour is calculated by common off for the fuel cycle operations. This does not correspond with the information given in the Appendix II of approximately 6 mills/Kwh.

Page 37

About 22% can be considered an upper bound for local production for materials. What is a realistic lower bound? Do we have any information as to how 22% compares to average local expenditures for a power plant? I am concerned that we may be significantly overestimating the local production.

Page 41

What does the phrase "walls face cardinal points" mean?
And what does it imply?

Page 43

There would seem to be a large number of changes that might be difficult to implement in this improved single family prototypes. For example, retrofitting the wall insulation and shading factors. If the shading factors are achieved with awnings, it may be possible, although awnings look fine on certain types of houses and not so great on others. In the problems of retrofitting walls with insulation are well known. What I had not been able to figure out in the Tables included in this section are to what extent the improvements are considered to apply to all single family homes or some fraction thereof. I would appreciate some additional tables that indicate what the percentage of penetration of each of the conservation measures would be for the different types of dwelling units.

Page 45 and thereafter

The changes in heating load are again much improved but I am unable to tell to what extent this is achieved in all homes. I also am not sure what units the measurements are in, other than millions of Btu per year, how and where are the measurements made? Does it refer to heat delivered to the inside of the house, or at the entrance to the house, or is it a fossil fuel equivalent.

Page 49

- A. I appreciate the difficulties of computing the combined effects of building envelope changes involving several different conservation measures and then changes in the heating and cooling systems. The extent to which these calculations were done correctly or incorrectly, unfortunately cannot be assessed from the information given.
- B. In the second full paragraph, the analysis of the value of individual measures should be shown in more detail, perhaps in an appendix. Alternatively, the assumptions and payback periods could be given in a Table up front.
- C. In the third full paragraph it would be useful to quantify the degree of subsidization by comparing, for example, the marginal cost of the latest Loco plant with the average rates charged to Loco customers.
- D. The concept of choosing how techniques for measures which had a payback period shorter than the lifetime of the measure seems a bit strange. This measure does not seem to make much economic sense and I would appreciate more explanation about the choice procedure.

Page 50

- A. Whenever "do-it-yourself" labor is assumed, it would be useful to refer to a table or other location in the book that describes how much was assumed as a percentage of total retrofit and perhaps some indication of why.

- B. The sources of the estimates of the number of houses to which a measure could be applied should be given. Additionally, it would be useful to include the data in itself.

Page 52

- A. The materials cost for storm windows seem rather low. How many of what kind of storm windows does the \$225.00 buy? It certainly seems low for sliding or casement type windows.
- B. The selection of attic fans given the degree of retrofit attic insulation seems strange since latest studies indicate that attic fans are not effective with 9 inches or more of attic insulation.
- C. What is the source of this cost information?

Page 53

- A. Heat pumps have a comparatively short life time on the order of 10 years. How has this cost been factored into the scenarios or the total cost of installation?
- B. Sixty man-hours to install solar domestic hot water heaters seems very high. Twenty to forty hours are the range of estimates that have been used by the labor impacts group in the domestic policy review of solar.

Page 57

- A. Is the term "insolation in new single family homes" the new term for passive solar installations?
- B. While overhangs or awnings can theoretically applied to most any kind of home for architectural styling reasons, they usually only apply to certain types of homes, and while they may be cost-less if that style of home is being built, it can impose design restrictions which are difficult to quantify but which are real.

Page 59

- A. In 80% efficiency for an oil fired heater seems to be very high. Is it realistic to use a number that large?
- B. The point at the bottom of the page is well taken.

Page 60

- A. There seems to be a missing sentence at the end of the first paragraph on the page.

Page 61

- A. It's interesting that we can install flue dampers for less than the retail price of flue dampers. Are these costs realistic?

Page 64

- A. In this and following tables it would be useful to explain the savings a bit more. I cannot follow the applicability of these savings to typical homes. It would also be useful to describe the total energy saved by that measure within the given scenario. Again I am concerned about the savings allocated to attic fans.

Page 69

- A. The 20 year lifetime attributed to heat pumps is a revelation to me. Certainly it does not apply to current designs and equipment.

Page 74

- A. In the second paragraph a study is referred to that found no correlation between refrigerator efficiency and price. It perhaps is only fair to refer to studies which have found such a correlation, if not with price of refrigerators, certainly with the cost of production.

Page 75

- A. In the third full paragraph, again I question the cost-effectiveness of attic fans.

Page 78

- A. Does the Table include any multiplier effects or purchases resulting from labor spending its income?

Page 80

- A. There must be a typo in the next to the last paragraph.
I assume that the dollar quantity mean is 0.514 billion dollars.

Page 85

- A. I assume in computing the depreciation of both the initial capital investment was included in the scenario as well as the annual depreciation except as noted.

Page 92

- A. From this description it would seem that materials are assumed to either be completely purchased locally or not be purchased locally at all. Is this zero or one type of operation reasonable? I do not know.

Page 98

- A. I recognize that the rims model may not allow indirect impacts to be separated from induced impacts but there is no reason to lump direct, indirect, and induced labor numbers together as they are in the calculation at the bottom of page 98.

Page 104

- A. Is labor getting less efficient or is it building more plant?

Page 106

- A. Is the 15% price rise the result of the average versus marginal cost pricing policy of the utilities? Does it imply that new high cost plants are being rolled in and the price is rising or the real marginal cost of new plants is increasing?

Page 104

- A. Since general construction costs have been inflating faster than the general rate of inflation? What does this imply for the cost of constructing conservation of solar facilities on new existing homes? Will the same problem apply to them?

Page 106

- A. The purpose of multiple scenarios is to elucidate issues not to cloud them. If large numbers of scenarios are not going to be included in the study, then at the very least, some sensitivity analysis should be done.

Page 107

- A A potentially very serious problem is alluded to in the second paragraph. It states that all conservation measures considered

in the study have payback periods which are less than their average expected service life. This is an absolutely absurd rule. It would seem to be very important for the purposes of the study. For example, if 60" of attic insulation has a 50 year lifetime and energy payback period of 45 years, it is still not a good investment when you allow for any reasonable rate of interest. If this rule derives from the assumption stated earlier that the rate of real price increase in fuels will equal the real rate of interest, it must be explicitly stated and dealt with. This is a very critical set of assumptions. If the study is going to make assumptions about the rate of real price increase in fuels versus the rate of interest, then it is critical that the basic data be given to allow the reader to analyze the data using whatever assumptions he chooses. In fact it would be extremely useful in this analysis if the tables in the text gave atleast some sensitivity analysis to these assumptions about real fuel price increases and rate of interest.

- C. There's a typo in the last paragraph. I assume that the dollar savings are 9.6 billion dollars. It must be noted that heat pumps and nuclear power plants also benefit the nation by saving fuel oil.

Page 82

- A This section describing the job impact model, while it is very interesting, seems to be out of place in this particular section. It disrupts the flow of analysis. Perhaps a short section saying that the model is available and referring to an appendix would be better.

Page 113

- A. Will the two by six studs require less labor? The studs themselves are more expensive and in some areas atleast there are building code variances that must be dealt with.

Page 114

- A. The direct and indirect job impact numbers must be separated to make this document more useful.

Page 117

- A. Is the argument in the first full paragraph one for regional self sufficiency? Does it make any difference whether the expenditures are retained within the region vs. elsewhere?

Page 119

- A. These diagrams of cost and savings over time are very helpful. I am glad they are included in this study. They allow one to begin to change the assumptions about rate of fuel price

increase and rate of interest as well as rate of inflation. I am assuming that constant fuel prices are shown in this diagram so that effectively the annual energy savings present annual Btu savings at constant prices.

Page 125

A. The New York Energy and Conservation act sounds quite attractive. I have a general concern as to who is responsible for performance of the insulation or any of the installation measures. My understanding is that the utility must inspect the final installation and provide a list of recommended installers. Does this imply that the utility is then responsible for performance? In addition, since the loans by law allow the customers seven years to repay at an interest rate of what ever the utilities' last allowed rate of return was with no provision for bad dead allowance or defaults or debt collection. Is there any possibility that the utility company is stuck with the bill? This is more a matter of an implementation question more than anything else. If the house is sold or a renter moves out who is then responsible for the loan?

Page 129

The Figure on page 129 seems to imply about a 15 year pay-back period. Is that correct? If so, it does not sound cost-effective.

- B. Since all of these scenarios seem to depend upon consumer willingness to install measures, they would also seem to depend upon consumer acceptance that the measures will be cost effective in the long run, which requires that the consumers accept the premise that real fuel prices will continue to increase at the real cost of money plus whatever inflation factor is allowed for. Thus, the implementation of many of these scenarios will probably be much slower than shown in these diagrams.
- C. Does this then present an argument that the changes should be mandatory because the benefit to society will be so great? This is an interesting point to consider.

Page 127

- A. The cost figures given in Table 14 are for a do-it-yourselfer. What do the rate of returns look like if the measures are installed by a contractor.

Page 133

- A. As peak electric power analysis, and it seems to be more of an analysis than a specific scenario, is quite interesting. It might also be useful to try to do a similar base load increment analysis to see whether or not it has much affect on the base-load to determine comparability with the nuclear scenario.

Page 141

- A. At the moment the peak scenario really has no conceptual comparability with the nuclear scenario. Why are we concerned with increasing its comparability?

Page 143

- A. Third Paragraph: It would seem that the implication from the analysis is that shading and insulation options are very good while the solar domestic hot water heater is not a particularly good additional option. What is the assumption for the remaining 70% of residential construction for heating hot water. Is it oil or what?
- B. The bottom of the page indicates 83% of the cost of the scenario could be produced locally. But again we have no meaningful figures on what might be likely to happen.

Page 147

- A. This section on policy options does not do justice to the rest of the report. The options are going to be described. Why not just list all of the problems associated with them? Rather than do this approach I would recommend just condensing the options to a simple list.
- B. The large list of pluses for the energy conservation solar case seems to be much more rhetoric than analysis. Most of these points are not made in this report. This chapter is very bad at this point.

Page 151

- A. It is interesting that the compromise position is indicated as one of adding subsidies for new energy sources while simultaneously removing subsidies from other depletable sources. There are other compromise positions.

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	Solar Thermal Central Receiver, 3 hour storage	Semi Peak	100	0.35	0.013	0.774	31.93	22.26	1.87
a	Solar Thermal Central Receiver, 6 hour storage	Semi Peak	100	0.50	0.017	0.708	32.69	23.84	2.00
a	Solar Thermal Central Receiver	Fuel Saver	100	0.30	0.010	0.695	32.69	24.00	2.01
a	PV with Storage Collector/Reflector 16% Si	Semi Peak	100	0.30	0.025	1.418	44.33	26.57	2.23
a	PV with Storage Collector/Reflector 10% Thin Film	Semi Peak	100	0.30	0.041	1.110	34.82	20.85	1.75
a	PV with Storage Collector/Reflector/16% silicon	Intermed.	100	0.45	0.04	1.540	48.20	28.96	2.43
a	PV with Storage Collector/Reflector/10% Thin Film	Intermed.	100	0.45	0.067	1.230	38.56	23.12	1.94
a	PV with Storage 10X Concentrating/Verticle Tracking	Intermed.	100	0.45	0.045	2.110	65.86	39.44	3.31
a	PV Collector/Reflector/16% Silicon	Fuel Saver	100	0.28	0.017	1.070	33.43	20.02	1.68
a	PV Collector/Reflector/10% Thin Film	Fuel Saver	100	0.26	0.027	0.810	25.46	15.25	1.28
a	PV 10XCPC/16% Silicon	Fuel Saver	100	0.30	0.035	2.020	63.17	37.89	3.18

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	WECS with Hydroelectric hybrid	Intermed.	100	0.48 18 mph	0.0054*	0.235	17.96	15.02	1.26
a	Advance WECS with gas turbine	Intermed.	100	0.49 14 mph	0.0050*	0.226	21.08	18.26	1.53
	Advanced WECS with combined cycle	Baseload	100	0.87 18mph	0.0085*	0.204	13.58	11.03	0.93
a	WECS	Fuel Sav.	1.5 (22.4 mph)	0.30	0.0051*	0.355	23.02	18.58	1.56
a	Advanced WECS	Fuel Sav.	1.5 (17.1 mph)	0.65	0.0085	0.273	14.04	10.63	0.89
a	Wood Fired Steam Plant	Intermed.	100	0.50	0.007	0.292	17.05	13.25	1.12
a	Wood Fired Steam Plant	Baseload	100	0.80	0.008	0.209	10.65	8.04	0.67
b	Solar Heated Textile Processing Water		68,750 MMBTU			0.330	8.73	9.00	0.50
b	50-100°F Hot air grain Dryer		70,200 MMBTU			0.219	9.85	7.11	0.59
b	50-100°F Hot water can washing system		38,250 MMBTU			0.187	9.22	6.88	0.57

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
b	100-150°F hot air plastic curing	29,565 MMBTU				0.670	26.48	15.89	1.33
c	Hydroelectric dam, and power plant	Baseload	0.981 x 10 ⁹ KWH			0.234	8.46	4.93	0.414
d	OTEC 4 plants	Baseload	266.5	0.61		0.974	33.28	19.97	1.676
d	OTEC 7 plants	Baseload	264.5	0.61		0.445	17.83	10.70	0.898
e	Biomass-Methanol		3.82 x 10 ⁶ MMBTU			0.135	4.23	0.213	
e	Biomass-Medium Btu gas		6.34 x 10 ⁶ MMBTU			0.33	1.03	0.62	0.052
e	Biomass-Substitute Natural gas		5.58 x 10 ⁶ MMBTU			0.066	2.09	1.25	0.105
e	Biomass-Process Heat 850 ODT/day	Steam	3.86 x 10 ⁶ MMBTU			0.064	2.01	1.20	0.101
	1700 ODT/day	Steam	8.40 x 10 ⁶ MMBTU			0.045	1.43	0.88	0.072
	3400 ODT/day	Steam	17.64 x 10 ⁶ MMBTU			0.035	1.09	0.66	0.055

Source: Unit labor estimates computed from data presented in:

- a - Systems Description and Engineering Costs for Solar-Related Technologies, Volume I, Summary. The Mitre Corporation, Metrek Division, June 1977.
- b - Systems Description and Engineering Costs for Solar-Related Technologies, Volume III, Agricultural and Industrial Process Heat. The MITRE Corporation, Metrek Division, June 1977.
- c - Escalation in the Costs of Manpower, Materials, and Equipment Needed for Energy Facilities, the Bechtel Corporation, October 1977. Resource Requirements, Impacts, and Potential Constraints Associated with various energy futures. Bechtel National, Inc., March 1978.
- d - Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII, Ocean Thermal Energy Conversion. The MITRE Corporation, Metrek Division, June 1977.
- e - Systems Description and Engineering Costs for Solar Related Technologies, Volume IX, Biomass Fuels Production and Conversion System, The MITRE Corporation, Metrek Division, June 1977.

MEMORANDUM

To: Allan Hoffman
From: DHR Staff
Subject: DPR Policy Options

We are in the process of reviewing the DPR policy options based upon impact on solar development, federal cost, political feasibility, and general workability. As part of this process we have established five general categories for options:

- A. Winners: Obvious good ideas that should be highlighted in the report to the President.
- B. Attractive but possibly problematic: attractive options that could have major problems if not carefully implemented; or that may face major barriers to effective implementation.
- C. Minor Winners: Good ideas that should be presented but either have limited scope or impact.
- D. Losers: These should not be advocated by the Administration.
- E. Ambiguous: We cannot fully understand the form, impacts or value of these proposals based upon the available information and analysis.

With some measure of trepidation, we are enclosing our preliminary rankings of the options. These are based on a 3 page list of one-line descriptions of about 35 options prepared by

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Ron White as well as our insights developed in the process of working with various DPR Panels and individuals.

The current list reflects the biases of the individuals who prepared it, and is meant to serve as a springboard for further discussion.

Preliminary Evaluation of DPR Policy Options

(To be used in the formulation
of an overall solar strategy)

A. Winners:

Federal Operations

1. Passive design and conservation in all new buildings and active systems on 15 percent of them.
7. FPGMA experiments and demos.

IIBP

7. Develop passive solar designs through competition, research, and foster their dissemination.
9. Consumer protection through warranties and information disclosure.
10. Marketplace development through new information programs.

Finance

2. Assure solar financing through FHA, VA, and other federal programs.
3. Cash grants in lieu of tax credits to low-income solar buyers.
13. Increased investment tax credits for solar
14. Accelerated depreciation for solar

B. Potential Winners, but Deserve a Careful and

Cautions Approach

Federal Operations

2. Retrofit active solar on existing buildings
3. Retrofit active solar on Postal Service buildings
8. FPGMA implement programs to accelerate solar use.

IIBP

1. Assist states in developing an appropriate utility rates and roles affecting solar
2. Exempt solar-oil and solar-gas hybrid boilers from coal conversion orders.
3. Give solar users higher priority under stand by Petroleum Allocation Regulations
4. Alter curtailment priorities for natural gas allocations.

Finance

8. Increase funding of solar projects through existing federal financial programs.

C. Minor Winners

Federal Operations

4. Establish an interagency solar coordination committee.

IIBP

6. 20 community test project to resolve sun right issues
8. Maintain competition through DOT monitoring, small business set-asides, and use of consensus standards

Finance

- 11. Finance community-based solar enterprises
- 15. Revision of REA lending program

D. Losers

Federal Operations

- 6. Use alternative fuels from biomass in federal vehicles

IIBP

- 5. Executive order requesting agencies to review current and potential authority that could be used to accelerate renewable energy resources.

Finance

- 7. Establish a Solar Energy Development Bank
- 9. Establish a quasi-public solar development corporation
- 10. Grant loans or loan guarantees to solar equipment manufacturers.
- 12. Employment-targeted venture capital for solar businesses.

E. Ambiguous Proposals

Federal Operations

- 5. Modify cost-effectiveness accounting procedures

Finance

- 4. Incentives for multifamily housing
- 5. Grants to businesses and homeowners
- 6. Tax incentives for residential sector

A. I.

- 1 - cost effective, easy implementation, effective demonstration of federal commitment to sound technology and solar,
- 7 - easy implementation, minor budgetary impacts, educational role for private utilities, demonstrates federal commitment, model of innovation - infrastructure already exists.

II.

- 7 - minor budgetary impact, transfer information to critical market sectors such as builders and designers, enhances free market allocations, minimizes federal intervention - infrastructure capable of task
- 9 - build consumer confidence and protects ~~early~~ ^{early} users of technology, removes ~~about~~ ^{early} liability in commercialization, obvious legislative support.
- 10 - easy implementation, cost effective, existing infrastructure, indirect federal intervention that stimulates market allocations.

III.

- 2 - easy implementation, cost effective, existing infrastructure, indirect federal stimulation of market allocations
- 3 - demonstrates federal commitment to equity principle in solar field, infrastructure exists, likely congressional support, minimal budgetary impact.
- 13 - infrastructure available, short term budgetary impacts but possible long term effects, enhances individual decision-making in choosing technology, minimizes federal regulations.
- 14 - All of the advantages of 13 but minor budgetary impact.

B. I.

2 and 3- legislative skepticism because of costs but all of the advantages of I-1. 3 raises the additional question about ownership jurisdiction of equipment on leased buildings and responsibility for maintenance.

8 - highly visible demonstration of federal commitments to solar use but higher costs, federal intervention, inequitable impacts, uncertainty of proper role of government regulation of utilities in promoting solar.

II.

1.- influence that recognizes state jurisdiction, consequences uncertain, utility role in promoting solar uncertain, possible budgetary impacts, legislative appeal.

2 - minimizes federal intervention in implementation of solar sources, enhances consumer choice in market, minimal budgetary impact, but possible negative consequences of widespread commercial use of solar to evade coal conversion mandates.

3 - same advantages as 2 but problem of evasion of fuel curtailments without real commitment to solar, no perceptible legislative impasse or budgetary costs.

4 - Same problems as 3.

2,3,4 have tremendous psychological value demonstrating federal commitment to solar.

III.

8 -

DRAFT

- III.8 - Possible substantial budgetary impact but psychological advantages, infrastructures for implementation.

Section C

- I.4 - Depends on implementation of Roman Numeral I - 1, 2, 3, impact not substantial, could prevent inefficient purchase of solar equipment.
- II.6 - Limited energy impact, substantial cost, potential for federal intervention because of nature of experimental project.
- II.8 - Limited effectiveness because of monitoring nature of proposal and _____ in proposal. How is consensus developed?
- III.11 - Impact minimal, cost could be high but proposal does enhance equity principal because of focus on low income sectors in areas of unemployment, proposal deals primarily with Community Development Corporation under DOC.
- III.15 - General concerns over future role of REA, but low cost solar loans are good idea. Unfortunately, few number of people would benefit immediately, but demonstrates federal commitment to low income world populations.

Section D

- I.6 - Concern that gasohole production will result in negative net energy balance, also questions about the conomics about gasohole, trade-offs in use of food grains in development of energy sources, limited impact. Good points, demonstrates commitment on part of federal government, promotes use of renewable energy source, improves and supports innovative technology, agriculture support.
- II.5 - Establish change of DPR policy option indicates that DPR has failed in carrying out and recognizes limitations of DPR process and contributes to continuing review of energy policy.
- III.7 - Creates major bureaucracy and leads to federal intervention in the market, purpose could be realized under existing bureaus, use of scarce capital resources that might be better spent.
- III.9 - Same liabilities as No. 7 but with even less legislative support.
- III.10 - Would foster federal intervention into market, ample manufacturing capability currently exists, optimal strategy would stimulate demand rather than create artifical non marketable manufacturing capability.

Section E

- I.5 - What precisely does this proposal entail? How does a modified cost effectiveness accounting procedure lead to any direct savings or impact in the area of energy? Proposal simply too ambiguous for judgment of policy impact.
- I.4 - Unclear as to whether the proposal is directed to renters or cooperatives. Needs clarification of target groups before judgment of policy can be made.
- I.5 - Are grants to be used in lieu of tax incentives at capital NEA levels or will these be additional grants? Proposal needs clarification of budgetary impact before judgment policy possible.
- I.6 - Do these tax incentives require new legislation or the expansion of grant programs above capital NEA levels? Budgetary impact of proposal too unclear to make judgment of policy options.
- I.12 - Need clarification of business size, location, manufacturing capability and labor base before judgment can be made regarding budgetary impact, energy impact and number of people affected by proposal.

Outline for Introduction Chapter

I. Overview and Purpose of the DPR Exercise

II. Organization of Report

A. Issues in Eizenstat memo basis for report

1. Potential for solar
2. Current federal role
3. Policies for increased federal effort

B. Eizenstat memo sets context in which report should be read

III. Analysis of Contribution Which Solar Energy Can Make to U.S. and International Energy Demand

A. Energy demand sectors

1. Residential/Commercial
2. Industrial
3. Transportation energy related

B. Caveats: Uncertainties

1. Population growth
2. Economic growth
3. Solar performance
 - a. technical
 - b. economic
4. Life styles and consumer trends

C. Base case strategies

1. Passage of N.E.A.
2. Continuation of RD&D programs

3. Tax incentives for homeowners and industrial users
4. Reduction of institutional barriers.

D. Base case scenarios

1. Fuels plentiful and relatively cheap
2. Supplies adequate, price increase moderate
3. Supplies scarce and expensive

E. Maximum practical case strategies and scenarios

F. Estimated conventional fuels displaced by solar technologies

1. Residential/Commercial heating, hot water, cooling
2. Industrial and agricultural, industry process heat, on-site electricity and heating and hot water
3. Biomass
4. Solar thermal electric
5. Wind
6. Hydro
7. OTEC
8. SPS

G. Impacts of alternative solar futures

1. Employment
 - a. Direct: design, manufacture, installation, operation and maintenance of solar units
2. Indirect: production of components and raw materials for solar units

IV. Overview of Technology

- A. Commercially available technologies
- B. Those with near-term commercialization potential
- C. Those for which considerable R&D required
- D. Emphasize differences in technologies
 - 1. Scale
 - 2. Impact of options upon
 - 3. Costs
 - 4. Potential impact

V. Current State of Solar and Federal Effort

- A. Areas of federal effort
 - 1. R&D
 - 2. Information and education
 - 3. Commercialization and market penetration
- B. Solar options in the NEA
- C. Present status of solar
 - 1. Market penetration impediments
 - 2. Non-Federal initiated effort
- D. Achievements of solar efforts to date

VI. Policy Evaluation Criteria

- A. General characteristics
 - 1. Options need to be integrated, some can stand alone, others need support or are interesting

2. Options have been identified which appear to be immediately implementable; some look good but need further work, and there are those that should not be considered.

B. Evaluation Criteria

1. Political and institutional feasibility
 - a. availability of infrastructure
 - b. barriers to implementation in federal, state, local, and private sector
 - c. budgetary considerations
 - d. legislative considerations
2. Energy conservation impact
 - a. displacement of critical fuels

C. Evaluation Considerations

1. State of technology
2. Infrastructure of production, distribution, installation and maintenance systems
3. State of awareness in consumer market and availability of knowledge to consumer

VII DPR Policies (Related to Winners and Losers List)

- A. Options which are both feasible and implementable
- B. Options which show potential but need further work
 1. As they presently stand could be implemented in many ways
- C. Options which should not be considered further at this time.

I am pleased to submit the attached report of the Domestic Policy Review of Solar Energy, as directed in your SUN DAY speech of May 3, 1978. This report summarizes the efforts of over 30 Federal Departments and agencies, and includes information obtained at twelve public forums attended by over 3,000 people where representatives from industry and labor, solar and consumer advocates, and technical specialists presented briefings. This three-month review was explicitly organized with reference to your expressed concern about the adequacy of federal involvement in all facets of policy relating to solar energy.

The overall purpose of this review is three-fold; first, to establish the contribution solar energy can make to the United States energy demand in the short and longer terms; second, to review the adequacy of current federal solar programs; and third, to lay out the elements of an overall solar strategy that will pull together federal, state, and private efforts to accelerate the use of solar technologies.

We have found that a strategy to accelerate the use of solar energy could lead to solar making a percent contribution to the nation's energy budget by 1985, and could grow further to *** percent by 2000. This could be achieved by continued support of solar R&D, implementation of solar tax incentives as contained in the National Energy Act, and an

additional program of financial assistance, federal demonstrations, and work to resolve the non-technical, non-economic barriers to solar use. We do not advocate an expensive "crash" program to develop solar energy, but instead believe that a judicious blend of federal research, federal support to early innovative solar buyers, and support and cooperation with states and local governments is the most effective means to speed solar energy use. Moreover, developments in solar energy will continue even with a minimum of federal effort. Thus, a properly chosen effort on the part of the federal government can take advantage of this situation, and significantly enhance the development of solar energy.

Our analysis shows that the nation already has made significant strides toward the technical development and efficient use of practical solar technologies. This trend is consistent with the administration's goals of reducing the nation's dependency on other, non-renewable sources of energy, especially those that must be purchased from foreign markets. Some solar technologies--such as hot water and space heating systems, passive solar building design and some biomass and wind energy systems--are already commercially available from private industry. A small yet growing number of Americans are using solar energy in homes, businesses, and industry, and we expect this trend to continue into the future.

In part because of the presently perceived social, economic and political benefits of solar energy that have lead to these advances, we recommend a redirection of federal efforts to create greater opportunities for rapid utilization of solar technologies and to remove the existing barriers to their use. This recommendation reinforces the President's own understanding of the need to redirect federal policy in the solar energy area; it provides the focus of much of the discussion which follows.

A number of factors unique to solar must be considered in the course of evaluating the strategies recommended to increase solar use. Solar energy does not depend on a single technology but rather on a multiplicity of diverse technological systems, some of which require an increased awareness of the role of energy in our daily lives. A decision to adopt solar energy technologies presents numerous options ranging from centralized to decentralized systems of production and distribution, from systems of direct heating to systems that produce electricity or portable fuels, from systems that actively utilize energy sources to passive, non-mechanical systems, and from reliance on simple hot water systems to development and production of technologically complex electric generating systems.

Solar energy is unique because millions of individuals must make the decision to use it--including technical experts, homeowners, businessmen, farmers, community organizers

and educators. Widespread use of solar energy will not occur unless its price is competitive with other available fuels and unless major institutional barriers to implementation are removed. Of course, a minority have invested in solar energy irrespective of the economic risks because of its perceived environmental and social advantages. And a small but growing number of Americans are using solar energy in their homes in spite of its marginal economics. These systems are predominantly either active systems supplying heat and hot water or the use of passive solar design principles in building design. Nonetheless, the majority of American citizens will continue to view solar energy with skepticism if it is not reliable, available and cost competitive. However, we feel that an ambitious national effort to promote solar energy use is desired and will be supported by a majority of citizens.

It is clear that federal and private efforts already have done much to facilitate the commercial application of solar technologies. The DPR Panels considered numerous solar technologies, and found that each has a unique potential, a different state of development, and would require different incentives for further development. They included long-term technologies for centralized electricity production as well as near-term, decentralized technologies supplying energy at the site of consumption.

There are a number of solar technologies that are not likely to require direct federal financial support, but will require cooperation with state and local governments to increase information transfer and removal of institutional barriers to speed their rate of implementation. These technologies, aggregated under the heading of passive solar design include such factors as building orientation, window design, and insulation levels, may be the most unheralded yet the most immediately applicable way of using solar energy.

Solar water heating has reached economic parity with electric water heating in certain regions. This technology along with solar space heating will require some federal assistance in overcoming high initial costs and institutional barriers before widespread utilization will occur. Solar technologies such as commercial liquid or gaseous fuel production from biomass and electricity generation from biomass or wind systems are close to widespread commercial

feasibility. A number of other electricity generating technologies, such as photovoltaics, OTEC, and solar thermal, clearly require extensive R&D over a period of five to thirty years.

In spite of the current and anticipated availability of solar technologies, we believe that several additional obstacles must be removed before large-scale market development will occur. These include:

- o high initial system costs;
- o no established record of performance to build consumer confidence;
- o Lack of an extensive business infrastructure to provide installation or maintenance;
- o lack of coordination between solar designer's and the energy backup systems that are required, such as electric and gas utilities; and,
- o widely varying building codes and zoning ordinances that discriminate or mitigate against the adoption of solar technologies.

Additionally, it should be noted that solar energy does not share a number of economic advantages granted to some of its competitors. For example:

- o businesses may write off fuel costs as a tax deduction but not a capital investment in solar equipment to save fuel;
- o environmental and health costs associated with coal use are not fully included in its fuel cost;
- o oil and gas producers benefit from numerous financial incentives granted over several decades when the nation recognized the advantages of their assured supply

If we are to speed solar energy use, we must act now to assure it equal economic footing with competitive fuels. However, the Domestic Policy Review cannot and should not be considered as a single effort to address and remove all the technological, institutional and economic problems facing solar energy. Rather, continued efforts are needed to emphasize those technologies with the greatest short-term potential by removing the major institutional and market-place barriers facing them.

A widespread movement towards solar can be best encouraged if these and other obstacles are reduced through a focused solar strategy. Elements of this strategy should include:

- o Subsidizing the early users of solar energy through grants and tax incentives;
- o Ensuring adequate financing for residential, commercial, and industrial solar systems, either through commercial loan institutions, utilities programs, or new and existing federal financing programs;
- o Establishing consumer confidence in solar investments through improved information systems, and warranty protection, so that viable, competitive solar industry can develop;
- o Encouraging and assisting state and local governments to formulate laws, codes, and ordinances that allow and encourage extensive use of available solar resources.

The bulk of these initiatives are of a non R&D nature. Some are amenable to further federal action, but others, clearly require the active support and initiative of states, local governments, private business, and the energy industries.

Government should continue to address the fundamental R&D needs of many solar technologies, but must coordinate this with efforts to accelerate the market penetration of the technologies which are readily available today.

In summary, we believe that many Americans are interested in and ready to consider the solar option, as evidenced by the growing numbers who have acted. The Federal Government has an important role to play in assuring continued and accelerated solar growth. This strategy must proceed on two fronts--first, continued R&D on promising, long-term solar technologies; and second, efforts to revise the institutional and economic structures surrounding solar to improve its price and availability. These goals can be realized through an adjustment of federal activities in energy-related areas--through RD&D, energy pricing policies, providing information, encouraging utilities and energy companies to work towards solar development and cooperating with state and local efforts to extend solar availability.

In order to assure speedy action in these areas, the Domestic Policy Review has developed a number of specific program initiatives. I look forward to assisting in the formulation of a solar program package for early action including these legislative and executive initiatives.

September 14, 1978

MEMORANDUM

To: Ed Blum and Jim MacKenzie
From: Carlo La Porta, Ken Johnson and Rich Silberglitt
Subject: Solar Heating and Cooling Industry

The purpose of this memo is to explore the possible ramifications for the solar heating and cooling (SHAC) industry of the DPR Impacts Panel Base Case scenarios. We have estimated the collector output in the low and high oil price scenarios using the scenario demand figures plus near-term growth assumptions that seem consistent with the overall assumptions of each scenario. We have also analyzed the potential implications of these requirements on the structure of the industry and the relation of this situation to Federal policy actions. We have included the residential and commercial demands projected by the DPR in our analysis, but have not treated the industrial sector.

Our principal conclusions are as follows:

- We foresee no major problems in obtaining the necessary capital investment required to reach projected levels of production, given the present state of technological development and with modest assumptions concerning the willingness of investors to back new technologies and markets.
- We foresee no major problems resulting from the projected production levels with relation to the availability of the basic materials used to manufacture SHAC systems using current technologies. Some spot shortages could occur if Federal or State policies lead to a massive demand, as in the recent case of building insulation. It is also possible that shortages of aluminum or copper could raise solar equipment prices or cause solar manufacturers to switch to iron-based metals and/or to

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plastics or glass. In the event of a major shift to glass or plastics, no critical raw material shortages are foreseen, given the levels of production forecast.

- The present SHAC industry should be able to support the range of near-term growth rates implicit in the DPR scenarios, assuming that currently dominating flat plate collector technology continues to lead market growth. However, it is possible that other technologies, e.g., evacuated tube collectors, could take over a large portion of the market. In this event, and particularly if alternative designs lead to new production techniques, near-term growth rates could be decreased and long-term growth accelerated when the new technology comes on line.
- The structure of the industry may depend heavily upon the near-term growth rate. A rapid growth in the near-term would probably force the industry to concentrate around a few well-automated, well-capitalized large firms, while more gradual growth would make it possible for smaller firms to remain competitive, as well as provide time and a resource base for them to acquire the investment necessary to grow and compete in the larger long-term market.
- If the Federal Government is to provide effective assistance to the SHAC industry it must carefully track demand growth and industry structure and design its programs to consistently treat these two parameters. For example, if large near-term growth is stimulated via tax incentives, regulatory activities, etc., then policies could be designed to specifically address the problems of small firms. These companies might survive in such a market by producing solar systems for local use in applications where sophistication is not especially important, or by becoming producers of specific components used by the larger manufacturers. Federal policies to encourage these activities could thus have a major influence in allowing these firms to contribute to overall SHAC system production. Other possible roles for the Federal Government are to provide incentives for investment in new production capacity or to help in the development of new technologies. In both cases, it is important to tailor proposed actions to the structure of the SHAC industry both by estimating where present trends are likely to lead and by carefully following market development.

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Assumptions and Calculations

The two cases considered in this memorandum were based on the high (\$32BBL) and low (\$18BBL) oil price scenarios developed by the DPR Impacts Panel. Our analysis considers only the industry producing medium temperature and special collectors for residential and commercial applications. Industrial applications have been omitted from this particular exercise in part because of uncertainty about demand levels and collector designs that will be used.

The DPR Impacts Panel Base Case Strategy provides average figures for collection area and system performance. These figures, presented below, suggest that primary energy replacement estimates are based on conventional flat plate collector technology:

Hot Water Systems

Collector Area: 60 ft² 49 million Btu/yr.

Hot Water and Space Systems

Collector Area; 310 ft² 119 million Btu/yr.

Hot Water, Space Heating and Cooling Systems

Collector Area: 310 ft² 147 million Btu/yr.

It is also assumed that commercial systems are five times as large as residential systems.

The Impacts Panel assumed two levels of solar penetration in its output forecast (see Appendix I, "Detailed Breakdown of

Impacts Panel Solar Estimate" of the Impacts Panel Memo on
Base Case Strategy).

Low Price - Year 2000

Residential Systems

*HW 1.36 million

**H+HW 2.50 million

***H+C+HW .44 million

Primary Energy Displaced Subtotal = .429 quads

Commercial Systems

HW 68,000

H+HW 85,000

H+C+HW 22,000

Primary Energy Displaced Subtotal = .083 quads

Oil at \$18/BBL: Total Solar Displaced Fuel = .512 quads

Residential Collector Area

HW 81.6 million ft²

H+HW 775.6 million ft²

H+C+HW 136.4 million ft²

Subtotal = 993 million ft²

Commercial Collector Area

HW 20.4 million ft²

H+HW 131.75 million ft²

*Hot Water

**Heating and Hot Water

***Heating, Cooling and Hot Water

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Commercial Collector-Area (cont'd)

H+C+HW 136.4 million ft²

Subtotal = 186 million ft²

Oil at \$18/BBL: Total Solar Collector Area = 1.2 billion ft²

High Price - Year 2000

Residential Systems

HW 3.7 million

H+HW 7.1 million

H+C+HW 1.3 million

Primary Energy Displaced = 1.22 quads

Commercial Systems

HW 379,000

H+HW 698,000

H+C+HW 122,000

Primary Energy Displaced = .6 quads

Oil at \$32/BBL: Total Solar Displaced Primary Fuel = 1.8 quads

Residential Collector Area

HW 222 million ft²

H+HW 2,201 million ft²

H+C+HW 403 million ft²

Subtotal = 2.826 billion ft²

Commercial Collector Area

HW 113.7 million ft²

H+HW 1,081.9 million ft²

H+C+HW 189.1 million ft²

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Commercial Collector Area (cont'd)

Subtotal = 1.385 billion ft²

Oil at \$32/BBL: Total Collector Area = 4.2 billion ft²

These DPR estimates suggest that the solar equipment manufacturing industry will have to produce and install one to four billion square feet of collectors by the year 2000 to reach the primary energy replacement levels forecast by the DPR Impacts Panels. There are some possible sources of error in these estimates that should be noted. First, the estimated market shares for the different types of systems may not accurately reflect market development through 2000. If, for example, solar cooling does not advance significantly until the 1990's, and solar water heating systems without space heating become the most popular application, then the amount of collector area and energy displaced could be significantly smaller. Or if more efficient evacuated tube collectors gain a significant market share somewhat less collector area will be needed to provide the same level of energy in the intermediate temperature range. The opposite could be true as well. That is, less efficient collectors with more area might prove to be more economically attractive in the long run, making the collector area necessary to achieve the same energy output larger.

Another area of concern regarding the penetration application mixes involves the level of retrofitted solar energy systems.

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Retrofit water heaters and commercial solar cooling systems may provide a fairly large share of the solar market. However, space heating retrofit applications may have a more difficult time, and never really provide a large market share for the solar manufacturing industry. It will be important for any penetration scenarios to take such an eventuality into consideration, and determine its likely effects on the manufacturing industry. For example, this could serve to smooth out the growth pattern of the SHAC industry, thus avoiding a large temporary retrofit demand bump that would disappear as this market saturates.

Another interesting production problem could arise because of the limited lifetime of major solar energy system components. Liquid collectors may last from 5 to 20 years, and air type units somewhat longer on average. The manufacturing industry will eventually reach a point where the replacement market becomes an important factor. For many systems being installed now and in the early 1980's, replacement of collectors could be required as soon as the mid-to-late 1990's. If a specific time period exists in the near future where these replacement retrofits provide a major share of the market, then the SHAC industry will be faced with periodic cycles of increased demand resulting from these replacement demands for some time to come. This problem could be accentuated if there is in fact a short period of intensive retrofit demand sometime before 2000.

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Despite the uncertainties resulting from the above considerations the DPR estimates represent a reasonable base case for the year 2000. In order to generate a scenario trajectory, we have estimated industry growth between now and 1985 under assumptions of the two DPR cases. For the low price case we assume that present trends and public interest continue, leading to production capacity doubling roughly every two years. For the high price case we assume a rapid growth rate resulting in a level of production in 1985 slightly less than that projected by Bezdek et al. In developing the trajectory from 1978 to 2000 we assume smooth growth after 1985 fed by new construction and a steady, rather than sharply peaked, distribution of retrofit applications. We also assume that the industry is dominated by medium temperature flat plate collectors, but that a significant, perhaps 20 to 30 percent, component of the new market may be devoted to special collector systems. The following tables illustrate our near-term growth assumptions, and the overall scenarios are plotted in the attached future.

Low-Price - SHAC Medium Temperature Flat Plate and Special Collector Production for Residential and Commercial - Hot Water, Heating and Hot Water and Cooling Applications

<u>Year</u>	<u>Million ft²</u>
1978	4
1979	7
1980	10
1981	13
1982	18
1983	25
1984	35
1985	45

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At this rate of growth, total 1985 collector area in place amounts to 157 million square feet. To get to a total of 1.2 billion square feet in 2000, the industry must grow at a rate of 10 1/2% per year after 1985 so that annual production in 2000 is about 220 million square feet.

High Price - SHAC Medium Temperature Flat Plate Plus Special Collector Production for Residential and Commercial Hot Water, Heating and Hot Water and Cooling Applications

<u>Year</u>	<u>Million ft²</u>
1978	4
1979	7
1980	15
1981	30
1982	60
1983	100
1984	130
1985	145

At this rate of growth, total 1985 collector area in place amounts to 461 million square feet. To reach a total of 4.2 billion square feet in place in 2000, the industry needs to grow at a 6.6% rate per year after 1985, so that annual production in 2000 is about 355 million square feet.

Implications for Industrial Development

The much faster scale-up of the SHAC industry and the nearly factor of two differences in growth rates between the high and low price scenarios has important ramifications. The high price scenario seems to favor large companies that can rapidly increase their capital stock and quickly achieve higher levels of production, then count on a smooth longer-term growth

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rate to support their investment. The low price scenario, with much more modest scale-up to 1985 may allow more small firms to stay in the game. These small companies may also have more success attracting additional investment funds with the industry promising a 10% growth rate.

We believe the current SHAC industry can progress smoothly to reach either of these production levels in the time frames noted, although heavy government intervention in the market could lead to fluctuations in the growth rate, especially in the early years. Analysis of the solar heating and cooling industry has revealed significant levels of unused capacity among current flat plate collector manufacturers. In 1977, a manufacturer in Florida reported that his facility was capable of producing ten times more collectors given available space and adding small quantities of equipment and more labor. A new production facility recently opened by an industry leader is capable of producing nearly 1,000,000 ft² of flat plate collectors per year on a round-the-clock basis with feed stock coming from the parent company and other component manufacturers. The company that owns this plant is but one of forty-five companies that have reported more than 50,000 square feet of production for the first six months of 1978. Furthermore, since the owner of the plant has a second facility, and we believe few, if any, medium temperature collector manufacturers have production greater than 500,000 ft² per year, one could conclude that this facility is running well

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below potential capacity. There are still other large companies that have developed flat plate technology but only produce small quantities of collectors while they wait to see if market development will support their own commercialization efforts. Thus, some major corporations are surely "waiting in the wings."

If designs other than conventional metal flat plate, glazed collectors come to dominate the hot water, heating and cooling field because of lowest cost then there may be cause for some concern about the SHAC industry's ability to quickly meet demand requirements described above. Estimates of solar collector production for 1977 shows that special liquid collectors, i.e., concentrators and evacuated tube-type units, only amounted to 162,000 ft², or 4.6% of total medium temperature collector production. Even though production increased to 200,000 ft² in the first six months of 1978, this is a small number compared to the two million square feet of medium temperature collectors produced. Fourteen manufacturers produced the 200,000 ft², making average production per company about 28,000 ft² per year. This figure is almost equal to the average for firms producing medium temperature flat plate collectors; the very largest companies appear to be producing nearly 10 times this amount on an annual basis.

If evacuated tube collectors lead industry growth, it is likely that sophisticated high speed glass manufacturing techniques could provide the large quantities of collectors needed for

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a rapidly expanding market, although a substantial lead time would be required, altering the shape of the growth curve. The few manufacturers of glass tube units include General Electric Company and Owen-Illinois-Inc., so that major resources ought to be available for new plants or conversion of existing capital equipment.

A similar situation may exist for plastics if new technological breakthroughs show that plastic collectors can handle medium temperature demand requirements. One of the leading solar manufacturers has developed a proprietary chemical process and its own extrusion machinery to make low-temperature plastic flat plate panels (unglazed) for heating swimming pools. This privately owned, small company is now developing medium temperature plastic collectors. This latter development is so new that several years would probably be necessary for plastic based collectors to become acceptable on the market. Consequently, a plastic based SHAC manufacturing industry might require more time to gain a market large enough to permit gearing up to meet large near-term demand levels. Yet, since the manufacturing process is similar to that for evacuated tubes--panels are continuously "squirted" out of extrusion equipment--one could expect high speed production facilities to be created which could rapidly expand to meet forecast production needs.

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Materials Availability

If solar production approaches a level of 400 million square feet per year in 2000, will basic raw materials such as aluminum be in short supply? All aluminum collectors can require as much as four pounds of aluminum per square foot, creating an annual demand in 2000 for 1.6 billion pounds of the metal. In 1976, U.S. aluminum production was 13 billion pounds. U.S. demand has been growing six percent per year while capacity is only increasing by two percent. Aluminum companies are locating new plants outside the U.S. Consequently shortages of domestically produced aluminum are foreseen in the next few years which could affect rapid growth of collector manufacturing. The aluminum industry should respond by increasing prices, increasing recycling and building new plants. The latter generally takes three years. Imports might also increase. Since 2000 demand for aluminum in the high price scenario represents but 12% of present production, the industry should be able to easily accommodate the demand. We have not carefully studied the situation for other metals (e.g. copper) but believe it to be no worse than for aluminum. Plastics and glass industries, based on past history, seem to have the capability to meet any projected demands given adequate lead time.

Capital Requirements

Most small collector manufacturers operate labor-intensive low capital businesses that fabricate flat plate collectors

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from already manufactured components. Thus, essential capital stock to produce collectors was already present throughout the U.S. industrial base. How much that base is capable of producing for solar manufacturers without large scale investment in new capacity is not known. Nor are the implications of this situation for future growth of the solar manufacturing industry. For example, in the high-growth scenario solar industry leaders might eventually respond by integrating backwards so that they increasingly produce the main components that are assembled into a flat plate collector. Such a move implies a shift to a more capital intensive industry with much larger plants, and more specialized automated manufacturing processes. Integration along these lines would definitely change the character of the solar manufacturing industry and would clearly make the solar manufacturers the most identifiable locus of investment, which is not the case at present. On the other hand, if the industry grows along present lines, capital investment to increase solar production capacity will flow into many different locations and it will be harder to predict just how new investment will stimulate growth.

If the solar industry progresses along current lines some very rough estimates about necessary investment levels can be made. A new 60,000 ft² facility was opened in California to produce liquid flat plate, medium temperature collectors. Costing \$1 million, the plant is supposed to have a capacity of

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1000, hot water heaters per month, or about 600,000 ft² of collectors per year. This facility thus costs \$1.66 per annual ft² of collector produced.

For comparison of production levels, another new solar plant in North Carolina is reportedly capable of producing 374,000 ft² of liquid medium temperature flat plate panels per year, with one shift. The plant is 42,000 ft² in size. A third company in California recently expanded its production facility, adding 73,000 ft² to its existing plant. The expanded facility is now 160,000 ft² in size and the company's annual report gave a figure of \$1,659,057 for buildings and improvements, and also noted that \$500,000 was spent for new machinery and equipment. If all these monies were spent on the new 73,000 building/ft² then investment cost would be \$25.59/ft² for the new plant. Combining these rough estimates, for purposes of our analysis, we assume an annual figure of \$2.25 per annual ft² of collector production. To produce 220 million square feet of collectors (low price scenario year 2000 production) would thus require \$495 million of investment. To produce 360 million square feet (high price scenario) would require an \$810 million investment.

It must be pointed out that this investment is only for a light manufacturing facility that assembles components supplied by other manufacturers using existing mass production processes. Potentially, large capital investment to increase this basic light

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manufacturing capacity and automate it will figure into the cost for industry development. Yet, even if these figures need to be raised by a factor of ten, the investment is not large when compared to consumer's cost of financing solar energy systems or the amount of investment necessary for competing energy systems.

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MEMORANDUM

September 15, 1978

TO: Alan Hoffman

FROM: Joel Rosenblatt

Enclosed is an expansion of our winners and losers list.

There are three important components of this list:

- 1) A description of the criteria used to evaluate each option.
- 2) A two part matrix summary of policy options developed by the Financing, Federal Operations, and IIB Panels. This includes a evaluation description of each option in terms that the criteria developed. These will be important when grouping them into strategies (e.g., budgetary cost, new regulatory requirements, etc.)
- 3) A revised and expanded winners/losers list. These represent our attempts to place options into four groups: 1) should be submitted under various strategies; 2) should be submitted but may require further work before submittal; 3) should be included but can either be readily implemented and/or have minor energy and budgetary impacts; 4) should not be submitted under any solar strategies. We still need details for several options.

These three components are each part of the larger piece and should be used in conjunction with each other.

We feel that this material will be most useful to you in a) planning additional DPR Panel work and b) formulating solar strategies and grouping individual options under these strategies and c) deciding on how to structure our present report material.

We will be available to assist in the integrating of options into strategies or the carrying out of additional analysis at your request.

There are several limitations to this material. For example, inevaluating the options we did not explicitly include energy impacts or quantified values of non-federal costs (including inflationary impacts). These topics can be pursued next week but will require inputs from the Impacts Panel.

We are working on a number of other items for delivery Monday COB. These include 1) drafting short responses to the Eisenstat questions; 2) fitting options to the strategies being considered; and 3) reviewing the findings/conclusions which we've already discussed. In addition, we are giving thought to the best ways of presenting all of this material. Please give me (or Steve) a call on Monday so we can best coordinate our work with your needs. If you need me, I will be available at (301) 881-8237 over the weekend.

Criteria Used to Evaluate
DPR Policy Options

A number of considerations were employed in evaluating and classifying each option. These include factors that would be used in grouping options under cohesive solar strategies as well as the factors that Congress would examine if the option was presented as new legislation. Our criteria included the following factors:

1. Will this option require a substantial Federal budget expenditure (or income reduction) if fully implemented?
2. Will this option entail additional Federal pre-emption of state or local authority?
3. Does this option rely primarily upon existing federal policy tools and/or infrastructures?
4. Would extensive additions to (or creation of) a federal bureaucracy be required?
5. Will an improvement in environmental quality result from this option?
6. Are non-energy social goals (such as job creation, urban revitalization, or farm support) advanced through this option?
7. How will the option effect energy mixes or savings (particularly oil and natural gas displacement)?

8. How does the option advance a solar strategy? In particular:
 - a) Which sector(s) are most affected
 - b) Does this promote short-run commercialization long-run R&D prospects, or set the stage for long-run solar advancement
 - c) Is this necessary to establish solar as viable contingency in case of a major technology failure?
9. What abuses or misallocations are most likely to arise from implementing this option?
10. What special political considerations must be accounted for when deciding whether to advise the Administration to consider this option?

Each DPR policy was read and considered in the context of these nine factors. In addition to evaluating each option we include a recommendation to either present it to the Administration, to drop it, or to carefully consider the details and implications that are not delineated in the Panel's option description.

A summary table of our evaluation of the DPR options is included on the following page. Short descriptions of our evaluation of individual policy options is included after the table.

We recognize that the details of various options are not fully worked out; furthermore, we realize that they may change the viability of each option.

Table 1a

Option Description

Federal Operations Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Other Social Goals?	How is a Solar Strategy Advanced?
Use Passive and Active Solar in New Buildings.	Ranges from \$25-125 million	None Required	Yes	None	Positive	No	Solar is demonstrated throughout the nation. Industry is supported through \$25-125 million in direct federal purchases
Solarize 10% of Existing Federal Buildings by 2000	\$19 billion over a 22 year period	None Required	Yes	None	Positive	No	Solar demonstrated across nation. Industry is supported. Shows federal commitment
Solarize leased USPS buildings	\$4-5 million per FY growing through the 80's	None Required	Yes	None	Positive	No	Demonstrates federal commitment to solar and supports solar industry
Interagency solar energy council	Minimal	None Required	Yes	Small additional requirement	None	No	Helps federal government coordinate an extensive movement towards purchasing solar

Table 1b

Option Description

Federal Operations Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Other Social Goals?	How is a Solar Strategy Advanced?
5. Modify life-cycle costing methods for federal procurement of solar	Minimal direct impact	None Required	Yes	None	None	No	Formally establishes several considerations unique to solar in the federal cost evaluation process
6. Use gasohol in federal vehicles at three different levels (low, medium, high)	Modest in low variation, but up to \$50 million per year in the high variation	No	Yes	Some additions in USDA, DOE, DOT, and GSA		Supports agricultural product prices	Promotes the use of biomass-derived fuels through federal purchases and research in the high variation
7. FPGMA experiments and demonstrations	?	No	Yes	NO		No	Demonstrates federal commitment to solar and provides regional leadership role
8. FPGMA's implement programs	?						Explores critical utility solar interface questions

Table 2a

Option Evaluation
Federal Operations Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation to DPR Chairman
1. Use passive and active solar in new buildings	Individual agencies and GSA must cooperate to support this program.	Generally favorable; however concern over the federal expense will be a factor	Allows Administration to demonstrate that it is putting its own house in order.	Submit base option
2. Solarize 10% of existing federal buildings by 2000	Same as Above	Same as above, except concern over cost will be greater	Same as Above	Submit base option
3. Solarize leased USPS buildings	Same as Above	Same as above, except concern over cost is lessened	Same as Above	Submit base option
4. Interagency solar energy council	Choosing an executive agency to execute these tasks (DOE, OMB, or White House?)	Favorable if an extensive federal program to purchase solar is approved	Good idea to speed the implementation of the ambitious programs proposed	Submit option
5. Modify life-cycle costing methods for federal procurement of solar	Revising costing methods to allow increased solar is unnecessary if a specific goal is mandated under options 1,2, and 3.	No legislation required	Brings attention to a means of improving federal procurement practices	Rewrite option to state that the President will direct this issue to the task force established under Option 4.

Table 2b

Option Evaluation

Federal Operations Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation to DPR Chairman
6. Use Biomass Fuel in Federal vehicles	Technical questions over the net energy balance of gasohol are significant. The high option could be a major, costly commitment to an impractical solar technology.	Concern over technical questions and cost of the high option. But, farm belt members will advocate this strategy.	Gasohol is a popular, easy to implement solar technology that must be supported	Submit low option
7. FPGMA experiments and demonstrations				
8. FBGMA's implement programs to accelerate solar				

Table 3a

Option Description
Financing Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Social Goals?	How is a Solar Strategy Advanced?
1. Pursue present programs and NEA	None	No	Yes	No	None	No	Base case strategy retained at cost of \$628 million
2. Revise federal home financing programs	Increase federal loans to home-owners	No	Yes	No		No	Increases number of home buyers eligible to finance solar
3. Grants to low income people in lieu of tax credits	Increased number of people ineligible for tax credits	No	Yes	No		Helps low income homeowners	Increases number of homeowners eligible to receive federal support for solar investments
4. Multi-family incentives							
5. Business/homeowner grants							

Table 3b

Option Description
Financing Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Social Goals?	How is a Solar Strategy Advanced?
6. Residen- tial tax credits	\$1 billion through FY 1985	No	Yes	No		No	Increases NEA tax credits for residen- tial solar applications
7. Solar Develop- ment Bank	Up to \$100 million for FY 80	No	No	Yes		Makes financing available to low income groups	Centralized source of financing for solar investments
8. Solar funding through existing finance programs	Minimal	No	Yes	No		No	Increases availability of capital for solar investments
9. Establish a quasi- public solar corpora- tion	One-time federal invest- ment of \$100 million	No	No	Yes		No	Provide investment capital for solar/ conservation firms
10. SBA study needs for loans or guarantees in solar industry	Minimal	No	Yes	No		No	Lays groundwork for future federal involve- ment in supplying the solar industry with capital

Table 3c

Option Description
Financing Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Social Goals?	How is a Solar Strategy Advanced?
11. Fund community-based solar enterprises	\$5-15 million in FY 80	No	Yes	No		Job creation for low income people	Focus CDC and CETA activities on creating jobs in solar and conservation industries for low-income workers
12. Employment targeted venture capital	None	No	No	Yes		Job and business creation in depressed areas	Provide solar entrepreneurs with equity capital based on the number of hard-core enemployed hired
13. Increased investment tax credit							
14. Accelerated depreciation	?	No	Yes	No		Tax relief to business	Improves solar economics for business/industry

Table 4a

Option Evaluation
Financing Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation to DPR Chairman
1. Pursue present programs plus NEA	None	Congress may desire additional solar incentive programs	May be interpreted as contradicting President's advocacy of solar	Do not include this option
2. Revise federal financial programs	Minor	Probably favorable		Submit this option
3. Grants to low income people in lieu of tax credits	Minor	Probably favorable		Submit this option
4. Multi-family incentives				
5. Business/homeowner grants				

Table 4b

Option Evaluation
Financing Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation to DPR Chairman
6. Residential tax credits	Minor	May be concern over the cost vs. need for new tax credits	Should this option be recommended if NEP tax credits are still hung up in Congress?	Submit option but do not make it a major element of a strategy.
7. Solar Development Bank	Solar Bank activities could be carried out by private finance institutions, and may become an expensive, ineffectual program	A bill has been introduced in the House (H.R. 7800) to establish a bank.	Must consider the likely course of H.R. 7800 before recommending a presidential position	State that this option is under consideration by Congress but do not make it a cornerstone of policy.
8. Solar funding through existing loans programs	May create more paperwork for loan applicants and lenders	No legislation required		Submit option
9. Establish a quasi-public solar corporation	May duplicate SBA activities and create anti-trust problems, major intervention into marketplace	May prefer loans or guarantees to supplying industry with equity		Do not submit option

Table 4c

Option Evaluation
Financing Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation to DPR Chairman
10. SBA study need for loans or guarantees in the solar industry	Minimal	No legislation required	Delays the decision to embark on a potentially expensive, risky course	Submit option
11. Fund community-based enterprises	CDC's may not be appropriate vehicles for industry development. May subsidize poor solar products	Authorization depends upon mood of Congress w.r.t. social welfare spending	One of the few options to address the solar/equity problem	Submit option
12. Employment targeted venture capital	Equity and cost problems due to definition of hard-core unemployed and calculation of displaced federal cost	Favorable to concept but concerned over implementation details	Address equity considerations	Submit option
13. Accelerated depreciation	Writing IRS regulations	Favorable		Submit option
14. Increased investment tax credit				

Table 5a

Option Description
Institutional I+B Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Social Goals?	How is a Solar Strategy Advanced?
1. Federal assistance to states to develop utility solar programs	\$50 million per FY	Yes under Option B; No under Option A	No	Yes		No	Provides financial assistance to (and requires in B) states to develop utility rates that promote solar energy
2. Market-place Development	\$20 million per FY	No	Yes	Expansion of existing programs		No	Expand existing outreach programs, coordinate federal activities, and intensify agri/indus commercialization
3. Consumer Protection	\$10 million per FY	No	No	Yes		No	Supports a warranty program, mandates disclosure of technical information
4. Maintaining Competition	Minimal	No	Yes	No		Maintain competition and support small business	Large numbers of small competitive firms enhances climate for change and innovation
5. Passive solar	\$30 million	No	Yes	No		No	Support design competition, info programs, design development, etc

Table 5b

Option Description

Institutional I+B Panel, Solar DPR

Option	Federal Expense?	Federal Preemption Required?	Existing Authority Applies?	New Bureau Needed?	Environ. Impact	Social Goals?	How is a Solar Strategy Advanced?
6. Land use/sunrights research	\$2 million	No	Yes	No		No	Test project in 20 communities to resolve policy issues in land use/sunrights issues
7. Federal Agency Efforts	Minimal	No	Yes	No		No	Continuing review of federal activities a la DPR
8. Modify gas curtailment policies	Minimal	No	Yes	No		No	Create a higher curtailment priority for industrial gas customers employing solar energy
9. Modify oil allocation priorities	Minimal	No	Yes	No		No	Create a higher priority for "hybrid" solar-oil users under the standby petroleum allocation and price regulations
10. Exemption from NEA coal use rules for solar users	Minimal	No	No	No		No	Exempt industries using solar from NEA boiler fuel conversion orders

Table 6a

Option Evaluation
Institutional I+B Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation
1. Federal assistance to states to develop utility solar programs	No assurance that states will develop an effective plan if awarded a study grant. Under Option B, feds may have to order compliance	Concern over cost and possible federal preemption of state regulation	Option leaves decision-making at the state level. More direct federal action is not advised at this time	Submit Option B, but caveat with concerns over cost and possibility of pre-emption
2. Marketplace Development	Producing additional information must be coupled with a growing market demand and additional technology development	Concern over program cost	Addresses a widely recognized weakness in the existing effort	This type of option is needed, but translating this into specific program initiatives must still be done
3. Consumer Protection	A federal warranty program could help perpetuate bad solar designs at considerable federal cost	Concern over cost and program details	Presidential interest in addressing this area	Submit option, but carefully consider details of final option draft
4. Maintaining Competition	Minor	No legislation required		Submit option
5. Stimulate passive solar	Potential for bureaucritization of passive solar design and building	Favorable but concerned over cost	Recognizes importance of passive solar designs	Submit option

Table 6b

Option Evaluation
Institutional I+B Panel, Solar DPR

Option	Potential Implementation Problems	Anticipated Congressional Reaction	Other Political Considerations	DHR Recommendation
6. Land use/ sun rights research		Authorization required		Submit option
7. Federal Agency efforts			This sounds like a rehash of the DPR	Do not submit this as an option. Rather, emphasize the continuing need for federal review in the transmittal document
8. Modify gas curtailment priorities	Must define amount of solar and conditions for a higher priority ranking	No legislation required	This could be a very big carrot. Potential for abuse?	Submit option
9. Modify oil allocation priorities	Must define amount of solar and conditions for a higher priority ranking	No legislation required	This could be a very big carrot. Potential for abuse?	Submit option
10. Exemption from NEA coal conversion rules for solar	Defining level of solar needed for exemption	No legislation beyond an NEA is required	Success depends upon wording and enforce- ment of NEA	Submit option

The following is a revised winners/losers policy option list. The four categories divide options on the basis of their immediate applicability, requirement for further work, options which might only have minor impacts, and those that should not be submitted.

A. Option Winners.

These are options which will have a major impact in implementing solar, relatively low costs, and ease of implementation.

1. Passive design and conservation in all new Federal buildings and active systems on 15 percent of them.

This option would be cost effective with minimum budgetary impact, due to short payback periods of passive design and energy conservation. It also serves to promote solar technologies without creating new bureaucracies and infrastructures.

2. FPGMA experiments and demonstrations.

Ease of implementation, due to existing infrastructures, and minor budgetary impacts are major advantages of this option. In addition to demonstrating a Federal commitment experiments such as new rate structures could serve as models for private utilities as well as provide much needed new information.

IIBP

3. Develop passive solar designs through competitions, and research, and foster their dissemination.

Increased research and design competitions for passive designs will aid in transferring information to critical market sectors such as builders and designers and help

to minimize Federal intervention in the market place. The existing infrastructure should be capable of implementing this option with minor budgetary impacts.

4. Consumer Protection through warranties and information disclosure.

This option will help to build consumer support by protecting users of the new solar technologies. This option should have legislative support, and may be implemented through existing Federal programs. However, warranties sometimes have the effect of standardizing a design too early in its development which limits improvement.

5. Market place development through new information programs.

This option affords ease of implementation due to the existing infrastructure and the relative cost effectiveness, of education programs. This would serve as indirect federal intervention that acts to stimulate market allocations.

6. Assure solar financing through FHA, VA, and other Federal programs.

This option acts to indirectly stimulate market allocations through the use of an established infrastructure. Legislative requirements and budgetary impacts would be minimal.

7. Cash grants in lieu of tax credits to low-income solar buyers.

This option demonstrates a Federal commitment to the equity principle and could use the existing solar grant infrastructure. This option will likely have Congressional support and minimal budgetary impact.

8. Increased investment tax credits for solar.

This option enhances individual decision-making (primarily in the industrial sector) in choosing a solar technology, while minimizing Federal intervention in the market. Short-term budgetary impacts will be minimal, but could become substantial over a longer time frame. The infrastructure is available for implementation. This option gives solar more equitable treatment with respect to other energy sources with minimal Federal involvement.

9. Accelerated tax depreciation schedule for solar.

This option has the same advantages as increased tax credits for industry, with the exception of a reduced budgetary impact.

10. Modify Cost/Effectiveness Accounting Procedures as Applied to Federal Procurement of Solar Systems.

This option will have minor or no legislative requirements and budgetary impacts. Implementation problems will be restricted to a change in format rather than substance. This option provides for more favorable treatment of solar in Federal operations, while providing a market for the private sector.

B. Potential winners, but Need Further Development or a Cautious Approach.

1. Use alternative fuels from biomass in Federal vehicles.

This option should have legislative support and can be supported through existing federal agencies and programs. The demonstration of federal commitment, in addition helping to establish a market for biomass fuels will be achieved by this option. Such a federal action would create a market demand, but not act to directly intervene in the supply side of the market.

2. Retrofit active solar equipment on existing Federal buildings.

This option demonstrates a federal commitment to sound solar technologies where implementation will be easily effected due to the already existing infrastructure. There may be legislative and budgetary constraints to this option due to high intail costs of solar equipment. Similar programs have run into significant cost overrun and implementation problems in the past. However, the program could be demonstrated to have an acceptable ROR which would act to reduce the long-term negative budgetary impacts.

3. Retrofit Active Solar on Postal Service buildings.

This option is similar to the one above, with the exception of equipment ownership problems on many of the Postal services leased buildings.

4. FPGMAS to implement programs to accelerate solar use.

This option would act as a highly visible demonstration of federal commitment to solar. However, it raises many questions of inequitable impacts on the consumers (effective penalties to those who do not use or cannot afford solar equipment) and uncertainty as to the proper role of government regulation of FPGMAS in promoting solar.

5. Assist states in developing appropriate utility rates and roles affecting solar.

Caution must be exercised in implementing this option to recognize state jurisdiction and how that can be most effectively influenced. The consequences of such an action and the role of utilities in promoting solar is uncertain. Such an option may have significant budgetary impact. This important option should have legislature appeal and could have significant impact towards implementing solar.

6. Exempt solar-oil and solar-gas hybrid boilers from coal conversion orders.

This option will have minimal budgetary impact, broad legislative support, and minimal federal intervention by enhancing individual decision making to be made about solar. However, impact may be small. There may also be negative consequences from industries using solar in a limited way for the purpose of coal conversion mandates. This option has major psychological value in demonstrating federal commitment to solar

7. Give solar users higher priority under stand-by Petroleum Allocation Regulations.

This option has advantages similar to those described for the exemption from coal conversion mandates. Again the problem of industry trying to evade fuel curtailments with no real commitment to solar may arise.

8. Alter curtailment priorities for Natural gas.

This option would enhance solar's market position without direct federal intervention. This option would be similar to the coal conversion and petroleum allocation options.

9. Grant loan or loan guarantees to solar equipment manufacturers.

The budgetary impact of this option could be significant. The infrastructure necessary is in place. Further study should be undertaken to determine whether there is need to support the supply of solar equipment or the demand. It appears that this option would act to foster Federal intervention into marketplace, more so than simply by stimulating demand.

10. Increase funding of solar projects through existing federal financial programs.

This option should have few legislative requirements. Although there exists Federal structures to implement this program, there is potential for substantial budgetary impact depending upon the level at which these initiatives are pursued.

C. Minor Winners. These options are thought to have minor impacts on solar, implementation as currently written. However, the impacts of the options could expand depending on their initial success.

1. Establish an interagency solar coordination committee.

Effectiveness would depend upon to what degree the Federal buildings solar effort is carried out. It would create a further agency, although with small budgetary impact, which might not have a substantial impact. However, it may help to prevent inefficient resource allocations for solar equipment.

2. Twenty community test projects to resolve sun rights issues.

This option could have a limited impact on implementing solar, may have a substantial budgetary impact, and raises potential for federal intervention. Success of such a program depends heavily upon program structure and federal role.

3. Maintain competition through DOE monitoring, small business set-asides, and use of consensus standards.

Impact on maintaining competition minimal due to diverse nature of industry and the inter-department cooperation required.

4. Finance community-based solar enterprises.

Minor impact due to small size and numbers of the CDC. Budgetary impact may be relatively high due to non-technical lack of and nature training facilities of the CDC's. Option does address equity issue by focusing on low income groups in areas of high unemployment.

5. Revision of REA lending programs.

Low interest solar loans would not have a substantial budgetary impact, due to existence of infrastructure. Concern over the future of the REA may limit the number of solar projects supported. Option could demonstrate Federal commitment to low-income rural population. Due to nature of REA, short term impact may not be significant.

D. Losers.

These are options that should not be submitted.

1. Executive order requesting agencies to review current and potential authority that could be used to accelerate renewable energy sources.

This is a major charge of the DPR. However, continuing reviews should be proposed. Budgetary impact and legislative requirements would be minimal.

2. Establish a Solar Energy Development Bank

This option creates a major bureaucracy which leads to major federal intervention in the market-place. Legislation is currently being considered. However, it's purpose might be realized under existing bureaus such as the SBA.

This use of capital may be determined by budgetary powers to be better spent elsewhere.

3. Establish a quasi-public solar development corporation.

This option suffers from problems similar to the development bank, with the addition that it has even less legislative support.

E. Ambiguous Proposals

1. Incentives for multi-family housing.

No details.

2. Grants to business & homeowners.

No details.

3. Tax incentives for residential section.

Do these require new legislation or expansion on NEA provisions.

Estimation of Direct and Indirect Labor Requirements
for Solar Technologies

A. Selection of Generic Solar System Configurations

Solar technologies, even those within a certain generic type (e.g., solar heating and cooling), take many forms. For example, the degree of complexity or mechanical configuration can vary among manufacturers, leading to various labor requirements for each unit. Therefore, for the analysis we have selected several technologies which we considered to be representative of each generic solar energy use. The selected technologies among the generic types were:

1. Solar Heating and Cooling

- a. Solar Hot Water. Single glaze liquid type collector with heat exchanger, storage, domestic hot water tank and controls.
- b. Solar Hot Water/Heating. Double glaze liquid type collector with two heat exchangers, storage, domestic hot water tank, space heat distribution system and controls.
- c. Solar Hot Water, Heating and Cooling. High performance collector with components similar to those shown in (b).

2. Passive Solar

This is basically modifications to houses to fully utilize solar energy, by adding insulation, south wall and roof modifications and storage systems.

3. Wind Energy Conversion System. The systems considered are large WECS systems for base and intermediate load power supply and smaller fuel saver units.
 - a. WECS with hydroelectric hybrid - Intermediate demand type; 100MW capacity.
 - b. WECS with gas turbine - Intermediate demand type; 100MW capacity.
 - c. WECS with combined cycle - Base load demand type; 100MW capacity.
 - d. WECS fuel saver; 1.5MW capacity.
 - e. Advanced, WECS fuel saver, 1.5MW capacity.
4. Solar Process Heat
 - a. Textile processing hot water - 68,750 MMBTU per year.
 - b. Hot air grain dryer - 70,200 MMBTU per year.
 - c. Hot water can washing system - 38,250 MMBTU per year.
 - d. Hot air plastic curing system - 29,565 MMBTU per year.
5. Solar Thermal Electric
 - a. Solar Thermal Central Receiver, 3-hour storage, semi-peak demand type, 100MW capacity.
 - b. Solar Thermal Central Receiver, 6-hour storage, intermediate demand type, 100MW capacity.
 - c. Solar Thermal Central Receiver, fuel saver demand type, 100MW capacity

6. Photovoltaics (PV)

- a. PV with Storage Collector/Reflector 16% Si, semi-peak demand type, 100MW capacity.
- b. PV with Storage Collector/Reflector 10% Thin Film; semi-peak demand type, 100MW capacity.
- c. PV with Storage Collector/Reflector/16% silicon, intermediate demand type, 100MW capacity.
- d. PV with Storage Collector/Reflector/10% Thin Film; intermediate demand type, 100MW capacity.
- e. PV with Storage 10X Concentrating/Verticle Tracking; intermediate demand type, 100MW capacity.
- f. PV Collector/Reflector/16% Silicon, fuel saver demand type, 100MW capacity.
- g. PV Collector/Reflector/10% Thin Film fuel saver demand type, 100MW capacity.
- h. PV 10XCPC/16% Silicon fuel saver demand type, 100MW capacity.

7. Biomass

- a. Wood Fired Steam Plant; intermediate demand type 100MW capacity.
- b. Wood Fired Steam Plant; baseload demand type 100MW capacity.
- c. Biomass-Methanol; 3.82×10^6 MMBTU
- d. Biomass-Medium Btu gas; 6.34×10^6 MMBTU
- e. Biomass-Substitute Natural gas; 5.58×10^6 MMBTU

- f. Biomass-Process Heat, 850 ton/day input;
steam; 3.86×10^6 MMBTU
1700 ton/day input; steam; 8.40×10^6 MMBTU.
3400 ton/day input; steam; 17.64×10^6 MMBTU.

8. Ocean Thermal Energy Conversion Systems

- a. OTEC 1 plant production; baseload demand type; 264.5 MW capacity.
- b. OTEC 4 plants production; baseload demand type; 264.5MW capacity.
- c. OTEC 7 plnats production; baseload demand type; 264.5MW capacity.

9. Hydroelectric Power Generation

Hydroelectric dam, and power plant; baseload demand type; 0.981×10^9 KWH output power.

B. Direct and Indirect Labor Requirements Estimation

Details of estimation methodology for the generic solar energy use types are given below:

1. Solar Hot Water, Heating and Cooling

The labor estimates used in this study were obtained from estimates made in several previous studies. Table 1 shows the estimation in employee hours per square foot of collector obtained in their previous studies.

Due to regional insolation variations the output per square foot of collector differs. According to Mitre¹ estimates peak heating and cooling demands of Washington, D.C. are average for the nation. Based upon a single glaze collector with an efficiency intercept of 0.70 and an efficiency at $\Delta T/g_i = 0.5$ of 0.30; operating in Washington, D.C.; the average annual useful energy available for heating hot water was 0.18 MMBTU per square foot. The corresponding value for a hot water and heating system using a double glaze collector with efficiency intercept of 0.67 and value at $T/g_i = 0.5$ equal to 0.50 was 0.14 MMBTU/ft². Bechtel² in their energy supply system model used a value of 0.15 MMBTU/ft².

¹The Mitre Corporation, System Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1, 1977.

²Bechtel Corporation, Escalation in the Costs of Manpower Material and Equipment Needed for Energy Facilities, 1977.

LABOR REQUIREMENTS FOR FLAT-PLATE SOLAR UNITS IN EH/FT²

	Collector Manufacturing*				System Design			System Installation				Maintenance Total	Distribution Total	Component Manufacturing (per unit)
	Total	Manual	Super.	Admin.	Total	Contractor	Professional	Total	Manual	Super.	Prof.			
<u>Bezdek-(Mitre)</u>														
HW		.225	.022	.033		.173	.15		.419	.078	.10			
SH & HW (liq)		.385	.038	.056		.138	.126		.745	.141	.179			
SH & HW (air)		.535	.050	.079		.176	.161		.865	.163	.207			
SC,SH,HW		.095	.009	.014		.138	.126		.850	.159	.204			
Solar H.P.		.385	.038	.056		.138	.126		.725	.136	.172			
<u>Navarro Study</u>														
DHW 50ft ²					.2			.80				.04		
SH & HW 300ft ²					.1			.45				.033		
<u>Jobs From the Sun</u>														
DHW (1-family) retro (48)	.103							.429				.197**	12.2	
DHW (1-family) new (49)														
SH/HW (1-family) retro (395)	.103							.453				.148**	14.5	
SH/HW (1-fam) new (395)	.103							.32				.115**	14.5	
<u>OTA</u>														
HWH (85ft ²)	.03													
<u>CEP-Long Island</u>														
HWH (50-60 ft ²)								1.0 ^a						

*Collector Only

**Includes Design Function; calculated as 25% of manufacturing

^aDesign and Installation (?)

Based upon the above output characteristics and data in Table 1, the following low, intermediate and high labor requirements estimates for MMBTU were obtained, as follows:

$$\text{Man-Hours per MMBTU (actual)} = (\text{Man-Hours/ft}^2) / (\text{MMBTU/ft}^2)$$

TABLE 2

System	Direct Labor Requirements (Man-hours/MMBTU (actual))		
	Low	Intermediate	High
Hot Water (HW)	2.0	2.8	3.7
Hot water & Space Heating (HW/H)	3.5	4.3	5.0
Hot Water, Space Heating and Cool- ing (HW/H/C)	4.3	5.0	7.0

Using data in Table 2, and information on mix of hot water, space heating, and space heating and cooling systems installed according to the Base Case Strategy, a weighted average direct labor requirement estimate was calculated as follows:

$$\begin{aligned} \text{Direct labor estimates (Man-hours/MMBTU(actual))} = \\ \frac{[(\text{HW units}) \times (\text{HW Labor}) + (\text{HW/H units}) \times (\text{HW/H Labor}) + \\ (\text{HW/H/C units}) \times (\text{HW/H/C labor})]}{\text{Total number of units.}} \end{aligned}$$

In order to convert labor requirements from MMBTU actual (3413 BTU/KWH) basis to a MMBTU of oil displaced (10,400 BTU/KWH) basis all labor estimates were divided by 3 ($=10,450/3413$).

The weighted labor requirements are shown below:

Direct Labor Requirements - Weighted Average

Low Estimate	1.033 man-hours/MMBTU (displaced)
Intermediate Estimate	1.300 man-hours/MMBTU (displaced)
High Estimate	1.567 man-hours/MMBTU (displaced)

Indirect labor; that is, labor required for manufacture of products and materials used for solar system manufacture is taken to be twice direct labor requirement.

Table 3 shows the direct and indirect labor requirements.

(BURMAN PLEASE ELABORATE)

Table 3

UNIT LABOR REQUIREMENTS
(On displaced energy basis)

Technology	Direct Labor			Indirect Labor		
	Man-Hour/MMBTU-Year			Man-Hour/MMBTU-Year		
	Low	Mid	High	Low	Mid	High
Solar hot water,	0.667	0.933	1.233	1.334	1.866	2.466
Solar heating	1.167	1.433	1.667	2.334	2.866	3.334
Solar Cooling	1.433	1.667	2.333	2.866	3.334	4.666
Solar Aggregated Hot water, heating and cooling	1.033	1.300	1.567	2.067	2.600	3.133
Solar Electric	0.695	0.726	0.774	1.870	1.960	2.010
Photovoltaic	0.810	1.410	2.110	1.280	2.220	3.310
Wind	0.204	0.259	0.355	0.890	1.230	1.560
Solar A/IPH	0.187	0.324	0.670	0.530	0.563	1.333
Biomass Process Heat	0.035	0.045	0.064	0.055	0.072	0.107
Biomass-Syn-Fuels	0.033	0.067	0.135	0.052	0.105	0.213
Biomass-Electric	0.209	0.250	0.292	0.670	0.867	1.120
Passive Solar	0.283	0.567	0.800	0.467	0.933	1.169
OTEC	0.445	0.667	0.874	0.898	1.134	1.676
Hydroelectric ^a		0.234			0.414	

^aBechtel Estimate

2. Passive Solar

Due to the multitude of techniques that can be classified on passive solar technologies, it is difficult to identify labor requirements that can be directly attributed to installation of passive solar systems. Following are estimates calculated from costs obtained from various sources.

Range of costs = \$1500 - 3000 (1976 dollars)

Average = \$2500

Possible

Energy Savings = 60% of total demand of about 80 MMBtu/year
= 48 MMBtu (actual)

Assuming that 40% of the cost is due to direct labor¹ and 60% due to materials and based on average value of \$2500.

Direct labor cost (40%) = \$21/MMBtu (actual)

Direct Labor = 1.7 man-hours/MMBtu (actual)
at \$12.50 per man-hour²
= 0.567 man-hour/MMBtu (displaced)

Indirect Labor (60%) = \$31.3/MMBtu (actual)
= 2.6 man-hours/MMBtu (actual) at
0.08392 man-hours/dollar indirect
labor cost¹.

1. Please elaborate.
2. Labor rate assumed by Mitre and approximate mean value Bechtels assumed in their supply model.

= 0.867 man-hours/MMBtu (displaced)

The range of values obtained is shown in Table 3.

3. Wind Energy Conversion System

The labor requirements were computed from data presented by Mitre in: Systems Description and Engineering Costs of Solar Related Technologies Volume 1, 1977. The relevant tables used are appended as Tables 4, 5, 6, 7, and 8.

Man-years was converted to manhours on a 1900 man-hours/man-year¹ basis. Note that direct labor estimates do not include labor for purchased components.

Indirect labor estimates were obtained as follows:

Direct labor cost = direct labor (man-hour) * \$12.50/man-hour

Material cost = (total cost - direct labor cost)

Indirect labor = 0.08392 x material costs.

Total energy output = rated capacity x capacity factor x 8760 Kwh/yr
where 8760 is the number of hours in one year.

Total energy output = KWH x 10,400 x 10⁻⁶ MMBtu (displaced) per
year

Labor per MMBtu (displaced) = total labor/total MMBtu (displaced).
Direct and indirect labor estimates were obtained for each WECS system and low intermediate and high ranges were obtained from this estimate. The labor estimates for each system are shown in Table 9 and ranges used in the computations are shown in Table 3.

¹See U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, Table 9 page 18 for man-hours per man-year estimates.

Table 4

GENERIC DESIGN FOR MOD-I WIND ENERGY CONVERSION SYSTEM HYDROELECTRIC HYBRID								
First Year of Operation: 1981 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.48 (18 MPH Wind Site); 0.30 (14 MPH); 0.21 (12 MPH)	PRIMARY & SECONDARY SOURCES ERDA METREK GE							
Capital Cost Not Subject to Experience: 598 \$/kW $\pm$ 10%	GE, Kaman, METREK							
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Rotor, Hub, Main Bearings</td><td align="center">1</td><td align="center">157 (+30% - 15%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	1	157 (+30% - 15%)	GE, Kaman, METREK	
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	1	157 (+30% - 15%)						
O&M Costs: 4.0 $\pm$ 40% mills/kWh	Kaman, Northeast Utilities							
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 Yrs. Lifetime: 30 Yrs. Land Use: 1.5×10^{-5} mi ² /kW Water Use: N/A Labor: 5.4×10^{-3} MY/kW Location for Generic Design: Regions 3, 5, 8, 9 Factor Determining Regional Variation: Relative Available Dam and Wind Sites	ERDA, METREK GE, Kaman METREK METREK							

*Exclusive of labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table 5

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM WITH GAS TURBINE								
First Year of Operation: 1983 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.49 (14 MPH Wind Regime)		PRIMARY & SECONDARY SOURCES ERDA METREK METREK						
Capital Cost Not Subject to Experience: 580 \$/kW		METREK						
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Rotor, Hub, Main Bearings</td><td align="center">1</td><td align="center">325 (+30% - 15%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	1	325 (+30% - 15%)		METREK
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	1	325 (+30% - 15%)						
O&M Costs: 21.3 $\pm$ 32% \$/kW/Yr		METREK						
Conventional Fuel Type: #2 Fuel Oil Burn Rate: 2700 Btu/kWh Construction Time: 3 Yrs. Lifetime: 30 Yrs. Land Use: 1.3×10^{-5} mi ² /kW Water Use: 0 Labor: * 5.0×10^{-3} MY/kW Location for Generic Design: All Regions Factor Determining Regional Variation: Relative Available Wind Speeds		METREK METREK ERDA METREK METREK						

*Exclusive of labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table 6

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM WITH COMBINED CYCLE								
First Year of Operation: 1983 Demand Type: Baseload Nameplate Rating: 100 MW Capacity Factor: 0.65 (12.1 MPH), 0.70 (14 MPH), 0.87 (18 MPH)	PRIMARY & SECONDARY SOURCES ERDA METREK METREK							
Capital Cost Not Subject to Experience: 710 \$/kW	METREK							
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Rotor, Hub, Main Bearings</td><td>67</td><td>325 (+30% - 15%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	67	325 (+30% - 15%)	METREK	
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	67	325 (+30% - 15%)						
O&M Costs: 5.4 +33% mills/kWh								
Conventional Fuel Type: #2 Fuel Oil Burn Rate: 1565 (0.65CF), 1460 (0.70CF), 1190 (0.87CF) Btu/kWh Construction Time: 3 years Lifetime: 30 years Land Use: 1.3×10^{-5} mi ² /kW Water Use: 2.6×10^{-3} Acre-Ft/yr/kW Labor: 8.5×10^{-3} MY/kW Location for Generic Design: All Factor Determining Regional Variation: Relative Available Wind Sites	METREK METREK ERDA METREK METREK							

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table 7

GENERIC DESIGN FOR MOD-I WIND ENERGY CONVERSION SYSTEM/FUEL SAVER			PRIMARY & SECONDARY SOURCES
First Year of Operation:	1981		ERDA
Demand Type:	Fuel Saver		
Nameplate Rating:	1.5 MW (22.4 MPH)		GE, Kaman
Capacity Factor:	0.48 (18 MPH Ave. Wind)		GE
	0.30 (14 MPH), 0.21 (12 MPH)		
Capital Cost Not Subject to Experience:	448 \$/kW		GE, Kaman, METREK
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Rotor, Hub, Main Bearings	1	157 (+30% -15%)	GE, Kaman, METREK
O&M Costs:	5.2 $\pm$ 50% mills/kWh		Kaman, Northeast Utilities
Conventional Fuel Type:	None		
Burn Rate:	N/A		
Construction Time:	2 Yrs.		ERDA, METREK
Lifetime:	30 Yrs.		GE, Kaman
Land Use:	6.6×10^{-6} mi ² /kW		METREK
Water Use:	0		
Labor:*	5.1×10^{-3} MY/kW		METREK
Location for Generic Design:	All Regions		
Factor Determining Regional Variation:	Relative Available Wind Speed		

*Exclusive of the labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table 8

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM/FUEL SAVER								
First Year of Operation: 1983 Demand Type: Fuel Saver Nameplate Rating: 1.5 MW (17.1 MPH) Capacity Factor: 0.65 (18 MPH), 0.49 (14 MPH), 0.44 (12 MPH)		PRIMARY & SECONDARY SOURCES ERDA ERDA, METREK METREK						
Capital Cost Not Subject to Experience: 475 \$/kW		METREK						
Capital Cost Subject to Experience: <table border="1"> <thead> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> </thead> <tbody> <tr> <td>Rotor, Hub, Main Bearings</td><td align="center">1</td><td align="center">325 (+30% -15%)</td></tr> </tbody> </table>		<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	1	325 (+30% -15%)	METREK
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	1	325 (+30% -15%)						
O&M Costs: 4.9 + 42% mills/kWh		METREK						
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 years Lifetime: 30 years Land Use: 1.2×10^{-5} mi ² /kW Water Use: 0 Labor: * 8.5×10^{-3} MY/kW Location for Generic Design: All Factor Determining Regional Variation: Relative Available Wind Speeds		ERDA, METREK ERDA METREK METREK						

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE 9

SUMMARY OF LABOR REQUIREMENTS FOR SOLAR TECHNOLOGIES

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	Solar Thermal Central Receiver, 3 hour storage	Semi Peak	100	0.35	0.013	0.774	31.93	22.26	1.87
a	Solar Thermal Central Receiver, 6 hour storage	Semi Peak	100	0.50	0.017	0.708	32.69	23.84	2.00
a	Solar Thermal Central Receiver	Fuel Saver	100	0.30	0.010	0.695	32.69	24.00	2.01
a	PV with Storage Collector/Reflector 16% Si	Semi Peak	100	0.30	0.025	1.418	44.33	26.57	2.23
a	PV with Storage Collector/Reflector 10% Thin Film	Semi Peak	100	0.30	0.041	1.110	34.82	20.85	1.75
a	PV with Storage Collector/Reflector/16% silicon	Intermed.	100	0.45	0.04	1.540	48.20	28.96	2.43
a	PV with Storage Collector/Reflector/10% Thin Film	Intermed.	100	0.45	0.067	1.230	38.56	23.12	1.94
a	PV with Storage IOX Concentrating/Verticle Tracking	Intermed.	100	0.45	0.045	2.110	65.86	39.44	3.31
a	PV Collector/Reflector/16% Silicon	Fuel Saver	100	0.28	0.017	1.070	33.43	20.02	1.68
a	PV Collector/Reflector/10% Thin Film	Fuel Saver	100	0.26	0.027	0.810	25.46	15.25	1.28
a	PV 10XCPC/16% Silicon	Fuel Saver	100	0.30	0.035	2.020	63.17	37.89	3.18

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	WECS with Hydroelectric hybrid	Intermed.	100	0.48 18 mph	0.0054*	0.235	17.96	15.02	1.26
a	Advance WECS with gas turbine	Intermed.	100	0.49 14 mph	0.0050*	0.226	21.08	18.26	1.53
	Advanced WECS with combined cycle	Baseload	100	0.87 18mph	0.0085*	0.204	13.58	11.03	0.93
a	WECS	Fuel Sav.	1.5 (22.4 mph)	0.30	0.0051*	0.355	23.02	18.58	1.56
a	Advanced WECS	Fuel Sav.	1.5 (17.1 mph)	0.65	0.0085	0.273	14.04	10.63	0.89
a	Wood Fired Steam Plant	Intermed.	100	0.50	0.007	0.292	17.05	13.25	1.12
a	Wood Fired Steam Plant	Baseload	100	0.80	0.008	0.209	10.65	8.04	0.67
b	Solar Heated Textile Processing Water		68,750 MMBTU			0.330	8.73	9.00	0.50
b	50-100°F Hot air grain Dryer		70,200 MMBTU			0.219	9.85	7.11	0.59
b	50-100°F Hot water can washing system		38,250 MMBTU			0.187	9.22	6.88	0.57

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
b	100-150°F hot air plastic curing	29,565 MMBTU				0.670	26.48	15.89	1.33
c	Hydroelectric dam, and power plant	Baseload	0.981 x 10 ⁹ KWH			0.234	8.46	4.93	0.414
d	OTEC 1 plant	Baseload	264.5	0.61		0.874			1.676
d	OTEC 4 plants	Baseload		0.61		0.667			1.134
d	OTEC 7 plants	Baseload	264.5	0.61		0.445			0.898
e	Biomass-Methanol		3.82 x 10 ⁶ MMBTU			0.135	4.23		0.213
e	Biomass-Medium Btu gas		6.34 x 10 ⁶ MMBTU			0.033	1.03	0.62	0.052
e	Biomass-Substitute Natural gas		5.58 x 10 ⁶ MMBTU			0.066	2.09	1.25	0.105
e	Biomass-Process Heat 850 ton/day	Steam	3.86 x 10 ⁶ MMBTU			0.064	2.01	1.20	0.101
	1700 ton/day	Steam	8.40 x 10 ⁶ MMBTU			0.045	1.43	0.88	0.072
	3400 ton/day	Steam	17.64 x 10 ⁶ MMBTU			0.035	1.09	0.66	0.055

Source: Unit labor estimates computed from data presented in:

- a - Systems Description and Engineering Costs for Solar-Related Technologies, Volume I, Summary. The Mitre Corporation, Metrek Division, June 1977.
- b - Systems Description and Engineering Costs for Solar-Related Technologies, Volume III, Agricultural and Industrial Process Heat. The MITRE Corporation, Metrek Division, June 1977.
- c - Escalation in the Costs of Manpower, Materials, and Equipment Needed for Energy Facilities, the Bechtel Corporation, October 1977. Resource Requirements, Impacts, and Potential Constraints Associated with various energy futures. Bechtel National, Inc., March 1978.
- d - Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII, Ocean Thermal Energy Conversion. The MITRE Corporation, Metrek Division, June 1977.
- e - Systems Description and Engineering Costs for Solar Related Technologies, Volume IX, Biomass Fuels Production and Conversion System, The MITRE Corporation, Metrek Division, June 1977.

4. Solar Process Heat

Solar process heat technologies selected for this analysis and their component costs are shown in Table 10, 11, 12, and 13. They are Mitre estimates presented in "System Description and Engineering Costs for Solar-Related Technologies, Volume III."

As before, direct labor was allocated 40% of total cost and costed at \$12.50 per man-hour. Indirect labor was costed at 0.08392 man-hours/dollar and all estimates were converted to displaced energy basis. Labor estimates for each technology are shown in Table 9 and estimates used in the analysis are shown in Table 3.

Table 10

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT
SOLAR HEATED TEXTILE PROCESS WATER COSTS

<u>Description</u>	<u>Total Cost</u>
Collectors	
Glass	360,180
Reflector	125,580
Header (Copper)	187,680
Insulation	187,680
Gasket	74,520
Labor	
Fabrication	249,260
Shipping	37,260
Insulation	157,320
Plumbing	83,300
Valves	28,800
Pumps	28,800
Controls	12,500
Storage	243,800
Total Capital	\$1,777,200
Recurring Annual Costs:	
Capital Charge (10%)	\$177,720
Maintenance (1%)	17,800
Operations (2 men part-time)	15,000
Total Annual Cost	\$ 210,520
Energy Collected	0.275
(MMBtu/ft ² /yr)	
(MMBtu/yr)	68,780
Annualized Cost	3.06

TABLE 11

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

80-100° HOT WATER CAN WASHING SYSTEM

<u>Description</u>	<u>Total Cost</u>
Collector (Copper Flat)	
Copper sheet	382,140
Paint	150,480
Glass	112,860
Insulation	52,570
Box	44,550
Labor	
Fabrication	150,480
Shipping	22,700
Installation	75,240
Pumps	7,000
Valves	7,000
Plumbing	42,000
Controls (Electrical/Electronic)	12,000
Total Installed Cost	\$1,058,000
<u>Recurring Annual Costs:</u>	
Maintenance	\$ 21,160
Operations	50,000
Capital (10%)	105,800
Total Annual Costs	\$ 176,960
Energy Produced:	
(MMBtu/ft ² /yr)	0.255
(MMBtu/Yr)	38,250
Cost of Solar Energy	
(\$/MMBtu)	\$4.63
Cost of Fuel Displaced	
(\$/MMBtu)	
(Assuming \$0.40/gal, 65% efficiency)	\$4.68

TABLE 12

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

50° - 100° HOT AIR--GRAIN DRYER

<u>Description</u>	<u>Total Cost</u>
Collectors	
Plastic	206,250
Labor	137,500
Aluminum	206,168
Paint	137,733
Steel Box	40,714
Glass	103,084
Insulation	48,510
Labor	
Fabrication	274,601
Shipping	13,860
Installation	41,580
Ductwork	36,100
Valves	16,000
Controls	22,000
Fans	17,300
Storage	592,500
Heat Exchangers	<u>180,000</u>
Total Installed Cost	\$2,074,900
Recurring Annual Costs:	
Capital (10%)	\$ 207,490
Maintenance (1%)	20,749
Operation (4 men)	<u>100,000</u>
Total Annual Costs	\$ 328,239
Energy Delivered	
(MMBtu/ft ² /yr)	0.2552
(MMBtu/yr)	70,200

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

50° - 100° HOT AIR--GRAIN DRYER

(continued)

<u>Description</u>	<u>Total Cost</u>
Energy Cost (\$/MMBtu)	\$4.68
Replacement Fuel Cost: (\$/MMBtu)	
Propane	\$6.67
Natural Gas	\$2.50
Natural Gas with Current Design (\$/MMBtu)	\$5.00

TABLE 13

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

100° - 150°C HOT AIR--PLASTIC CURING

<u>Description</u>	<u>Total Cost</u>
Collector (Winston Parabolic)	
Copper	101,520
Steel	108,520
Paint	27,000
Insulation	101,520
Glass	101,520
Sealant	4,104
Labor	
Fabrication	405,000
Shipping	27,000
Installation	168,480
Ductwork	18,300
Valves	7,300
Controls	13,500
Fans	8,600
Storage(Rockbed)	142,500
Heat Exchangers	86,400
Total Installed Cost	\$1,321,264
Recurring Annual Costs:	
Capital (10%)	\$ 135,660
Maintenance (2%)	27,132
Operations (3 men)	75,000
Total Annual Cost	\$ 237,792
Energy Delivered:	
(MMBtu/ft ² /yr)	0.219
(MMBtu/Yr)	29,565
Energy Cost:	\$8.04
(\$/MMBtu)	
Replacement Energy Cost:	
(\$/MMBtu)	
Synfuel/Propane	\$8.89
Electricity	\$16.39

5. Solar Thermal Electric

Systems evaluated are described in Tables 14, 15, 16¹. Direct and Indirect labor requirements per MMBtu displaced were calculated as in WECS. The estimates are shown in Table 9 and range of values used in the analysis is shown in Table 3.

¹Mitre, Volume 1., op cit.

TABLE 14

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER-3HR STORAGE			
First Year of Operation: 1990 Demand Type: Semi-Peak Nameplate Rating: 100 MW Capacity Factor: 0.35		PRIMARY & SECONDARY SOURCES METREK METREK, Aerospace METREK, Aerospace METREK, Aerospace	
Capital Cost Not Subject to Experience: 274 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK, McDonnell-Douglas	
Capital Cost Subject to Experience:			
Description Heliostats (331 Ft ²) Receiver (46 Ft) ² Aperture Cavity Type Tower (650 Ft., Concrete) Control (Field Controller with 1 Master Unit) Storage	Quantity/System 15,000 2 2 600 210 MWh _e Steel Ingot Type	Mass Produced Cost (\$/kW) 390 41 91 63 120 705 \$/kW (+40%, -20%)	METREK, McDonnell-Douglas METREK, Martin-Marietta METREK, Honeywell METREK METREK, JPL
O&M Costs: 14 \$/kW/Yr (+40%, -20%)		METREK, McDonnell-Douglas	
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 Yrs. Land Use: 1.0 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Acre-Ft/Yr/kW Labor: 0.013 Man-Years/kW Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Direct Sunlight		METREK METREK METREK, ERDA/DSE* METREK, Aerospace METREK, ERDA/DSE METREK METREK Aerospace METREK, Aerospace	

*ERDA - Division of Solar Energy

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE 15

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER - 6 HR. STORAGE			
First Year of Operation: 1986 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.5		<u>PRIMARY & SECONDARY SOURCES</u> METREK ERDA/DSE Aerospace, ERDA/DSE METREK	
Capital Cost Not Subject to Experience: 315 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK	
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Heliostats (331 Ft ²)	22,500	595	McDonnell-Douglas, METREK Martin-Marietta, METREK
Receiver (46 Ft) ² Aperture	3	62	
Cavity Type			
Tower (650 Ft., Concrete)	3	136	Honeywell, METREK
Control (Field Controller with 1 Master Unit)	900	95	McDonnell-Douglas, METREK JPL, METREK
Storage	420 MWh _e Steel Ingot Type	239	
Total Modules Cost:		1117 \$/kW (+40%, -20%)	
O&M Costs: 20 \$/kW/Yr. (+40%, -20%)		METREK estimate based on above McDonnell-Douglas Avail. Est.	
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.5 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Acre-Ft/yr/kW (Dry Cooling Tower) Labor: 0.017 Man-Years/kW Location for Generic Design: Regions 7, 8 and 9 Factor Determining Regional Variation: Relative Available Direct Sunlight		METREK, ERDA/DSE All Contractors, ERDA/DSE METREK ERDA/DSE METREK Aerospace METREK, Aerospace, ERDA/DSE	

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE 16

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER-FUEL SAVER			
First Year of Operation:	1990		PRIMARY & SECONDARY SOURCES
Demand Type:	Fuel Saver		METREK
Nameplate Rating:	100 MW		METREK
Capacity Factor:	0.25 to 0.362		METREK
Capital Cost Not Subject to Experience:	274 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK, McDonnell-Douglas
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Heliostats (331 Ft ²)	15,000	390	McDonnell-Douglas, METREK
Receiver (46 Ft) ² Aperture	2	41	Martin-Marietta, METREK
Cavity Type			
Tower (650 Ft., Concrete)	2	91	Honeywell, METREK
Control (Field Controller with 1 Master Unit)	600	63	METREK
Total Modules Costs		585 \$/kW (+40% -20%)	
O&M Costs:	12 \$/kW/Yr (+40%, -20%)		METREK, McDonnell-Douglas
Conventional Fuel Type:	None		
Burn Rate:	N/A		
Construction Time:	2 Yrs.		METREK
Lifetime:	30 Yrs.		METREK, ERDA/DSE
Land Use:	1.0 x 10 ⁻⁵ mi ² /kW		METREK, Aerospace
Water Use:	0.0 Acre-Ft/Yr/kW		METREK, ERDA/DSE
Labor:	0.010 Man-Years/kW		METREK
Location for Generic Design:	Regions 7, 8, and 9		METREK Aerospace
Factor Determining Regional Variation:	Relative Available Direct Sunlight		METREK, Aerospace

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

6. Photovoltaics

Systems considered were large central stations providing semi-peak, intermediate and fuel saver demand types. Costs are based on the availability of photovoltaic arrays at \$500/KW peak. Tables 17 to 24 obtained from Mitre, Volume 1, shows the capital costs and expected energy output for each technology.

As in solar process heat, direct labor costs were allocated 40% of the capital costs, indirect labor costs were calculated as in WECS. Table 9 shows the labor costs for each unit and Table 3 shows the range selected for the necessary labor impact computations.

TABLE 17

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/16% SILICON														
First Year of Operation: 1990 Demand Type: Semi-Peak Nameplate Rating: 100 MW Capacity Factor: 0.30		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK, Aerospace METREK, Aerospace, Westinghouse Aerospace												
Capital Cost Not Subject to Experience: 200 \$/kW (Power Conditioning, Facility) (+90%, -30%)		METREK, Westinghouse												
Capital Cost Subject to Experience: <table> <tr> <th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr> <tr> <td>Solar Array Modules (100 M² Collector & Reflector)</td><td>7351</td><td>890</td></tr> <tr> <td>Storage</td><td>250</td><td>75</td></tr> <tr> <td>Total Modules Costs</td><td></td><td>965 \$/kW (+90%, -30%)</td></tr> </table>	Description	Quantity/System	Mass Produced Cost (\$/kW)	Solar Array Modules (100 M ² Collector & Reflector)	7351	890	Storage	250	75	Total Modules Costs		965 \$/kW (+90%, -30%)		METREK, Aerospace, Westinghouse METREK, Aerospace
Description	Quantity/System	Mass Produced Cost (\$/kW)												
Solar Array Modules (100 M ² Collector & Reflector)	7351	890												
Storage	250	75												
Total Modules Costs		965 \$/kW (+90%, -30%)												
O&M Costs: 30.5 \$/kW/yr (+25%, -25%)		METREK, Westinghouse												
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 5.7 x 10 ⁻⁶ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace												

Source: Mitre Volume 1 op. cit.

TABLE 18

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/10% THIN FILM														
First Year of Operation: 1990 Demand Type: Semi-Peak Nameplate Rating: 100 MW Capacity Factor: 0.30		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK, Aerospace METREK, Aerospace, Westinghouse Aerospace												
Capital Cost Not Subject to Experience: 220 \$/kW (Power Conditioning, Facility) (+90%, -30%)		METREK, Aerospace, Westinghouse												
Capital Cost Subject to Experience: <table> <tr> <th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr> <tr> <td>Solar Array Modules (100 M² Collector & Reflector)</td><td>12,650</td><td>620₀</td></tr> <tr> <td>Storage</td><td>250</td><td>75</td></tr> <tr> <td>Total Modules Costs</td><td></td><td>695 \$/kW (+90%, -30%)</td></tr> </table>	Description	Quantity/System	Mass Produced Cost (\$/kW)	Solar Array Modules (100 M ² Collector & Reflector)	12,650	620 ₀	Storage	250	75	Total Modules Costs		695 \$/kW (+90%, -30%)		METREK, Aerospace, Westinghouse METREK, Aerospace
Description	Quantity/System	Mass Produced Cost (\$/kW)												
Solar Array Modules (100 M ² Collector & Reflector)	12,650	620 ₀												
Storage	250	75												
Total Modules Costs		695 \$/kW (+90%, -30%)												
O&M Costs: 40.5 \$/kW/yr (+25%, -25%)		METREK, Westinghouse												
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 9.8 x 10 ⁻⁶ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace												

Source: Mitre Volume 1 op. cit.

TABLE 19

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/16% SILICON														
First Year of Operation: 1990 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.45	PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK, Aerospace METREK, Aerospace, Westinghouse Aerospace													
Capital Cost Not Subject to Experience: 320 \$/kW (Power Conditioning, Facility) (+90%, -30%)	METREK, Westinghouse													
Capital Cost Subject to Experience:														
<table><tr><td><u>Description</u></td><td><u>Quantity/System</u></td><td><u>Mass Produced Cost (\$/kW)</u></td></tr><tr><td>Solar Array Modules (100 M² Collector & Reflector)</td><td>11,703</td><td>1400</td></tr><tr><td>Storage</td><td>600 MWh</td><td>180</td></tr><tr><td>Total Modules Cost</td><td></td><td>1580 \$/kW (+90%, -30%)</td></tr></table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Solar Array Modules (100 M ² Collector & Reflector)	11,703	1400	Storage	600 MWh	180	Total Modules Cost		1580 \$/kW (+90%, -30%)	METREK, Aerospace, Westinghouse METREK, Aerospace	
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>												
Solar Array Modules (100 M ² Collector & Reflector)	11,703	1400												
Storage	600 MWh	180												
Total Modules Cost		1580 \$/kW (+90%, -30%)												
O&M Costs: 65 \$/kW/yr (+25%, -25%)	METREK, Westinghouse													
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 9 x 10 ⁻⁶ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight	Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace													

Source: Mitre Volume I, op cit.

TABLE 20

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE - COLLECTOR/REFLECTOR/10% THIN-FILM															
First Year of Operation: 1990 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.45			PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK, Aerospace METREK, Aerospace, Westinghouse Aerospace												
Capital Cost Not Subject to Experience: 350 \$/kW (Power Conditioning, Facility) (+90%, -30%)			METREK, Westinghouse												
Capital Cost Subject to Experience:															
<table><thead><tr><th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr></thead><tbody><tr><td>Solar Array Modules (100 M² Collector & Reflector)</td><td>20,139</td><td>990</td></tr><tr><td>Storage</td><td>600 MWh</td><td>180</td></tr><tr><td>Total Modules Costs</td><td></td><td>1170 \$/kW (+90%, -30%)</td></tr></tbody></table>			Description	Quantity/System	Mass Produced Cost (\$/kW)	Solar Array Modules (100 M ² Collector & Reflector)	20,139	990	Storage	600 MWh	180	Total Modules Costs		1170 \$/kW (+90%, -30%)	METREK, Aerospace Westinghouse METREK, Aerospace
Description	Quantity/System	Mass Produced Cost (\$/kW)													
Solar Array Modules (100 M ² Collector & Reflector)	20,139	990													
Storage	600 MWh	180													
Total Modules Costs		1170 \$/kW (+90%, -30%)													
O&M Costs: 90.3 \$/kW/yr (±25%, -25%)			METREK, Westinghouse												
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.6 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight			Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace												

Source: Mitre Volume I, op cit.

TABLE 21

GENERIC DESIGN FOR 10X CONCENTRATING* PHOTOVOLTAIC ARRAY SYSTEM (VERTICAL AXIS TRACKING) WITH STORAGE (SILICON CELL)											
First Year of Operation: 1990 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.39		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK METREK									
Capital Cost Not Subject to Experience: \$200/kW (Power Conditioning, Facility)		METREK, Westinghouse									
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Photovoltaic Array Modules (100 M² Collector/Module)</td><td>14322</td><td>1980</td></tr> <tr> <td>Storage</td><td>232 MWH</td><td>70 \$2050/kW (+90%, -30%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Photovoltaic Array Modules (100 M ² Collector/Module)	14322	1980	Storage	232 MWH	70 \$2050/kW (+90%, -30%)		METREK, Westinghouse
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>									
Photovoltaic Array Modules (100 M ² Collector/Module)	14322	1980									
Storage	232 MWH	70 \$2050/kW (+90%, -30%)									
O&M Costs: \$34.5/kW/Yr. (+25%)		METREK, Westinghouse									
Conventional Fuel Type: N/A Burn Rate: N/A Construction Time: 2 Yrs. Lifetime: 30 Yrs. Land Use: 1.7 x 10 ⁻⁵ MI ² /kW Water Use: N/A Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Availability of Solar Radiation		METREK, Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace									

*Compound Parabolic Concentrator, Factor of Ten Concentration

Source: Mitre Volume I, op cit.

TABLE 22

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER--COLLECTOR/REFLECTOR ARRAY/16% SILICON								
First Year of Operation: 1990 Demand Type: N/A Nameplate Rating: 100 MW Capacity Factor: 0.28		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK, Westinghouse METREK, Westinghouse						
Capital Cost Not Subject to Experience: 150 \$/kW (Power Conditioning, Facility) (+90%, -30%)		METREK, Westinghouse						
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Solar Array Modules (100 M² Collector & Reflector)</td><td>5518</td><td>670 (+90%, -30%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Solar Array Modules (100 M ² Collector & Reflector)	5518	670 (+90%, -30%)		METREK, Westinghouse
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Solar Array Modules (100 M ² Collector & Reflector)	5518	670 (+90%, -30%)						
O&M Costs: 18.4 \$/kW/yr (+25%, -25%)		METREK, Westinghouse						
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 4.3×10^{-6} mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace						

Source: Mitre Volume I, op cit.

TABLE 23

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER--COLLECTOR/REFLECTOR ARRAY/10% THIN-FILM			
First Year of Operation: 1990 Demand Type: N/A Nameplate Rating: 100 MW Capacity Factor: 0.26			PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK, Westinghouse METREK, Westinghouse
Capital Cost Not Subject to Experience: 150 \$/kW (Power Conditioning, Facility) (+90%, -30%)			METREK, Westinghouse
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	8838	430 (+90%, -30%)	METREK, Westinghouse
O&M Costs: 22.3 \$/kW/yr (+25%, -25%)			
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 years Lifetime: 30 yrs. Land Use: 6.8 x 10 ⁻⁶ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight			Westinghouse, METREK METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace

Source: Mitre Volume 1, op cit.

TABLE 24

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER - 10XCPC*ARRAY/16% SILICON SOLAR CELLS (VERTICAL AXIS TRACKING)								
First Year of Operation: 1990 Demand Type: N/A Nameplate Rating: 100 MW Capacity Factor: 0.30		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK, Westinghouse METREK, Westinghouse						
Capital Cost Not Subject to Experience: \$160/kW (Pwr. Ccnd., Facility) (+90% -30%)								
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Solar Array Modules (100 M² Collector)</td><td>11,218</td><td>1500 (+90%, -30%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Solar Array Modules (100 M ² Collector)	11,218	1500 (+90%, -30%)		METREK, Westinghouse
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Solar Array Modules (100 M ² Collector)	11,218	1500 (+90%, -30%)						
O&M Costs: \$20/kW/yr. (#25%)		METREK, Westinghouse						
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.3 x 10 ⁻⁵ mi ² /kW Water Use: N/A Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse, METREK METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace						

*Factor of Ten Concentration, Compound Parabolic Concentrator (10XCPC)

Source: Mitre Volume I, op cit.

7. Biomass

Technology characterization tables for wood fired electricity generation, for biomass synthetic fuels production, and biomass process heat generation systems are shown in Tables 25 to 30. Biomass Process Heat Systems are assumed to be similar to electricity production systems without the electricity generating equipment. Note that costs do not include silvaculture. Direct and indirect labor costs are calculated as shown in WECS. They are presented in Tables 9 and 3.

TABLE 25

GENERIC DESIGN FOR WOOD-FIRED STEAM PLANT (INTERMEDIATE)		
First Year of Operation: 1980 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.50		PRIMARY & SECONDARY SOURCES METREK METREK METREK METREK
Capital Cost Not Subject to Experience: 747 \$/kW (+59%, -31%)		METREK
Capital Cost Subject to Experience: N/A <div> <div> <u>Description</u> </div> <div> <u>Quantity/System</u> </div> <div> <u>Mass Produced Cost (\$/kW)</u> </div> </div>		
O&M Costs: 34.7 \$/kW/yr (+40%, -30%)		METREK
Conventional Fuel Type: Wood or Logging Residues Burn Rate: 12,000 Btu/kWh Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.0×10^{-6} mi ² /yr/kW Water Use: 1.3×10^{-2} Acre-ft/yr/kW Labor: 7×10^{-3} MY/kW Location for Generic Design: All but Region 8 Factor Determining Regional Variation: Wood Availability		METREK METREK METREK METREK METREK METREK METREK METREK METREK

Source: Mitre Volume I, op cit.

TABLE 26

GENERIC DESIGN FOR WOOD-FIRED STEAM PLANT (BASE)		
First Year of Operation:	1980	PRIMARY & SECONDARY SOURCES METREK METREK METREK METREK
Demand Type:	Baseload	
Nameplate Rating:	(1) 46 MW (2) 100 MW (3) 210 MW	
Capacity Factor:	0.80	
Capital Cost Not Subject to Experience:	(1) 1190 \$/kW (2) 747 \$/kW (3) 512 \$/kW (+ 10%)	METREK
Capital Cost Subject to Experience:		
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>
O&M Costs: (1) 78 \$/kW/yr; (2) 55.6 \$/kW/yr; (3) 39.1 \$/kW/yr ($\pm 15\%$)		METREK
Conventional Fuel Type: Wood or Logging Residues		METREK
Burn Rate: (1) 13,000 Btu/kWh; (2) 12,000 Btu/kWh; (3) 11,500 Btu/kWh		METREK
Construction Time: (1) 1.5 yr.; (2) 2.0 yr.; (3) 2.5 yr.		METREK
Lifetime: 30 yrs.		METREK
Land Use: 1.0×10^{-6} mi ² /kW		METREK
Water Use: (1) 2.5×10^{-2} Acre-ft/kW/yr; (2) 2.2×10^{-2} ; (3) 2.1×10^{-2}		METREK
Labor: (1) 10×10^{-3} ; (2) 8×10^{-3} ; (3) 7×10^{-3} MY/kW		METREK
Location for Generic Design: All but Region 8		METREK
Factor Determining Regional Variation: Wood Availability		METREK

Source: Mitre Volume I, op cit.

TABLE 27

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION
AND METHANOL SYNTHESIS PROCESSES
(COSTS IN MILLION DOLLARS)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Wood-biomass feed capacity, ODT/day	1700
Gasification plant output, Btu/day	2.170×10^{10}
Gasification plant capital cost, MM\$	28.64
Gasification plant annual O&M cost, MM\$	5.28
Methanol output, T/day	670
Methanol output, Btu/Day	1.310×10^{10}
<u>CAPITAL COST (METHANOL SYNTHESIS PLANT)</u>	
Syn Gas Compressor I	2.4
CO Shift	.81
Shift Conversion	
Absorber	
Regenerator	
K.O. Process	
Iron Sponge Drum	12.36
Guard Drum	
Separator	
Compressor II	.80
Compressor III	.48
Methanol Converter	1.2
Heat Exchanger	.05
Separator	.03
Flash Drum	.02
Cooling and Waste ter Treatment	.90

TABLE 27 (continued)

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION
AND METHANOL SYNTHESIS PROCESSES
(COSTS IN MILLION DOLLARS)
(continued)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Steam Plant	.18
Storage and Handling	.40
Buildings and Structures	.30
SUBTOTAL METHANOL SYNTHESIS PLANT	19.93
TOTAL GASIFICATION/METHANOL SYN- THESIS PLANTS	48.57
<u>OPERATIONS AND MAINTENANCE COST</u>	
Direct Labor Cost	.82
Labor-Related Cost	.79
Power Cost	.67
Other Utility Cost	.48
Maintenance Cost	1.41
Miscellaneous Equipment Repair Cost	.28
SUBTOTAL ANNUAL, METHANOL SYNTHESIS PLANT	4.45
TOTAL ANNUAL, GASIFICATION/METHANOL SYNTHESIS PLANTS	9.73

Source: Mitre/Metrek 1977

TABLE 28

CAPITAL AND OPERATING COSTS PUROX GASIFICATION PROCESS
FOR PRODUCING MEDIUM-BTU GAS
(COSTS IN MILLION DOLLARS)

<u>ITEM OF COST</u>	<u>PLANT SIZE II</u>
Feed Capacity, ODT/day	1700
Plant fuel gas output, Btu/day	2.170×10^{10}
<u>CAPITAL COSTS</u>	
Front End Process	1.71
Shaft Furnace	1.00
Electrostatic Precipitator	.49
Product Gas Compressor Unit	.80
Product Gas Condensing Unit	.16
Oil Separator	.08
Oxygen Generator and Storage	12.80
General Mechanical and Plumbing	.60
Process Controls and Instrumentation	.06
Plant Services Air, Water, etc.	.04
Electric Supply and Distribution	.80
Cooling Tower and Water Treatment	.96
Buildings and Structures	.30
TOTAL	19.80

TABLE 28
CAPITAL AND OPERATING COSTS PUROX GASIFICATION PROCESS
FOR PRODUCING MEDIUM-BTU GAS
(COSTS IN MILLION DOLLARS)

Continued - 2

OPERATIONS AND MAINTENANCE COSTS

Direct Labor Cost	1.38
Labor-Related Cost	1.31
Power Cost	.64
Other Utility Cost	.48
Maintenance Cost	1.18
Miscellaneous Equipment Repair Cost	.29
TOTAL ANNUAL COST	5.28

Source: Mitre Volume IX, op cit.

TABLE 29

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION AND METHANATION PROCESSES
FOR SUBSTITUTE NATURAL GAS PRODUCTION
(COSTS IN MILLION DOLLARS)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Feed capacity, ODT/day	1700
Gasification plant output, Btu/day	2.170×10^{10}
Gasification plant capital cost	28.64
Gasification plant annual O&M cost	5.28
SNG output, Btu/Day @ 800 Btu/ SCF gross	1.912×10^{10}
<u>CAPITAL COST (METHANATION PLANT)</u>	
Shift conversion	.42
Gas purification	2.016
Methanation	.513
Product gas drying	.220
Instrumentation	.238
Electrical	.822
Mechanical	1.155
Building and structure	.836
SUBTOTAL METHANATION PLANT	6.21
TOTAL GASIFICATION/METHANATION PLANTS	34.85
<u>OPERATIONS AND MAINTENANCE COSTS</u>	
Direct Labor Cost	.72
Labor-Related Cost	.68

TABLE 29 (continued)

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION AND METHANATION PROCESSES
FOR SUBSTITUTE NATURAL GAS PRODUCTION
(COSTS IN MILLION DOLLARS)
(continued)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Power Cost	.6
Other Utility Cost	.4
Maintenance Cost	.46
Miscellaneous Equipment Repair Cost	.09
SUBTOTAL ANNUAL, METHANATION PLANT	2.95
TOTAL ANNUAL, GASIFICATION/ METHANATION PLANTS	8.23

Source: Mitre Volume IX, op cit.

TABLE 30

CAPITAL AND OPERATING COSTS CONVENTIONAL
WOOD-FIRED PROCESS HEAT
(COSTS IN MILLION DOLLARS)

<u>ITEM OF COST</u>	<u>PLANT SIZE I</u>	<u>PLANT SIZE II</u>	<u>PLANT SIZE III</u>
Feed capacity, ODT/day	850	1700	3400
Plant power output, MWe	46	100	210
<u>CAPITAL COSTS</u>			
Front End	1.5	1.71	3.16
Steam Generator	11.0	17.6	28.16
Water Treatment Plant	.32	.40	.50
HP/HT Valves	.22	.28	.35
Control Valves	.46	.69	1.04
Control Panels	.20	.20	.20
Transducers	1.20	1.40	1.80
Condenser	.37	.45	.58
G.P. Valves and Pumps	.12	.18	.28
Cooling Towers	1.1	1.73	2.80
Electrical	1.4	1.75	2.20
Mechanical	1.28	2.76	4.41
Supplementary Fuel Tank	.05	.07	.12
Instruments and Controls	1.28	1.6	2.00
General Construction	4.7	6.15	8.00
TOTAL	25.20	36.98	55.61

TABLE 30 (continued)

CAPITAL AND OPERATING COSTS CONVENTIONAL
WOOD-FIRED PROCESS HEAT
(COSTS IN MILLION DOLLARS)

<u>ITEM OF COST</u>	<u>PLANT SIZE I</u>	<u>PLANT SIZE II</u>	<u>PLANT SIZE III</u>
<u>OPERATING AND MAINTENANCE COSTS</u>			
Direct Labor Cost	.71	1.14	1.8
Labor-Related Cost	.67	1.07	1.7
Other Related Cost	.25	.40	.64
Maintenance Cost	1.65	2.46	3.4
Miscellaneous Equipment Repair Cost	.32	.49	.68
TOTAL ANNUAL COST	3.6	5.56	8.22

Source: Mitre Volume IX, op cit.

8. Ocean Thermal Energy Conversion (OTEC)

Capital costs and labor estimates are obtained from "Mitre Corporation, System Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII". Based upon cost reductions due to experience, capital and labor costs are shown in Table 31. Calculations of direct and indirect labor costs follow the methodology used in WECS. Range of values is obtained by using capital and labor costs corresponding to 1, 4 and 7 production units and a capacity factor of 0.61 as estimated by Mitre. The estimated labor requirements are shown in Tables 9 and 3.

TABLE 31

COMMERCIAL PLANT PRODUCTION PARAMETERS AND CAPITAL COSTS
(\$/kW)

Plant No.	Capital Costs Excluding HE		Capital Costs of HE		Engineer etc. 12.25%	Capital Costs	Comments
	Materials	Labor	Materials	Labor			
1	919	267	900	330	296	2712	Production Improved Titanium Shell & Tube HE
2	827 10% Cost Red.	227 15% Labor Red.	680	370	258	2362	Enhanced Heat Transfer Titanium Shell & Tube HE
3	827	227	424	248	211	1937	Enhanced Heat Transfer. Aluminum Shell & Tube HE
4	827	216 5% Labor Red.	404	240	207	1894	Maximum Enhancement Aluminum Shell & Tube HE
5	827	216	362	212	198	1805	Aluminum Plate and Fin HE
6	827	216	202	120	167	1532	Plastic Shell & Tube HE
7	827	216	148	88	157	1436	Plastic Plate & Fin HE

Source: Mitre Volume VII, op cit.

9. Hydroelectric Power Generation

Costs and labor requirements for this technology are estimated using data presented by Bechtel (op cit). It is based on a system with a total output of 0.981×10^9 KWh (actual) (10.2×10^6 MMBtu displaced). Total direct labor costs are shown in Table 32.

Table 32

Labor Type	Total Cost (Millions of 1977 Dollars)	Labor Rate (\$/man-hour)
Technical	7.758	14.37
Non-Technical	0.465	8.45
Manual	27.747	15.50

$$\text{Total labor required per plant} = \left(\frac{7.758}{14.37} + \frac{0.465}{8.45} + \frac{27.747}{15.50} \right) \times 10^6 \text{ man-hour}$$

$$= 2.385 \times 10^6 \text{ man-hours/plant}$$

$$= 0.234 \text{ man-hours/MMBtu (displaced)}$$

$$\text{Material and Equipment Cost} = 50.351 \times 10^6/\text{plant}$$

$$\text{Indirect labor @ 0.08392/} \\ \text{dollar} = 4.225 \times 10^6/\text{plant}$$

$$= 0.436 \text{ man-hours/MMBtu (displaced)}$$

C. Total Labor Requirements Estimation

Using the displaced energy quads estimates obtained from scenario analysis and the unit energy requirements for solar technologies in Table 3, total labor requirements are easily computed

by multiplication. Note that no attempt has been made to incorporate economies of scale into the final computations. Therefore one can assume that the labor estimates obtained would be closer to an upper bound, rather than to a mean or median value. Note also that the labor estimates are cumulative to 2000 and annual labor demand calculation would require more information on expected dates and rates of market penetration of the solar technologies.

Employment Impacts

The labor demands for supplying solar energy can be broken into two major categories: 1) direct employment, or the labor input required to design, manufacture, install operate and maintain a given unit throughout its lifetime, and 2) indirect employment, or the labor required to produce components and raw materials for the solar unit over its lifetime, plus an allowance for equipment and fuel use in construction.

In addition to the direct and indirect impacts, jobs are created as the labor and capital income generated by solar systems is spent on goods and services. Furthermore, to the extent that solar options save capital and fuel, jobs will be created as these savings are spent on additional goods and services. Conversely, a solar alternative that costs more per energy output, than its conventional alternative, and is made available to the public, will decrease employment by diverting spending from other (more labor-intensive) sectors of the economy. Unfortunately, the magnitude of these additional impacts has not been systematically analyzed in past empirical work. Hence, they could not be estimated for this analysis.

Table IV presents a comparison of the estimated solar and conventional energy labor requirements over 22 years for the Base, Maximum Practical and Technical Limit Cases, assuming an oil price of \$25 per barrel. As indicated in the table, total employment in the energy sector for the Maximum Practical Case is 6 percent higher than for the Base Case; for the Technical Limits Case, total employment is 16 percent higher than in the Base Case. These results represent net jobs created, that is, they take account of the conventional energy jobs displaced by an increased use of solar energy. The details of the methods used in this analysis is presented in Appendix _____.

We also developed a range of estimates for energy sector demands in the year 2000, based on two alternative growth paths for solar implementation. The first implies that 19 percent of all solar capacity is added in the year 2000, while the second implies that only 7 percent of cumulative capacity is added in 2000. As indicated in Table V, labor demands rise significantly in the accelerated solar cases. According to our estimates, the additional jobs created in the Maximum Practical Case (relative to the Base) would reduce the unemployment rate in 2000 by 0.1 to 0.7 percent. * Implementation of the Technical Limits Case would reduce the unemployment rate by 0.3 to 2 percent, depending on the implementation path of solar applications. To the extent that accelerated solar strategies promote economic growth (by freeing up capital) or increase labor participation rates (via program targeting), the employment impacts will be even greater.

*/ According to one estimate, based on BLS census projections of population and participation rates, the total labor force in year-2000 will be 132 million man-years, with unemployment of 7 million man-years.

These results clearly indicate that, over the period from 1978-2000, the accelerated solar strategies will have a positive impact on employment relative to the Base Case. Furthermore, in terms of their employment impacts, these strategies compare favorably with federal public service and public works programs. It is important to emphasize, however, that the impact of these strategies on unemployment in any one year depends significantly on the rate of their implementation over the period.

In addition to the cumulative number of jobs, the qualitative aspects of job creation were examined to the extent possible. Unfortunately, current employment impact analyses are sorely lacking in qualitative comparisons. Nonetheless, preliminary analysis of the demand for plumbers and sheet-metal workers indicate there should be no particular bottlenecks in the Base Case. In the accelerated solar cases, however, there could be some shortages in these categories, depending on the rates at which technologies grow and on the demand for these occupations in other industries.

A preliminary assessment of the skill levels associated with solar indicates that the larger industrial and community solar systems require a mix of skills well suited to those in conventional energy production. Smaller solar systems (e.g., for individual residential and commercial units), on the other hand, are particularly appropriate to the needs and skills of those hardest hit by chronic unemployment.

TABLE IV: Net Cumulative Net Labor Requirements,
Direct and Indirect 1978-2000 For
Total Energy Produced
(Man-Years In Thousands)

	<u>Base Case</u> (\$25 per Barrel)	<u>Maximum Practical</u>	<u>Technical Limits</u>
Solar	4,128	11,129	21,831
Conventional	<u>55,677</u>	<u>52,210</u>	<u>47,501</u>
TOTAL =	59,805	63,339	69,332
Net Change*	--	+3,534	+9,527

*from Base Case

**TABLE V: Total Energy Sector Labor Requirements
in Year-2000 of Accelerated Cases Re-
lative to Base (\$25/bbl)**

(Man-Years in Thousands)

	<u>Upper Bound</u> 19% of Cumulative	<u>Lower Bound</u> 7% of Cumulative
Maximum Practical	+1033	+195
Technical Limits	+2723	+427

APPENDIX : LABOR IMPACTS OF SOLAR
ENERGY DEVELOPMENT

REPORT TO THE IMPACTS PANEL BY THE
EMPLOYMENT IMPACTS TASK FORCE

SEPTEMBER 13, 1978

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APPENDIX - LABOR IMPACTS OF SOLAR ENERGY DEVELOPMENT

This appendix presents a discussion of the broad quantitative labor aspects of solar energy development to the year 2000 for three alternatives developed by the Impacts Panel: (1) the Base Case (which itself consists of three scenarios, each driven by a different set of assumed real price energy prices); (2) the Maximum Practical Case, the highest level of solar penetration thought reasonably conceivable to attain by the year 2000; and (3) the Technical Limits Case. A brief discussion of the data sources and methodology for deriving the labor demand estimates are included. In addition to the overall quantitative impacts, the qualitative impacts of solar development are examined to the extent possible.

A. Total Quantitative Impact

The labor demands for solar, like any process which involves the use of materials and services supplied by more than one producing unit, are of two kinds. The first kind is the direct impacts of labor demands: the labor required to design, manufacture, install, operate and maintain a given solar unit throughout its lifetime. There are also indirect demands, those labor hours required to produce components and ingredient materials, mostly in the capital which goes into the solar unit (the components and ingredients used in the installation phase, plus allowance for builders' equipment and fuel used in the construction phase). In addition, over the lifetime, there will be some indirect demands for the materials used in the operation and maintenance of the unit.

In addition to the direct and indirect impacts, jobs are created as the labor and capital income generated by the design, manufacturing, installation and servicing of solar systems is spent on goods and services. Furthermore, to the extent that solar options save capital and fuel, jobs will be created as these savings are spent on additional goods and services. Conversely, a solar system that costs more per energy output, than its conventional alternative and is made available to the public, will decrease employment by diverting spending from other (more labor-intensive) sectors of the economy. Unfortunately, the magnitude of these additional impacts has not been systematically analyzed in past empirical work. Hence, they could not be estimated for this analysis.

1. Methodology

A variety of source materials were used to estimate the direct and indirect employment impacts associated with solar implementation. It should be emphasized, however, that data analysis in this area is limited by the paucity of job information on solar technologies. Efforts to date to estimate employment impacts have been piecemeal and to a certain extent superficial. The basic technique for estimating labor requirements has been surveying firms involved in the production and installation of solar systems. The basic method of survey has been a short mailed questionnaire which has requested only limited information, in the hope that this would increase the response rate. As a result, the information obtained is often rather general and the statistical reliability of the results less than desirable. Also, the information is limited to reports on technologies presently thought to have

commercial viability, basically flat-plate collector systems to supply residential heat and hot water. There has generally been little if any attempt to link up these results with a determination of the indirect labor impacts -- those jobs created in manufacturing, in the basic extraction industries, and in operation and maintenance. Hence, the actual magnitude of job creation in the solar industry is subject to error.

With these caveats in mind, we present the assumptions and methodology used in estimating employment impacts of various solar technologies. 1/

Solar Hot Water, Heating and Cooling. The labor estimates used in this study were obtained from estimates made in several previous studies. Table 1 shows estimates of employee hours per square foot of collector obtained in five previous studies. The output per square foot of collector differs due to regional insolation variations. According to Mitre 2/ estimates, peak heating and cooling demands of Washington, D.C. are average for the nation. Based upon a single glaze collector with an efficiency intercept of 0.70 and an efficiency at $T/g_1 = 0.5$ of 0.30, operating in Washington, D.C., the average annual useful energy available for heating hot water was 0.18 MMBTU per square foot. The corresponding value for a hot water and heating system using a double glaze collector with efficiency intercept of 0.67 and value at $T/g_1 = 0.5$ equal to 0.50 was 0.14 MMBTU/ft². Bechtel 3/ in their energy supply system model used a value of 0.15 MMBTU/ft².

1/ For description of the generic solar systems used in this analysis, see Attachment A.

2/ The Mitre Corporation, System Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1, 1977.

3/ Bechtel Corporation, Escalation in the Costs of Manpower Material and Equipment Needed for Energy Facilities, 1977.

TABLE 1: LABOR REQUIREMENTS FOR FLAT-PLATE SOLAR UNITS IN EH/FT²

	Collector Manufacturing*				System Design			System Installation				Maintenance Total	Distribution Total	Component Manufacturing (per unit)
	Total	Manual	Super.	Admin.	Total	Contractor	Professional	Total	Manual	Super.	Prof.			
<u>Bezdek-(Mitre)</u>														
HW		.225	.022	.033		.173	.15		.419	.078	.10			
SH & HW (liq)		.385	.038	.056		.138	.126		.745	.141	.179			
SH & HW (air)		.535	.050	.079		.176	.161		.865	.163	.207			
SC,SH,HW		.095	.009	.014		.138	.126		.850	.159	.204			
Solar H.P.		.385	.038	.056		.138	.126		.725	.136	.172			
<u>Navarro Study</u>														
DHW 50ft ²					.2			.80				.04		
SH & HW 300ft ²					.1			.45				.033		
<u>Jobs From the Sun</u>														
DHW (1-family) retro (48)	.103							.429					.197**	12.2
DHW (1-family) new (49)														
SH/HW (1-family) retro (395)	.103							.453					.148**	14.5
SH/HW (1-fan) new (395)	.103							.32					.115**	14.5
<u>OTA</u>														
HWH (85ft ²)	.03													
<u>CEP-Long Island</u>														
HWH (50-60 ft ²)								1.0 ^a						

*Collector Only

**Includes Design Function; calculated as 25% of manufacturing

^aDesign and Installation (?)

Based upon the above output characteristics and data in Table 1, the following low, intermediate and high labor requirements estimates for MMBTU were obtained, as follows:

$$\text{Man-Hours per MMBTU (actual)} = (\text{Man-Hours/ft}^2) / (\text{MMBTU/ft}^2)$$

TABLE 2

System	Direct Labor Requirements (Man-hours/MMBTU (actual))		
	Low	Intermediate	High
Hot Water (HW)	2.0	2.8	3.7
Hot water & Space Heating (HW/H)	3.5	4.3	5.0
Hot Water, Space Heating and Cool- ing (HW/H/C)	4.3	5.0	7.0

Using data in Table 2, and information on mix of hot water, space heating, and space heating and cooling systems installed according to the Base Case Strategy, a weighted average direct labor requirement estimate was calculated as follows:

$$\begin{aligned} \text{Direct labor estimates (Man-hours/MMBTU(actual))} = \\ \frac{[(\text{HW units}) \times (\text{HW Labor}) + (\text{HW/H units}) \times (\text{HW/H Labor}) + \\ (\text{HW/H/C units}) (\text{HW/H/C labor})]}{\text{Total number of units.}} \end{aligned}$$

In order to convert labor requirements from MMBTU actual (3413 BTU/KWH) basis to a MMBTU of oil displaced (10,400 BTU/KWH basis all labor estimates were divided by 3 (-10,450/3413).

The weighted labor requirements are shown below:

Direct Labor Requirements - Weighted Average

Low Estimate	1.033 man-hours/MMBTU (displaced)
Intermediate Estimate	1.300 man-hours/MMBTU (displaced)
High Estimate	1.567 man-hours/MMBTU (displaced)

Indirect labor; that is, labor required for manufacture of products and materials used for solar system manufacture is taken to be twice the direct labor requirement. The ratio of indirect to direct labor requirements was determined as follows: The indirect labor requirements of a bill of goods for a flat-plate hot water system were determined using an input/output and the total compared with direct labor requirements. The indirect labor requirements were between 97 and 106 man-hours, compared with direct requirements of 40 to 60 man-hours, giving a ratio of indirect to direct of 1.6 to 2.6. A ratio of 2.0 was chosen as a reasonable average. Independent input/output estimates were provided by BLS and Bob Herendeen of the Center for Advanced Calculation at the University of Illinois.

Passive Solar. Due to the multitude of techniques that can be classified as passive solar technologies, it is difficult to identify labor requirements that can be directly attributed to installation of passive solar systems. Following are estimates calculated from costs obtained from various sources:

Range of costs = \$1500 - 3000 (1976 dollars)

Average = \$2500

Possible

Energy Savings = 60% of total demand of about 80 MMBTU/year
= \$48 MMBTU (actual)

Assuming that 40% of the cost is due to direct labor 1/ and 60% due to materials and based on average value of \$2500:

Direct Labor cost (40%) = \$21/MMBTU (actual)

Direct Labor = 1.7 man-hours/MMBTU (actual)
at \$12.50 per man-hours 2/
= 0.567 man-hour/MMBTU (displaced)

Indirect Labor (60%) = \$31.3/MMBTU (actual)
= 2.6 man-hours/MMBTU (actual) at 0.08392 man-hours/dollar indirect labor cost 1/
= 0.867 man-hours/MMBTU (displaced)

The range of values obtained is shown in Table 3.

1/ This assumption conforms to the general pattern of flat-plate systems. However, the direct/indirect ratio tends to be slightly higher in the case of passive solar. This is because passive employs different (rather than additional) materials than those employed in conventional construction.

2/ Labor rate assumed by Mitre and approximate mean value Bechtels assumed in their supply model.

Table 3

UNIT LABOR REQUIREMENTS
(On displaced energy basis)

Technology	Direct Labor			Indirect Labor		
	Man-Hour/MMBTU-Year			Man-Hour/MMBTU-Year		
	Low	Mid	High	Low	Mid	High
Solar hot water,	0.667	0.933	1.233	1.334	1.866	2.466
Solar heating	1.167	1.433	1.667	2.334	2.866	3.334
Solar Cooling	1.433	1.667	2.333	2.866	3.334	4.666
Solar Aggregated Hot water, heating and cooling	1.033	1.300	1.567	2.067	2.600	3.133
Solar Electric	0.695	0.726	0.774	1.870	1.960	2.010
Photovoltaic	0.810	1.410	2.110	1.280	2.220	3.310
Wind	0.204	0.259	0.355	0.890	1.230	1.560
Solar A/IPH	0.187	0.324	0.670	0.530	0.563	1.333
Biomass Process Heat	0.035	0.045	0.064	0.055	0.072	0.107
Biomass-Syn-Fuels	0.033	0.067	0.135	0.052	0.105	0.213
Biomass-Electric	0.209	0.250	0.292	0.670	0.867	1.120
Passive Solar	0.283	0.567	0.800	0.467	0.933	1.169
OTEC	0.445	0.667	0.874	0.898	1.134	1.676
Hydroelectric ^a		0.234			0.414	

^aBechtel Estimate

Wind Energy Conversion System (WECS). The labor requirements for WECS were computed from data presented by Mitre in Systems Description and Engineering Costs of Solar Related Technologies Volume 1, 1977. The relevant tables used are appended as Tables A1, A2, A3, A4 and A5 in Attachment A.

Man-years was converted to man-hours on a 1900 man-hours/man-year 1/ basis. Note that direct labor estimates do not include labor for purchased components.

Indirect labor estimates were obtained as follows:

Direct labor cost = direct labor (man-hour) * \$12.50/man-hour (1976 wage rates)

Material cost = (total cost - direct labor cost)

Indirect labor = 0.08392 x material costs.

Total energy output = rated capacity x capacity factor x 8760 Kwh/yr
where 8760 is the number of hours in one year.

Total energy output = Kwh x $10,400 \times 10^{-6}$ MMBTU (displaced) per year
year

Labor per MMBTU (displaced) = total labor/total MMBTU (displaced).

Direct and indirect labor estimates were obtained for each generic WECS system and low, intermediate and high ranges were obtained from this estimate. The labor estimates for each system are shown in Table 4; the ranges used in the computations are shown in Table 3.

Solar Process Heat. Solar process heat technologies selected for this analysis and their component costs are shown in Tables A6, A7, A8 and A9 in Attachment A. They are Mitre estimates presented in "System Description and Engineering Costs for Solar-Related Technologies, Volume III."

1/See U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985. Bulletin 1831, Table 9, p. 18 for man-hours per man-year estimates.

TABLE 4

SUMMARY OF LABOR REQUIREMENTS FOR SOLAR TECHNOLOGIES

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Direct Labor: Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
1	Solar Thermal Central Receiver, 3 hour storage	Semi Peak	100	0.35	0.013	0.774	31.93	22.26	1.87
1	Solar Thermal Central Receiver, 6 hour storage	Semi Peak	100	0.50	0.017	0.708	32.69	23.84	2.00
1	Solar Thermal Central Receiver	Fuel Saver	100	0.30	0.010	0.695	32.69	24.00	2.01
1	PV with Storage Collector/Reflector 16% Si	Semi Peak	100	0.30	0.025	1.418	44.33	26.57	2.23
1	PV with Storage Collector/Reflector 10% Thin Film	Semi Peak	100	0.30	0.041	1.110	34.82	20.85	1.75
1	PV with Storage Collector/Reflector/16% silicon	Intermed.	100	0.45	0.04	1.540	48.20	28.96	2.43
1	PV with Storage Collector/Reflector/10% Thin Film	Intermed.	100	0.45	0.067	1.230	38.56	23.12	1.94
1	PV with Storage 10X Concentrating/Verticle Tracking	Intermed.	100	0.45	0.045	2.110	65.86	39.44	3.31
1	PV Collector/Reflector/16% Silicon	Fuel Saver	100	0.28	0.017	1.070	33.43	20.02	1.68
1	PV Collector/Reflector/10% Thin Film	Fuel Saver	100	0.26	0.027	0.810	25.46	15.25	1.28
1	PV 10XCPC/16% Silicon	Fuel Saver	100	0.30	0.035	2.020	63.17	37.89	3.18

Table 4 (continued)

rce	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
	WECS with Hydroelectric hybrid	Intermed.	100	0.48 18 mph	0.0054*	0.235	17.96	15.02	1.26
	Advance WECS with gas turbine	Intermed.	100	0.49 14 mph	0.0050*	0.226	21.08	18.26	1.53
	Advanced WECS with combined cycle	Baseload	100	0.87 18mph	0.0085*	0.204	13.58	11.03	0.93
	WECS	Fuel Sav.	1.5 (22.4 mph)	0.30	0.0051*	0.355	23.02	18.58	1.56
	Advanced WECS	Fuel Sav.	1.5 (17.1 mph)	0.65	0.0085	0.273	14.04	10.63	0.89
	Wood Fired Steam Plant	Intermed.	100	0.50	0.007	0.292	17.05	13.25	1.12
	Wood Fired Steam Plant	Baseload	100	0.80	0.008	0.209	10.65	8.04	0.67
	Solar Heated Textile Processing Water		68,750 MMBTU			0.330	8.73	9.00	0.50
	50-100°F Hot air grain Dryer		70,200 MMBTU			0.219	9.85	7.11	0.59
	50-100°F Hot water can washing system		38,250 MMBTU			0.187	9.22	6.88	0.57

Table 4 (continued)

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
b	100-150°F hot air plastic curing	29,565 MMBTU				0.670	26.48	15.89	1.33
c	Hydroelectric dam, and power plant	Baseload	0.981 x 10 ⁹ KWH			0.234	8.46	4.93	0.414
d	OTEC 1 plant	Baseload	264.5	0.61		0.874			1.676
d	OTEC 4 plants	Baseload		0.61		0.667			1.134
d	OTEC 7 plants	Baseload	264.5	0.61		0.445			0.898
e	Biomass-Methanol		3.82 x 10 ⁶ MMBTU			0.135	4.23		0.213
e	Biomass-Medium Btu gas		6.34 x 10 ⁶ MMBTU			0.033	1.03	0.62	0.052
e	Biomass-Substitute Natural gas		5.58 x 10 ⁶ MMBTU			0.066	2.09	1.25	0.105
e	Biomass-Process Heat 850 ton/day	Steam	3.86 x 10 ⁶ MMBTU			0.064	2.01	1.20	0.101
	1700 ton/day	Steam	8.40 x 10 ⁶ MMBTU			0.045	1.43	0.88	0.072
	3400 ton/day	Steam	17.64 x 10 ⁶ MMBTU			0.035	1.09	0.66	0.055

Table 4 (continued)

Source: Unit labor estimates computed from data presented in:

- a - Systems Description and Engineering Costs for Solar-Related Technologies, Volume I, Summary. The Mitre Corporation, Metrek Division, June 1977.
- b - Systems Description and Engineering Costs for Solar-Related Technologies, Volume III, Agricultural and Industrial Process Heat. The MITRE Corporation, Metrek Division, June 1977.
- c - Escalation in the Costs of Manpower, Materials, and Equipment Needed for Energy Facilities, the Bechtel Corporation, October 1977. Resource Requirements, Impacts, and Potential Constraints Associated with various energy futures. Bechtel National, Inc., March 1978.
- d - Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII, Ocean Thermal Energy Conversion. The MITRE Corporation, Metrek Division, June 1977.
- e - Systems Description and Engineering Costs for Solar Related Technologies, Volume IX, Biomass Fuels Production and Conversion System, The MITRE Corporation, Metrek Division, June 1977.

As before, direct labor was allocated 40% of total cost and costed at \$12.50 per man-hour. Indirect labor was costed at 0.08392 man-hours/dollar and all estimates were converted to displaced energy basis. Labor estimates for each technology are shown in Table 4 and the range of values used in the analysis are shown in Table 3.

Solar Thermal Electric. Systems evaluated are described in Tables A10, A11, A12 ^{1/}. Direct and indirect labor requirements per MMBTU displaced were calculated as in WECS. The estimates are shown in Table 4 and range of values used in the analysis is shown in Table 3.

Photovoltaics. Systems considered were large central stations providing semi-peak, intermediate and fuel saver demand types. Costs are based on the availability of photovoltaic arrays at \$500/Kw peak. Tables A13 to A20 (see Attachment A) obtained from Mitre, Volume 1, shows the capital costs and expected energy output for each technology.

As in solar process heat, direct labor costs were allocated 40% of the capital costs, indirect labor costs were calculated as in WECS. Table 4 shows the labor costs for each unit and Table 3 shows the range selected for the necessary labor impact computations.

Biomass. Technology characterization tables for wood fired electricity generation, for biomass synthetic fuels production, and biomass process heat generation systems are shown in Tables A21 to A26. Biomass Process Heat Systems are assumed to be similar to electricity production systems without the electricity generating equipment. Note that costs do not include

^{1/} Mitre, Volume 1, op cit.

silvaculture. Direct and indirect labor costs are calculated as shown in WECS. They are presented in Tables 4 and 3.

Ocean Thermal Energy Conversion (OTEC). Capital costs and labor estimates are obtained from "Mitre Corporation, System Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII." Based upon cost reductions due to experience, capital and labor costs are shown in Table A27 in Attachment A. Calculations of direct and indirect labor costs follow the methodology used in WECS. Range of values is obtained by using capital and labor costs corresponding to 1, 4, and 7 production units and a capacity factor of 0.61 as estimated by Mitre. The estimated labor requirements are shown in Tables 4 and 3.

Hydroelectric Power Generation. Costs and labor requirements for this technology are estimated using data presented by Bechtel (op cit). It is based on a system with a total output of 0.981×10^9 Kwh (actual) (10.2×10^6 MMBTU displaced). Total direct labor costs are shown below:

Direct Labor Costs

Labor Type	Total Cost (Millions of 1977 Dollars)	Labor Rate (\$/man-hour)
Technical	7.758	14.37
Non-Technical	0.465	8.45
Manual	27.747	15.50

$$\begin{aligned}
 \text{Total Labor required per plant} &= \left(\frac{7.758}{14.37} + \frac{0.465}{8.45} + \frac{27.747}{15.50} \right) \times 10^6 \text{ man-hour} \\
 &= 2.385 \times 10^6 \text{ man-hours/plant} \\
 &= 0.234 \text{ man-hours/MMBTU (displaced)}
 \end{aligned}$$

Material and Equipment Cost = 50.351×10^6 plant

Indirect Labor 0.08392/
dollar

= 4.225×10^6 plant

= 0.436 man-hours/MMBTU (displaced)

2. Summary of Labor Requirements For Three Cases

Using the displaced energy quads estimates obtained from scenario analysis and the unit energy requirements for solar technologies in Table 3, total labor requirements are easily computed by multiplication. The employment impacts of each solar case are described in greater detail below.

Base Case. Table 5 presents the cumulative mid-range estimates of total labor demanded for the various solar technologies required to achieve the energy output levels (measured as quads of conventional fuels displaced) specified by the Base Case scenarios. Note that no attempt has been made to incorporate economies of scale into the final computations. Therefore one can assume that the labor estimates obtained would be closer to an upper bound, rather than to a mean or median value.

Table 5 indicates that a mid-range estimate of cumulative labor requirements for solar range from about 1.9 million man-years for the \$18/bbl. Base Case to 6.2 million for the \$32/bbl. case. In the lower price case, flat plate systems for residential and commercial hot water, heat and cooling are the dominant source of labor demand, accounting for over 50 percent; the next is wind and hydro (which includes pumped storage requirements), with about one seventh each. Together they account for over 4/5 of all labor requirements over the period. As oil prices rise, other technologies become more important; in the high price case, flat plate applications account for only about two-fifth of total requirements and hydro another 6 percent. Biomass electric, solar process heat, and wind each account for about 10 percent

TABLE 5

Direct and Indirect Labor Requirements: Cumulative and Year 2000
for the Base Case Scenarios - Mid-range Coefficient Estimates
(in Millions of Man-Years)

	(Quads) (Added)	<u>Low Price \$18/bbl Case</u> <u>Cumulative M-Y (1978-2000)</u>		
		<u>Direct</u>	<u>Indirect</u>	<u>Total</u>
Water Heat, Cooling	0.5	.342	.684	1.026
Geothermal Solar	0.1	.030	.049	.079
	0.3	.041	.194	.235
Geothermal Heat	0.2	.034	.059	.093
Geothermal Syn-Fuels	0.1	.003	.006	.009
Geothermal Process Heat	0.2	.005	.008	.013
Geothermal Electric	0.1	.026	.094	.120
Geothermal Syn-Fuels	0.2	.007	.011	.018
	0.3	.176	.083	.259
TOTAL =		.664	1.188	1.852

<u>Mid-Price Case \$25/ bbl.</u>				
Water Heat, Cooling	1.0	.684	1.368	2.052
Geothermal	0.2	.060	.098	.158
	0.6	.082	.388	.470
Thermal Electric	0.1	.038	.103	.141
Geothermal voltaic	0.1	.074	.117	.191
Geothermal Process Heat	1.0	.170	.295	.465
Geothermal Fuel Cells	0.2	.006	.012	.018
Geothermal Process Heat	0.5	.018	.028	.046
Geothermal Electric	0.2	.052	.188	.240
Geothermal Syn-Fuels	0.4	.015	.023	.036
	0.8	.198	.111	.309
TOTAL =		1.397	2.731	4.128

<u>High-Price Case: \$32/ bbl.</u>				
Water, Heat, Cooling	1.3	.890	1.778	2.668
Geothermal	0.3	.090	.148	.237
	0.9	.123	.582	.705
Thermal	0.2	.076	.206	.282
Geothermal voltaic	0.2	.148	.234	.382
Geothermal Heat	1.4	.238	.413	.651
Geothermal Cells	0.4	.012	.026	.036
Geothermal Process Heat	1.0	.026	.040	.066
Geothermal Electric	0.6	.156	.564	.720
Geothermal Syn-Fuels	0.6	.022	.034	.054
	0.5	.220	.139	.359

Earlier in the text, the estimates in Table 5 were described as being "mid-range" estimates. The estimates should be considered to have a range of about 28% on the low side and 22% on the high side -- on average, about 25% on either side of the range. Table 6 presents cumulative demands incorporating high and low range estimates. There are many sources of error. In the case of flat plate applications, on which there are numerous of engineering studies and various studies directed at the determination of actual labor demands, the different studies present a fairly wide range of estimates of the direct labor demands per square foot of collector. There is some uncertainty as to the actual Btu output per square foot of collector space as well. Other sources of uncertainty regarding the direct labor requirements are the unknown nature of learning curve effects and other factors affecting the productivity of the production and installation and the fact that some sources of labor demand may have been overlooked in the sources which formed the basis for these estimates. Postulated learning curves are embodied where needed to make the technology competitive. In addition, because experience with these units is limited (to say the least), the operation and maintenance requirements are unknown. For the other technologies which are presently in the design or pilot testing stage, the uncertainties must be regarded as even greater; technological or managerial breakthroughs may be on the horizon for some -- and are necessary for some if the application is to become commercially viable at all.

Sensitivity Analysis for Cumulative Labor Requirements to 2000, Base Case

Solar Technology	Additional Quads Displaced in 2000	Direct Labor Requirements			Indirect Labor Requirements			Total Labor Requirements		
		Man-Years (10 ⁶)			Man-Years (10 ⁶)			Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Low Price Scenario \$18/bbl										
Solar Hot Water, Heat, Cooling	0.5	0.272	0.342	0.412	0.544	0.684	0.825	0.816	1.026	1.237
Passive Solar	0.1	0.015	0.030	0.042	0.025	0.049	0.061	0.040	0.079	0.103
Wind	0.3	0.032	0.041	0.056	0.141	0.194	0.246	0.173	0.235	0.302
Solar Process Heat	0.2	0.020	0.034	0.071	0.053	0.059	0.140	0.073	0.093	0.211
Solar Syn-Fuels	0.1	0.002	0.003	0.007	0.003	0.006	0.011	0.005	0.009	0.019
Biomass Process Heat	0.2	0.004	0.005	0.007	0.006	0.008	0.011	0.010	0.13	0.027
Biomass Electric	0.1	0.022	0.026	0.031	0.071	0.094	0.118	0.093	0.120	0.149
Biomass Syn-Fuels	0.2	0.003	0.007	0.014	0.006	0.011	0.022	0.009	0.018	0.036
TOTAL	1.6	0.370	0.488	0.640	0.849	1.105	1.434	0.219	1.593	2.075
Mid Price Scenario \$25/bbl										
Solar Hot Water, Heat, Cooling	1.0	0.544	0.684	0.824	1.038	1.368	1.650	1.632	2.052	2.474
Passive Solar	0.2	0.030	0.060	0.084	0.050	0.098	0.122	0.080	0.158	0.206
Wind	0.6	0.064	0.082	0.112	0.282	0.388	0.492	0.346	0.470	0.604
Solar Thermal Electric	0.1	0.037	0.038	0.041	0.098	0.103	0.106	0.135	0.141	0.147
Photovoltaic	0.1	0.043	0.074	0.111	0.098	0.117	0.174	0.141	0.191	0.285
Solar Process Heat	1.0	0.100	0.170	0.355	0.265	0.295	0.700	0.365	0.465	1.055
Solar Syn-Fuels	0.2	0.004	0.006	0.014	0.006	0.012	0.022	0.010	0.018	0.038
Biomass Process Heat	0.5	0.014	0.018	0.025	0.021	0.028	0.039	0.035	0.046	0.064
Biomass Electric	0.2	0.044	0.052	0.062	0.142	0.188	0.236	0.186	0.240	0.298
Biomass Syn-Fuels	0.3	0.007	0.015	0.028	0.012	0.023	0.044	0.019	0.036	0.072
TOTAL	4.5	0.281	1.190	1.053	2.053	2.606	2.563	2.836	2.796	2.205
High Price Scenario \$32/bbl										
Solar Hot Water, Heat, Cooling	1.3	0.707	0.890	1.071	1.414	1.778	2.145	2.122	2.668	3.216
Passive Solar	0.3	0.045	0.090	0.126	0.375	0.147	0.183	0.120	0.237	0.309
Wind	0.9	0.096	0.123	0.168	0.423	0.582	0.738	0.519	0.705	0.906
Solar Thermal Electric	0.2	0.074	0.076	0.082	0.196	0.206	0.212	0.270	0.282	0.294
Photovoltaic	0.2	0.086	0.148	0.222	0.196	0.234	0.348	0.282	0.382	0.570
Solar Process Heat	1.4	0.14	0.238	0.491	0.371	0.413	0.98	0.511	0.651	1.477
Solar Syn-Fuels	0.4	0.008	0.012	0.028	0.012	0.024	0.044	0.020	0.036	0.072
Biomass Process Heat	1.0	0.020	0.026	0.036	0.030	0.040	0.056	0.050	0.066	0.092
Biomass Electric	0.6	0.132	0.156	0.186	0.426	0.564	0.708	0.558	0.720	0.894
Biomass Syn-Fuels	0.6	0.010	0.022	0.042	0.018	0.034	0.066	0.028	0.054	0.108
TOTAL	6.9	1.318	1.780	2.450	3.161	4.022	3.480	4.479	5.001	7.938

NOTE: Hydro is not included because no range estimates or coefficients are available.

Maximum Practical and Technical Limits Cases. Table 7 presents cumulative estimates of the labor required for solar technologies in the two high penetration cases. The Maximum Practical Case represents about a two-thirds increase over the high-oil-price variant of the Base Case. The Technical Limits Case implies that labor requirements for solar will more than triple from even the high-price Base Case. The figures here, as in the Base Case, do not incorporate potential economies of scale. Note, also that the labor requirements are gross; they do not take account of the conventional labor offset due to the expansion of solar. Estimates of net total employment effects are developed below.

TABLE 7

Cumulative Direct and Indirect Labor Requirements to 2000 for the Maximum
and Technical Limits Cases

Solar Technology	Quads Displaced in 2000	Direct Labor Requirements Man-Years (10 ⁶)			Indirect Labor Requirements Man-Years (10 ⁶)			Total Labor Requirements Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Maximum Practical Case										
Solar Hot Water, Heat, Cooling	2.0	1.088	1.368	1.648	2.176	2.736	3.300	3.264	4.104	4.948
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.490	0.610	0.400	0.790	1.030
Wind	1.5	0.160	0.205	0.280	0.705	0.970	1.230	0.865	1.175	1.510
Solar Process Heat	2.0	0.200	0.340	0.710	0.530	0.590	1.400	0.730	0.930	2.110
Solar Thermal Electric	0.5	0.185	0.190	0.205	0.490	0.515	0.530	0.675	0.705	0.735
Photovoltaics	1.5	0.645	1.110	1.665	1.470	1.755	2.610	2.115	2.865	4.275
Biomass	4.5	0.090	0.117	0.162	.035	0.180	0.252	0.225	0.297	0.414
OTEC	0.1	0.023	0.035	0.046	0.047	0.060	0.088	0.070	0.095	0.134
Hydro	0.5		0.059			0.109			0.168	
TOTAL	13.6		1.724			7.405			11.129	
Technical Limits Case										
Solar Hot Water, Heat, Cooling	4.0	2.176	2.736	3.296	4.352	5.472	6.000	6.528	8.208	9.896
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.400	0.010	0.400	0.790	1.030
Wind	3.0	0.320	0.410	0.560	0.410	1.940	2.460	1.730	2.350	3.020
Solar Process Heat	3.5	0.350	0.595	1.243	0.928	1.033	2.450	1.278	1.628	1.693
Solar Thermal Electric	1.5	0.555	0.570	0.615	1.470	1.545	1.590	2.025	2.115	2.205
Photovoltaic	2.5	1.075	1.850	2.775	2.450	2.925	6.350	3.525	4.775	7.125
Biomass	5.2	.104	.135	.187	.156	.208	.291	.260	.343	.478
OTEC	1.0	0.230	0.350	0.460	0.470	0.600	0.830	0.700	0.950	1.340
Hydro	2.0		0.236			0.436			0.672	
TOTAL	28.5		7.182			14.649			21.831	

Total Net Labor Requirements. Total energy sector demands, including the conventional, are necessary to present a comparison of the estimated total labor requirements over 22 years for the Base Maximum Practical and Technical Limit case assuming an oil price of \$25/barrel. As indicated in the table, total employment in the energy sector for the Maximum Practical case is 6 percent higher than for the Base Case. For the Technical Limits case, total employment is 16 percent higher than in the Base Case. Because these estimates do not incorporate economies of scale (i.e.; they assume that labor input remains constant, even as prices decrease over time), the employment figures in Table 8 for solar should be regarded as an upper bound.

The estimates in Table 8 represent net jobs created; that is, they take account of the conventional energy jobs displaced by an increased use of solar energy. Net figures were computed by scaling down conventional labor requirements (as given in the Bechtel run) for each Base Case scenario in proportion to the reduction in quads assumed in each of the accelerated cases. For example, in the Maximum Practical Case, nuclear is assumed to be reduced from 15 to 12.1 quads. Thus, labor was reduced by 19 percent 1/, except in the area of transmission and distribution of electricity (where no reductions were taken).

1/ $0.19 = 1 - \frac{12.1}{15} \text{ quads}$

TABLE 8

Net Cumulative Labor Requirements (Direct and Indirect)
For Total Energy Produced, 1978-2000 (Man-Years in Thousands)

	<u>Base</u> (\$25/bbl)	<u>Maximum Practical</u> (\$25/bbl)	<u>Physical Limits</u> (\$25/bbl)
Solar <u>a/</u>	4,128	11,129 <u>b/</u>	21,831 <u>b/</u>
Conventional	<u>55,677</u>	<u>52,210</u>	<u>47,501</u>
TOTAL	59,805	63,339	69,332
<u>Net Change c/</u>	--	+3,534	+9,527

a/ From Table 1

b/ From Table 3

c/ From Base Case

This method slightly overestimates conventional components for the construction components, where an estimate based on incremental quads would have been more accurate. However, it provides a very reasonable approximation to the reduction in operation and maintenance labor requirements. As discussed in part 2, the implementation of solar is not expected to reduce labor requirements for transmission and distribution.

Using similar methodology, we also estimated year-2000 energy sector demands. Estimates of labor requirements in a given year are particularly relevant for assessing such labor impacts as training demands, identification of possible bottlenecks, and impacts on the overall unemployment rate. An analysis of this kind requires information on the expected dates and rates of market penetration of the solar technologies. Since explicit implementation

paths have not been specified for the solar cases, we assume here two alternative growth curves for solar implementation. The first is an exponential growth curve which implies that 19 percent of all solar capacity for the solar applications is added in the year 2000. Although this is a relatively large amount, it is dictated by the negligible size of their output at present. This set of estimates should be regarded as an upper limit. The second growth path is S-shaped and implies that 7 percent of all solar capacity is added in the year 2000. The set of estimates based on this growth curve provides a lower bound. Table 9 presents the estimates for direct and indirect labor requirements in the energy sector under the two sets of growth assumptions.

As indicated in Table 9, labor demands rise significantly in the accelerated solar cases. Estimating solar demand as 19 percent of cumulative -- an upper bound estimate, as noted earlier -- total energy sector demands rise by about 1 million man-years for the Maximum Practical Case and 2.7 million man-years for the Technical Limits Case, assuming \$25/bbl energy costs. The lower bound estimates indicate an increase of about 200 thousand man-years for the Maximum Practical Case and 427 thousand man-years for the Technical Limits Case. These comparisons are summarized in Table 10 below.

Table 9

Total Energy Sector Requirements in Year - 2000
(Thousands of Man-Years)

Upper Bound 19% of Cumulative										Lower Bound 7% of Cumulative								
Base Case:	\$18/bbl			\$25/bbl			\$32/bbl			\$18/bbl			\$25/bbl			\$32/bbl		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Conventional	1770	700	2470	2113	883	2996	2206	830	3030	1770	700	2470	2113	883	2996	2206	830	3030
Solar	103	206	309	249	525	784	350	820	1170	38	76	114	92	194	290	130	303	433
Total	1873	906	2779	2352	1308	3780	2556	1650	4200	1808	776	2584	2205	1077	3286	2336	1133	3463

Accelerated Solar Cases:

	Maximum Practical (\$25/bbl)		
	Direct	Indirect	Total
Conventional	1911	787	2698
Solar	708	1407	2115
Total	2619	2194	4813

	Technical Limits (\$25/bbl)		
	Direct	Indirect	Total
Conventional	1677	678	2355
Solar	1365	2783	4148
Total	3042	3461	6503

	Maximum Practical (\$25/bbl)		
	Direct	Indirect	Total
Conventional	1911	787	2698
Solar	262	521	783
Total	2173	1308	3481

	Technical Limits (\$25/bbl)		
	Direct	Indirect	Total
Conventional	1677	678	2355
Solar	505	1030	1535
Total	2182	1708	3890

Sources: Conventional: estimated from Bechtel computer run for DPR.
Accelerated solar cases estimated as described for cumulative labor requirements to allow for reduction in quads supplied.
Solar: Table 5 for base case demands; accelerated cases are 19% and 7% of cumulative labor requirements shown in Table 8.

TABLE 10

Total Energy Sector Labor Requirements in
Year-2000: Accelerated Cases Relative to
Base Case (\$25/bbl)

(in Thousands of Man Years)

	<u>Upper-Bound</u> <u>19% of Cumulative</u>	<u>Lower-Bound</u> <u>7% of Cumulative</u>
Maximum Practical	+1033	+195
Technical Limits	+2723	+427

It is useful to relate the differential employment impacts of the alternative solar strategies to overall unemployment levels. According to one estimate, based on BLS census projections of population and participation rates, the total labor force in year-2000 will be about 132 million man-years, with unemployment at an estimated 7 million man-years. ^{1/} The additional net jobs created in the Maximum Practical Case would reduce the number of unemployed persons by 3 to 15 percent depending on the implementation path of solar applications, or, put another way, it would reduce the unemployment rate by 0.1 to 0.7 percent. The employment impact of the Technical Limits case is over twice as great: Implementation of this strategy would reduce the number of unemployed by 6 to 39 percent, and reduce the unemployment rate by 0.3 to 2 percent. To the extent that the accelerated solar strategies promote economic growth by freeing up capital to be invested

^{1/} Total labor force participation was estimated using the BLS census projections of population and participation rates (by major age and sex categories) for the year 1990 (data for year-2000 is unavailable). The BLS 1974 unemployment rates were applied to each major age/sex category in order to estimate total unemployment. Each employed person is assumed to equal one man-year.

in other sectors of the economy) or increase participation rates (via a targeting program to the underemployed), the employment impacts will be even greater.

To put these estimates in perspective; we compared them to the number of jobs created by two major federal employment programs. For example, the Department of Commerce's Local Public Works Program, authorized under the Public Works Employment Act of 1976, created 82,000 (direct and indirect) jobs in FY 1978. This figure is considerable lower than the lower bound estimates for energy job creation in Table 10. The Public Service Program, authorized under CETA, employed 725,000 persons in FY 1978. Although this figure is within the relevant range in Table 10, it is towards the lower bound estimates for the Technical Limits Case.

These results clearly indicate that, over the period from 1978 to 2000, the accelerated solar strategies will have a positive impact on employment relative to the Base Case. In terms of their employment impacts, these strategies compare favorably with federal public service and public works programs. It is important to note, however, that the impact of these strategies on unemployment in any one year depends on their rate of implementation over the period.

B. Qualitative Impacts

In addition to the quantitative impact, the qualitative impact of solar energy development on labor should be considered. A comprehensive employment impact analysis would examine the occupational demand and potential bottlenecks arising from solar implementation, the time and geographic

distribution of the jobs created, the stability of the demand for labor, and the impact on the work-place environment and occupational safety.

Although we do not have enough data to make a complete assessment of occupational demands, some indications are possible based on the information available on flat plate requirements. According to the Navarro College study done by Orsek, et al, the direct requirements for flat plate solar installations put heavy emphasis on three occupational categories: The first category is "solar technician", comprising such post-high school skills as determining heating loads, placing collectors, general system design, etc. This skill accounts for about 20 percent of solar direct demands. The other two categories are plumbers in the case of liquid systems and sheet metal workers in the case of air-type systems. For each system, this specialty accounts for about 55% of total direct labor hours required. For the latter two categories, the Navarro college findings are roughly confirmed by Bechtel estimates as reported through work done by the Center for Advanced Computation of the University of Illinois, where plumbers represent about 40-45 percent of solar liquid space heat and space air conditioning requirements for the design and construction phase.

Table 11 indicates the numbers and rates of growth from present supplies required to meet the solar labor demands for the year 2000, and how these compare (where data are available) to recent growth in the occupation. The breakdown between sheet metal workers and plumbers assumes that three quarters of flat plate applications will be liquid systems and the remainder will be air systems.

According to these estimates, there does not seem to be an appreciable problem on the horizon for any of the specialities identified arising from flat plate solar applications alone. For plumbers and sheet metal workers, the annual rates of growth are within the annual growth rates experienced over the last six years. For sheet metal workers, demands have actually shrunk somewhat over 1970-76, so there is undoubtedly a reservoir of unused manpower from which to draw (the BLS does project a substantial growth of demand for this category of worker between 1976 and 1985, however). It should be borne in mind that plumbers are an apprenticed trade and the training time for a journeyman plumber is about four years. Generalizations about solar technicians are more hazardous; like some of the exotic solar technologies, there is little experience upon which to draw. The Navarro study estimates that training for this specialty would take about two years.

TABLE 11

Range of Occupational Demands - \$25 Case; 2000 = 19%
of Cumulative Labor Requirements (Flat Plate Tech only)
Numbers in Thousands of Man-Years, except percents

<u>2000 = 19% of Cum.</u>				
Base Case (\$25/bbl Case)	Cumulative Demand (000)	# in 2000	Avg. ann. Growth 1970-76	% Growth
Plumbers	316	60	2.5	0.6
Sheet Metal	105	20	.83	0.5
Solar Tech.	153		1.33	NA
<u>Maximum Practical \$25 Case</u>				
Plumbers	564	107	4.5	1.0
Sheet Metal	188	36	1.2	0.9
Solar Tech.	274	52	2.2	NA
<u>Technical Limits \$25 Case</u>				
Plumbers	1129	215	9.0	1.8
Sheet Metal	376	71	3.0	1.7
Solar Tech.	547	104	4.3	NA

Assumptions: Mid-range coefficient estimates; Plumbers - 41.15% of direct labor requirements based on 55% of total for liquid systems & liquid system time are 3 of total Sheet Metal Workers 13.75% of total - 1/4 x.55 Solar Technician = 20% of total for all systems

As indicated in Table 12, the conventional energy sectors by themselves put only moderate demands on most occupational categories. (And, as already shown, these demands would be reduced somewhat if solar implementation exceeded base case levels). The energy sector employs a relatively small fraction of most occupational specialties; hence even when high rates of growth for an occupation are projected within the energy sector, this translates into a relatively small pressure on the economy as a whole. That is the picture shown by Table 12 taken relative to national occupational supplies. Even those occupations in highest demand within the conventional energy sector -- boiler-makers, mining engineers, and equipment operators -- need to grow at a rate of only 1 percent per year, well within their historical rates of growth. In the case of mining engineers, the absolute number needed is rather small and well within the capability of existing colleges (and could be met by less than five years graduating classes at 1975 rate).

To all these optimistic notes, however, must be added the caveat that other sectors of the economy -- where most occupations will be employed -- may at times be at high levels of activity, so that there are few surplus workers to supply energy sector needs. In this case bottlenecks could occur, leading probably to rising wages until reduced demands and increased supplies can relieve them.

One possible area of concern is coal mining, where worries have been expressed both for the underground specialties and for the smaller number of miners needed to man the open pit mines to some of the more remote areas of

the west. On the whole, coal mine demands are expected to double between now and 2000 according to Bechtel projections for the Base Case. Years of declining coal demand (before 1975) and an agency workforce have shrunken some supplies. However, younger men are entering the mines in sufficient number (although spot shortages exist) and a recent examination of coal mine capacity by the General Accounting Office was optimistic that labor shortages would not pose a problem to meeting coal production targets. 1/ Improving working conditions, higher rates of pay, and better fringe benefits indicate that the necessary applicants will be found. There is general agreement that due to the increasing complexity of mining and health and safety requirements, increasing training, both at educational institutions and on-the-job, will be needed. 2/

1/ Comptroller General of the United States, U.S. Coal Development - Promises, Uncertainties (Report #B-151071, Sept. 22, 1977), esp. pp. 4.18-19.

2/ Ibid., 4.21-4.24.

TABLE 12

Base Case Occupational Requirements For Conventional
Energy Sector: Increases 1978-2000 for Selected Skills

<u>Category</u>	<u>in Thousands</u>	<u>Comment</u>
Nuclear Engrs.	.3	No growth avail. peak 1985
Elect Engrs.	7.4	*
Mining Engrs.	1.65	1% ann. growth implied
Mech Engrs.	5.2	*
Designers, Drafts	7.8	*
Supers-Mgrs	83	*
Plumbers	50	*
Welders	7	*
Electricians	56	*
Boilermakers	9	1% growth v. 2.1% 70-76
Iron wkrs.	6	*
Carpenter	14	*
Equip. Ops.	110	1% growth v. 1.6% 70-76
Linesmen	17	*
Team s	106	**
Mechanics	60	*
Other Technical	60	*
Machinists		*

*Required ann. growth rate to meet demand is less than 0.4% from the 1976 base for U.S. as a whole. ** Ann. growth required is 0.7% per year 1976-2000.

The occupational requirements for solar energy strategies is also important when considering the displacement of labor employed in conventional energy production. According to studies by the Office of Technology Assessment (OTA) and Critical Mass, about 25-30 percent of the work required to build and maintain a conventional electric systems is associated with providing fuel supply. 1/ For natural gas production and delivery, the percentage is even greater. 2/ Solar implementation will affect these jobs by displacing fuel consumption. Furthermore, to the extent that solar alternatives cut demand for peak generating capacity, they will also affect jobs in construction and O&M of generating equipment (about 40 percent of total work force). There is one job area, however, that solar is unlikely to affect: namely, transmission and distribution. Conventional energy backup -- and hence distribution and transmission facilities -- will be an economic necessity for solar space and water heating for the short- and medium-term. Hence, any solar alternative is unlikely to affect employment in this area, except in the extreme case when all or a very large fraction of local energy needs are met with solar.

These considerations highlight the importance of examining skill level "mixes" associated with solar in direct comparison with the jobs they may displace. Unfortunately, current employment impact analyses are sorely lacking in qualitative comparisons. Nonetheless, some general observations can be made, based on preliminary analysis in this area.

1/ See: Application of Solar Technology to Today's Energy Needs. Volume I. OTA. June 1977, pp. VII - 27 to VII - 29; Manpower Requirements For Coal And Nuclear Power Plants Skip Laitner, Critical Mass.

2/ See: Project Independence Task Force Labor Report. FEA, Nov. 1974, pp. 73-97.

1. Solar and Space Heating

Most of the employment directly created by expanding solar water and space heating will be in the installation of the equipment by conventional building trades, and in the creation of new manufacturing industries. According to the OTA analysis, Application of Solar Technology to Today's Energy Needs (1977), the skills required for installation of the equipment will be very similar to those required for conventional construction projects, although some brief training programs will undoubtedly be needed. The work will be nearly identical to the installation of sophisticated air-conditioning and heating systems in conventional buildings. Specific tasks will mostly involve framing roofs, laying footings, plumbing collectors and storage tanks, excavating trenches and pits for pipe-runs and storage tanks, installing sheet metal ducting, insulating pipes and tanks, installing electronic control units, etc.

A jobs survey conducted by the California Public Policy Center also determined that, even with a "crash solar program", conventional backup systems would still be required for 20-30 percent of space and water heating requirements in California. 1/ Hence, solar installation jobs would be just an "add-on" to jobs installing conventional systems, and the labor displacement problems would be minimal. A study done for the Sheet-Metal Workers International Association by the Stanford Research Institute comes to similar conclusions. 2/

However, it is also true that small scale solar installations require a different "mix" of skill levels than conventional power. According to OTA,

1/ Jobs From the Sun: Employment Development in the California Solar Energy Industry California Public Policy Center. February, 1978 p. 22

2/ Cited in above; p. 22.

solar installations on individual buildings typically require one supervisor for each ten workmen, while the ratio for the conventional coal equipment shown in Table 13 is closer to 1 to 3. Hence, while small solar systems may enhance job opportunities for blue collar workers and for construction workers overall, higher level skill categories may be displaced in the implementation of solar energy alternatives.

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TABLE 13

**Skills Required for Constructing a Coal-Fired Electric Generating Plant and Operating the System
over a 30 Year Period ***

I. Skills Required for Plant Construction (as a percentage of the 3,774 man-years required to construct the plant and the transmission and distribution network)

	Coal-Fired Electric Generating Plant	Transmission and Distribution Facilities	Total
Non-manual construction work	10% (63% engineers & 25% supervisors)	12% (50% electrical engineers, 25% draftsmen and designers)	22%
Manual construction work	48% (variety of trades)	28% (40% electrical engineers, 30% draftsmen and designers)	76%
TOTAL CONSTRUCTION WORK	58%	42%	100%

II. Skills Required to Operate and Maintain Equipment for a 30 Year Interval (as a percentage of the 9,692 man-years required)

	Coal Mining and Coal Transport	Coal-Fired Generating Plant	Transmission and Distribution Facilities	Total
Non-manual operating work	15% (mostly trainmen)	8% (66% supervisors and managers)	4% (mostly supervisors working on distribution system)	27%
Manual operating work	32% (mostly miners)	19% (variety of trades)	23% (mostly electricians and meter readers for distribution system)	73%
TOTAL OPERATING EMPLOYMENT	47%	27%	27%	100%

Source: Based on data in "Manpower, Materials, and Capital Costs for Energy-Related Facilities," Bechtel Corporation, April 1976.

In: Application of Solar Technology to Today's Energy Needs, U.S. Congress, Office of Technology Assessment, (DRAFT) June 1977.

The larger industrial and community solar systems, on the otherhand, require much more professional work. They employ supervisors, managers, draftsman, designers and engineers in roughly the same proportions as these skills are required in the construction of conventional power-generating facilities. According to Table 13, these skill categories represent over 50 percent of total construction workers in a conventional plant. Since many large solar facilities are likely to be supplemental to conventional boilers and generators, it follows that the solar equipment would simply add work in these areas at each installation. Thus, solar heating systems in these larger installation could also provide work for manual construction workers in the building trades (about 48 percent of total construction job requirements).

Employment opportunities in the manufacturing of solar collectors and components are more difficult to define. This is because the pattern of growth in the industry is presently unpredictable. None of the studies we examined provided a detailed breakdown of manufacturing skill categories. From Table 14 we can generally conclude that solar heating systems provide about 3 to 4 times as many direct manufacturing jobs as conventional electric power for an equivalent amount of energy production. Without a more detailed comparison, however, this conclusion is tentative at best.

2. Photovoltaics (P/V)

Analysis of the qualitative -- as well as the quantitative -- employment impacts in this area is highly speculative, since the manufacturing process will be changing dramatically as a result of technical innovations and automation. About 30-50 percent of the manpower requirements for current, tracking silicon photovoltaic systems is associated with

collector and cell manufacture (see Table 14). Since P/V manufacturing currently involves a labor-intensive, handcrafted process, this proportion is expected to decrease with increased automation. Installation job requirements (currently 30-60 percent of total requirements) will probably involve the same types of skills required in conventional construction trades. Unfortunately information on the relative proportion of skilled versus unskilled labor is currently unavailable. It is reasonable to expect, however, that the larger P/V systems will require more professional work than smaller systems.

TABLE 14

A COMPARISON OF LABOR REQUIREMENTS FOR A CONVENTIONAL 800 MWe COAL PLANT AND TWO TYPES OF DISTRIBUTED SOLAR ENERGY SYSTEMS
(in person hours per megawatt year)

	<u>Construction</u>	<u>Operating & Maintenance</u>	<u>Total</u>
I. Conventional Electric Power System			
800 MWe coal plant	270	320	590
coal strip mine using western coal	20	370	390
coal transportation	20	150	170
electric transmission	30	1	51
electric distribution	140	540	680
turbine/generator manufacturing	170	0	170
TOTAL	<u>670</u>	<u>1,380</u>	<u>2,050</u>
II. Solar hot water heaters (8m² flat plate)			
--manufacture collector	900-1,800	0	900-1,800
--install collector	2,500	0	2,500
--routine O&M	-	700-1,400	700-1,400
TOTAL FOR HOT WATER SYSTEM	<u>3,400-4,300</u>	<u>700-1,400</u>	<u>4,100-5,700</u>
TOTAL FOR HOT WATER SYSTEM INCLUDING BACKUP	<u>3,740-4,640</u>	<u>-</u>	<u>4,440-6,040</u>
III. Tracking silicon photovoltaic system (50 m²)			
--manufacture collector and cells	3,000	-	3,000
--install collector	1,700-5,500	-	1,700-5,500
--operate system	-	1,200	1,200
TOTAL FOR TRACKING PHOTO-VOLTAIC SYSTEM	<u>4,700-8,500</u>	<u>1,200</u>	<u>5,900-9,700</u>
TOTAL FOR TRACKING PHOTO-VOLTAIC SYSTEM INCLUDING BACKUP	<u>5,040-8,840</u>	<u>-</u>	<u>6,240-10,040</u>

(TABLE 14, CONTINUED)

Assumptions: For Conventional System:

- 800 MWe coal plant operating at 75 per cent peak capacity for 30 years;
- western coal strip mine with 40 mile train line and 237 train roundtrips per year;
- all data based on Bechtel data with the exception of the turbine generator manufacture. It was assumed that the turbine/generator cost of \$150/KW of which 25 per cent was labor and that this labor was paid at an average rate of \$10/hr;
- calculations divide the sum of construction manpower and 30 year operating manpower requirements by the total number of megawatt years of energy produced by the plant.

For Solar System:

- 20 year system life;
- installation includes 75 feet of piping costing 0.12 MC/ft to install;
- flat plates installed for 1.3 MH/m² and tracking collector installed for 0.83-3.33 MH/m²;
- cells assumed to be 18 per cent efficient, optical efficiency 80 per cent.
- labor for providing backup power is assumed to be 50 per cent of the construction labor shown in Table 1 (e.g., 340 man-hours/MW-year).

Source: Application of Solar Technology to Today's Energy Needs
Volume I. OTA. June 1977, pp. VII-27-VII-29.

In addition to examining the level and variety of job skills created, employment impact analyses should also consider the timing, duration and geographic distribution of jobs created. An energy project that puts a lot of people to work today is preferable to labor than one that creates a few jobs each year over a long period, particularly during periods of high unemployment. Conventional plant construction as well as the widespread development of larger solar systems are preferred for this reason.

Furthermore, jobs that can be readily targeted to underemployed communities and regions will ease structural unemployment. In general, small-scale solar programs are the best candidates for this type of targeting -- both because of their relative size and low-skill requirements. Unfortunately, none of the studies examined even attempts to analyze these qualitative aspects in a comprehensive way. None considers a specific mix of solar technologies that could provide appropriate jobs for displaced workers of, for example, a nuclear plant. Hence, this analysis is limited by "the state of the art" to describing the national, cumulative demand for labor.

C. Conclusion

While a number of recent analysis have provided valuable insights, it can be safely asserted that the employment effects of alternative solar applications are not well known. In particular, current employment impact studies are sorely lacking in qualitative analysis, such as the occupational demand and potential bottlenecks arising from solar implementation, the mix of skills required for solar in direct comparison with those displaced in conventional energy, and the time and geographic distribution of the jobs created.

Nevertheless, it is possible at this time to make some tentative estimates of the employment impact of the three solar cases (Base, Maximum Practical and Technical Limits). Our analysis indicates that total cumulative employment in the Maximum Practical Case (63 million man-years) is 6 percent higher than for the Base Case (60 million man-years). For the Technical Limits Case, total employment (69 million man-years) is 16 percent higher than in the Base Case. These results represent net jobs created, that is, they take account of the conventional energy jobs displaced by an increased use of solar energy.

These results clearly indicate that, on a cumulative basis, the accelerated solar strategies will have a positive impact on employment, relative to the Base Case. The job impact of these strategies also compare favorably with federal public works and public service programs. It is important to note, however, that the employment impact in any one year depends on the implementation rate of solar applications over the period.

In addition to the cumulative number of jobs, the qualitative aspects of job creation were examined to the extent possible. Analysis of the demand for plumbers and sheet-metal workers for installing flat-plate collectors indicate there should be no particular bottlenecks in the Base Case. In the accelerated solar cases, however, there could be some shortages in these categories depending on the rates at which technologies grow and on the demand for these skills in other industries.

A preliminary examination of the skill levels associated with solar indicates that larger industrial and community solar systems require a mix of skills well suited to those in conventional energy production. Smaller

solar systems (e.g., for individual residential and commercial units), on the otherhand, are particularly appropriate to the needs and skills of those hardest hit by chronic unemployment.

Attachment A: Generic Solar System Configuration

Solar technologies, even those within a certain generic type (e.g., solar heating and cooling), take many forms. For example, the degree of complexity or mechanical configuration can vary among manufacturers, leading to various labor requirements for each unit. Therefore, for the analysis we have selected several technologies which we considered to be representative of each generic solar energy use. The selected technologies among the generic types were:

1. Solar Heating and Cooling

- a. Solar Hot Water. Single glaze liquid type collector with heat exchanger, storage, domestic hot water tank and controls.
- b. Solar Hot Water/Heating. Double glaze liquid type collector with two heat exchangers, storage, domestic hot water tank, space heat distribution system and controls.
- c. Solar Hot Water, Heating and Cooling. High performance collector with components similar to those shown in (b).

2. Passive Solar

This is basically modifications to houses to fully utilize solar energy, by adding insulation, south wall and roof modifications and storage systems.

3. Wind Energy Conversion System. The systems considered are large WECS systems for base and intermediate load power supply and smaller fuel saver units.

- a. WECS with hydroelectric hybrid - Intermediate demand type;

100MW capacity.

- b. WECS with gas turbine - Intermediate demand type;

100MW capacity.

- c. WECS with combined cycle - Base load demand type;

100MW capacity.

- d. WECS fuel saver; 1.5MW capacity.

4. Solar Process Heat

- a. Textile processing hot water - 68,750 MMBTU per year.

- b. Hot air grain dryer - 70,200 MMBTU per year.

- c. Hot water can washing system - 38,250 MMBTU per year.

- d. Hot air plastic curing system - 29,565 MMBTU per year.

5. Solar Thermal Electric

- a. Solar Thermal Central Receiver, 3-hour storage, semi-peak demand type, 100MW capacity.

- b. Solar Thermal Central Receiver, 6-hour storage, intermediate demand type, 100MW capacity.

- c. Solar Thermal Central Receiver, fuel saver demand type, 100MW capacity.

6. Photovoltaics (PV)

- a. PV with Storage Collector/Reflector/16% Si, semi-peak demand type, 100MW capacity.

- b. PV with Storage Collector/Reflector/10% Thin Film; semi-peak demand type; 100MW capacity.

- c. PV with Storage Collector/Reflector/16% silicon, intermediate demand type; 100MW capacity.

- d. PV with Storage Collector/Reflector/10% Thin Film;
intermediate demand type; 100MW capacity.
- e. PV with Storage 10X Concentrating/Verticle Tracking;
intermediate demand type; 100MW capacity.
- f. PV Collector/Reflector/16% Silicon; fuel saver demand
type; 100MW capacity.
- g. PV Collector/Reflector/10% Thin Film fuel saver; demand
type; 100MW capacity.
- h. PV 10XCPC/16% Silicon fuel saver; demand type; 100MW
capacity.

7. Biomass

- a. Wood Fired Steam Plant; intermediate demand type; 100MW
capacity.
- b. Wood Fired Steam Plant; baseload; demand type; 100MW
capacity.
- c. Biomass-Methanol; 3.82×10^6 MMBTU
- d. Biomass-Medium Btu gas; 6.34×10^6 MMBTU
- e. Biomass-Substitute Natural gas; 5.58×10^6 MMBTU
- f. Biomass-Process Heat, 850 ton/day input; steam;
 3.86×10^6 MMBTU
1700 ton/day input; steam; 8.40×10^6 MMBTU.
3400 ton/day input; steam; 17.64×10^6 MMBTU.

8. Ocean Thermal Energy Conversion Systems

- a. OTEC 1 plant production; baseload demand type; 264.5 MW
capacity.
- b. OTEC 4 plants production; baseload demand type; 264.5 MW

- c. OTEC 7 plants production; baseload demand type;
264.5MW capacity.

9. Hydroelectric Power Generation

Hydroelectric dam, and power plant; baseload demand type;
 0.981×10^9 KWH output power.

Technology characterization tables for the system configurations are presented in Tables A1 through A27.

Table A1

GENERIC DESIGN FOR MOD-1 WIND ENERGY CONVERSION SYSTEM HYDROELECTRIC HYBRID								
First Year of Operation: 1981 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.48 (18 MPH Wind Site); 0.30 (14 MPH); 0.21 (12 MPH)	PRIMARY & SECONDARY SOURCES ERDA METREK GE							
Capital Cost Not Subject to Experience: 598 \$/kW $\pm 10\%$	GE, Kaman, METREK							
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Rotor, Hub, Main Bearings</td><td>1</td><td>157 (+30% - 15%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	1	157 (+30% - 15%)	GE, Kaman, METREK	
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	1	157 (+30% - 15%)						
O&M Costs: 4.0 $\pm$ 40% mills/kWh	Kaman, Northeast Utilities							
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 Yrs. Lifetime: 30 Yrs. Land Use: 1.5×10^{-5} mi ² /kW Water Use: N/A Labor: 5.4×10^{-3} MY/kW Location for Generic Design: Regions 3, 5, 8, 9 Factor Determining Regional Variation: Relative Available Dam and Wind Sites	ERDA, METREK GE, Kaman METREK METREK							

*Exclusive of labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table A2

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM WITH GAS TURBINE								
First Year of Operation: 1983 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.49 (14 MPH Wind Regime)	PRIMARY & SECONDARY SOURCES ERDA METREK METREK							
Capital Cost Not Subject to Experience: 580 \$/kW	METREK							
Capital Cost Subject to Experience: <table border="1"> <thead> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> </thead> <tbody> <tr> <td>Rotor, Hub, Main Bearings</td><td align="center">1</td><td align="center">325 (+30% - 15%)</td></tr> </tbody> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	1	325 (+30% - 15%)	METREK	
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	1	325 (+30% - 15%)						
O&M Costs: 21.3 $\pm$ 32% \$/kW/Yr	METREK							
Conventional Fuel Type: #2 Fuel Oil Burn Rate: 2700 Btu/kWh Construction Time: 3 Yrs. Lifetime: 30 Yrs. Land Use: 1.3×10^{-5} mi ² /kW Water Use: 0 Labor: * 5.0×10^{-3} MY/kW Location for Generic Design: All Regions Factor Determining Regional Variation: Relative Available Wind Speeds	METREK METREK ERDA METREK METREK							

*Exclusive of labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table A3

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM WITH COMBINED CYCLE								
First Year of Operation: 1983 Demand Type: Baseload Nameplate Rating: 100 MW Capacity Factor: 0.65 (12.1 MPH), 0.70 (14 MPH), 0.87 (18 MPH)		PRIMARY & SECONDARY SOURCES ERDA METREK METREK						
Capital Cost Not Subject to Experience: 710 \$/kW		METREK						
Capital Cost Subject to Experience: <table border="1"> <thead> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> </thead> <tbody> <tr> <td>Rotor, Hub, Main Bearings</td><td>67</td><td>325 (+30% - 15%)</td></tr> </tbody> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Rotor, Hub, Main Bearings	67	325 (+30% - 15%)		METREK
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>						
Rotor, Hub, Main Bearings	67	325 (+30% - 15%)						
O&M Costs: 5.4 +33% mills/kWh								
Conventional Fuel Type: #2 Fuel Oil Burn Rate: 1565 (0.65CF), 1460 (0.70CF), 1190 (0.87CF) Btu/kWh Construction Time: 3 years Lifetime: 30 years Land Use: 1.3×10^{-5} mi ² /kW Water Use: 2.6×10^{-3} Acre-Ft/yr/kW Labor: 8.5×10^{-3} MY/kW Location for Generic Design: All Factor Determining Regional Variation: Relative Available Wind Sites		METREK METREK ERDA METREK METREK						

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table A4

GENERIC DESIGN FOR MOD-I WIND ENERGY CONVERSION SYSTEM/FUEL SAVER			PRIMARY & SECONDARY SOURCES
First Year of Operation:	1981		ERDA
Demand Type:	Fuel Saver		GE, Kaman
Nameplate Rating:	1.5 MW (22.4 MPH)		GE
Capacity Factor:	0.48 (18 MPH Ave. Wind) 0.30 (14 MPH), 0.21 (12 MPH)		
Capital Cost Not Subject to Experience:	448 \$/kW		GE, Kaman, METREK
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Rotor, Hub, Main Bearings	1	157 (+30% -15%)	GE, Kaman, METREK
O&M Costs:	5.2 ± 50% mills/kWh		Kaman, Northeast Utilities
Conventional Fuel Type:	None		
Burn Rate:	N/A		ERDA, METREK
Construction Time:	2 Yrs.		GE, Kaman
Lifetime:	30 Yrs. - 6 ²		METREK
Land Use:	6.6 x 10 ⁻⁶ mi ² /kW		
Water Use:	0		
Labor:*	5.1 x 10 ⁻³ MY/kW		METREK
Location for Generic Design:	All Regions		
Factor Determining Regional Variation:	Relative Available Wind Speed		

*Exclusive of the labor content of purchased components.

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

Table A5

GENERIC DESIGN FOR ADVANCED DESIGN WIND ENERGY CONVERSION SYSTEM/FUEL SAVER								
First Year of Operation: 1983 Demand Type: Fuel Saver Nameplate Rating: 1.5 MW (17.1 MPH) Capacity Factor: 0.65 (18 MPH), 0.49 (14 MPH), 0.44 (12 MPH)		PRIMARY & SECONDARY SOURCES ERDA ERDA, METREK METREK						
Capital Cost Not Subject to Experience: 475 \$/kW		METREK						
Capital Cost Subject to Experience: <table border="1"> <thead> <tr> <th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr> </thead> <tbody> <tr> <td>Rotor, Hub, Main Bearings</td><td>1</td><td>325 (+30% -15%)</td></tr> </tbody> </table>		Description	Quantity/System	Mass Produced Cost (\$/kW)	Rotor, Hub, Main Bearings	1	325 (+30% -15%)	METREK
Description	Quantity/System	Mass Produced Cost (\$/kW)						
Rotor, Hub, Main Bearings	1	325 (+30% -15%)						
O&M Costs: 4.9 ± 42% mills/kWh		METREK						
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 years Lifetime: 30 years Land Use: 1.2×10^{-5} mi ² /kW Water Use: 0 Labor: 8.5×10^{-3} MY/kW Location for Generic Design: All Factor Determining Regional Variation: Relative Available Wind Speeds		ERDA, METREK ERDA METREK METREK						

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for
Solar-Related Technologies, Volume 1,

Table A6

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT
SOLAR HEATED TEXTILE PROCESS WATER COSTS

<u>Description</u>	<u>Total Cost</u>
Collectors	
Glass	360,180
Reflector	125,580
Header (Copper)	187,680
Insulation	187,680
Gasket	74,520
Labor	
Fabrication	249,260
Shipping	37,260
Insulation	157,320
Plumbing	83,300
Valves	28,800
Pumps	28,800
Controls	12,500
Storage	243,800
Total Capital	\$1,777,200
Recurring Annual Costs:	
Capital Charge (10%)	\$177,720
Maintenance (1%)	17,800
Operations (2 men part-time)	15,000
Total Annual Cost	\$ 210,520
Energy Collected	0.275
(MMBtu/ft ² /yr)	
(MMBtu/yr)	68,780
Annualized Cost	3.06

TABLE A7

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

80-100° HOT WATER CAN WASHING SYSTEM

<u>Description</u>	<u>Total Cost</u>
Collector (Copper Flat)	
Copper sheet	382,140
Paint	150,480
Glass	112,860
Insulation	52,570
Box	44,550
Labor	
Fabrication	150,480
Shipping	22,700
Installation	75,240
Pumps	7,000
Valves	7,000
Plumbing	42,000
Controls (Electrical/Electronic)	12,000
Total Installed Cost	\$1,058,000
<u>Recurring Annual Costs:</u>	
Maintenance	\$ 21,160
Operations	50,000
Capital (10%)	105,800
Total Annual Costs	\$ 176,960
Energy Produced:	
(MMBtu/ft ² /yr)	0.255
(MMBtu/Yr)	38,250
Cost of Solar Energy	
(\$/MMBtu)	\$4.63
Cost of Fuel Displaced	
(\$/MMBtu)	
(Assuming \$0.40/gal, 65% efficiency)	\$4.68

TABLE A8

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

50° - 100° HOT AIR--GRAIN DRYER

<u>Description</u>	<u>Total Cost</u>
Collectors	
Plastic	206,250
Labor	137,500
Aluminum	206,168
Paint	137,733
Steel Box	40,714
Glass	103,084
Insulation	48,510
Labor	
Fabrication	274,601
Shipping	13,860
Installation	41,580
Ductwork	36,100
Valves	16,000
Controls	22,000
Fans	17,300
Storage	592,500
Heat Exchangers	<u>180,000</u>
Total Installed Cost	\$2,074,900
Recurring Annual Costs:	
Capital (10%)	\$ 207,490
Maintenance (1%)	20,749
Operation (4 men)	<u>100,000</u>
Total Annual Costs	\$ 328,239
Energy Delivered	
(MMBtu/ft ² /yr)	0.2552
(MMBtu/yr)	70,200

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT
50° - 100° HOT AIR—GRAIN DRYER
(continued)

<u>Description</u>	<u>Total Cost</u>
Energy Cost (\$/MMBtu)	\$4.68
Replacement Fuel Cost: (\$/MMBtu)	
Propane	\$6.67
Natural Gas	\$2.50
Natural Gas with Current Design (\$/MMBtu)	\$5.00

TABLE A9

INDUSTRIAL AND AGRICULTURAL PROCESS HEAT

100° - 150°C HOT AIR--PLASTIC CURING

<u>Description</u>	<u>Total Cost</u>
Collector (Winston Parabolic)	
Copper	101,520
Steel	108,520
Paint	27,000
Insulation	101,520
Glass	101,520
Sealant	4,104
Labor	
Fabrication	405,000
Shipping	27,000
Installation	168,480
Ductwork	18,300
Valves	7,300
Controls	13,500
Fans	8,600
Storage(Rockbed)	142,500
Heat Exchangers	86,400
Total Installed Cost	\$1,321,264
Recurring Annual Costs:	
Capital (10%)	\$ 135,660
Maintenance (2%)	27,132
Operations (3 men)	75,000
Total Annual Cost	\$ 237,792
Energy Delivered:	
(MMBtu/ft ² /yr)	0.219
(MMBtu/Yr)	29,565
Energy Cost:	\$8.04
(\$/MMBtu)	
Replacement Energy Cost:	
(\$/MMBtu)	
Synfuel/Propane	\$8.89
Electricity	\$16.39

TABLE A10

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER-3HR STORAGE			
First Year of Operation: 1990 Demand Type: Semi-Peak Nameplate Rating: 100 MW Capacity Factor: 0.35		PRIMARY & SECONDARY SOURCES METREK METREK, Aerospace METREK, Aerospace METREK, Aerospace	
Capital Cost Not Subject to Experience: 274 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK, McDonnell-Douglas	
Capital Cost Subject to Experience:			
Description Heliostats (331 Ft ²) Receiver (46 Ft) ² Aperture Cavity Type Tower (650 Ft., Concrete) Control (Field Controller with 1 Master Unit) Storage	Quantity/System 15,000 2 2 600 210 MWH _e Steel Ingot Type	Mass Produced Cost (\$/kW) 390 41 91 63 120 705 \$/kW (+40%, -20%)	METREK, McDonnell-Douglas METREK, Martin-Marietta METREK, Honeywell METREK METREK, JPL
O&M Costs: 14 \$/kW/Yr (+40%, -20%)		METREK, McDonnell-Douglas	
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 Yrs. Land Use: 1.0 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Acre-Ft/Yr/kW Labor: 0.013 Man-Years/kW Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Direct Sunlight		METREK METREK METREK, ERDA/DSE* METREK, Aerospace METREK, ERDA/DSE METREK METREK Aerospace METREK, Aerospace	

*ERDA - Division of Solar Energy

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE A11

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER - 6 HR. STORAGE																										
First Year of Operation: 1986 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.5		<u>PRIMARY & SECONDARY SOURCES</u> METREK ERDA/DSE Aerospace, ERDA/DSE METREK																								
Capital Cost Not Subject to Experience: 315 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK																								
Capital Cost Subject to Experience: <table border="1"> <thead> <tr> <th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr> </thead> <tbody> <tr> <td>Heliostate (331 Ft²)</td><td>22,500</td><td>595</td></tr> <tr> <td>Receiver (46 Ft)² Aperture</td><td>3</td><td>62</td></tr> <tr> <td>Cavity Type</td><td></td><td></td></tr> <tr> <td>Tower (650 Ft., Concrete)</td><td>3</td><td>136</td></tr> <tr> <td>Control (Field Controller with 1 Master Unit)</td><td>900</td><td>95</td></tr> <tr> <td>Storage 420 MMH₂O Steel Ingot Type</td><td></td><td>239</td></tr> <tr> <td>Total Modules Cost:</td><td></td><td>1117 \$/kW (+40%, -20%)</td></tr> </tbody> </table>		Description	Quantity/System	Mass Produced Cost (\$/kW)	Heliostate (331 Ft ²)	22,500	595	Receiver (46 Ft) ² Aperture	3	62	Cavity Type			Tower (650 Ft., Concrete)	3	136	Control (Field Controller with 1 Master Unit)	900	95	Storage 420 MMH ₂ O Steel Ingot Type		239	Total Modules Cost:		1117 \$/kW (+40%, -20%)	McDonnell-Douglas, METREK Martin-Marietta, METREK Honeywell, METREK McDonnell-Douglas, METREK JPL, METREK
Description	Quantity/System	Mass Produced Cost (\$/kW)																								
Heliostate (331 Ft ²)	22,500	595																								
Receiver (46 Ft) ² Aperture	3	62																								
Cavity Type																										
Tower (650 Ft., Concrete)	3	136																								
Control (Field Controller with 1 Master Unit)	900	95																								
Storage 420 MMH ₂ O Steel Ingot Type		239																								
Total Modules Cost:		1117 \$/kW (+40%, -20%)																								
O&M Costs: 20 \$/kW/Yr. (+40%, -20%)		METREK estimate based on above McDonnell-Douglas Avail. Est.																								
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.5 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Acre-Ft/yr/kW (Dry Cooling Tower) Labor: 0.017 Man-Years/kW Location for Generic Design: Regions 7, 8 and 9 Factor Determining Regional Variation: Relative Available Direct Sunlight		METREK, ERDA/DSE All Contractors, ERDA/DSE METREK ERDA/DSE METREK Aerospace METREK, Aerospace, ERDA/DSE																								

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE A12

GENERIC DESIGN FOR SOLAR THERMAL CENTRAL RECEIVER-FUEL SAVER																							
First Year of Operation: 1990 Demand Type: Fuel Saver Nameplate Rating: 100 MW Capacity Factor: 0.25 to 0.362		PRIMARY & SECONDARY SOURCES METREK METREK METREK METREK																					
Capital Cost Not Subject to Experience: 274 \$/kW (Cooling Tower, Electric Plant, Other) (+40%, -20%)		METREK, McDonnell-Douglas																					
Capital Cost Subject to Experience: <table> <tr> <th><u>Description</u></th><th><u>Quantity/System</u></th><th><u>Mass Produced Cost (\$/kW)</u></th></tr> <tr> <td>Heliostats (331 Ft²)</td><td>15,000</td><td>390</td></tr> <tr> <td>Receiver (46 Ft)² Aperture</td><td>2</td><td>41</td></tr> <tr> <td>Cavity Type</td><td></td><td></td></tr> <tr> <td>Tower (650 Ft., Concrete)</td><td>2</td><td>91</td></tr> <tr> <td>Control (Field Controller with 1 Master Unit)</td><td>600</td><td>63</td></tr> <tr> <td>Total Modules Costs</td><td></td><td>585 \$/kW (+40% -20%)</td></tr> </table>	<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	Heliostats (331 Ft ²)	15,000	390	Receiver (46 Ft) ² Aperture	2	41	Cavity Type			Tower (650 Ft., Concrete)	2	91	Control (Field Controller with 1 Master Unit)	600	63	Total Modules Costs		585 \$/kW (+40% -20%)		McDonnell-Douglas, METREK Martin-Marietta, METREK Honeywell, METREK METREK
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>																					
Heliostats (331 Ft ²)	15,000	390																					
Receiver (46 Ft) ² Aperture	2	41																					
Cavity Type																							
Tower (650 Ft., Concrete)	2	91																					
Control (Field Controller with 1 Master Unit)	600	63																					
Total Modules Costs		585 \$/kW (+40% -20%)																					
O&M Costs: 12 \$/kW/Yr (+40%, -20%)		METREK, McDonnell-Douglas																					
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 Yrs. Lifetime: 30 Yrs. Land Use: 1.0 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Acre-Ft/Yr/kW Labor: 0.010 Man-Years/kW Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Direct Sunlight		METREK METREK, ERDA/DSE METREK, Aerospace METREK, ERDA/DSE METREK METREK Aerospace METREK, Aerospace																					

Source: Mitre Corporation, Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1.

TABLE A13

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/16% SILICON			
First Year of Operation:	1990	PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK, Aerospace METREK, Aerospace, Westinghouse Aerospace	
Demand Type:	Semi-Peak		
Nameplate Rating:	100 MW		
Capacity Factor:	0.30		
Capital Cost Not Subject to Experience:	200 \$/kW (Power Conditioning Facility) (+90%, -30%)	METREK, Westinghouse	
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	7351	890	METREK, Aerospace, Westinghouse
Storage	250	75	METREK, Aerospace
Total Modules Costs		965 \$/kW (+90%, -30%)	
O&M Costs:	30.5 \$/kW/yr (+25%, -25%)	METREK, Westinghouse	
Conventional Fuel Type:	None	Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace	
Burn Rate:	N/A		
Construction Time:	2 yrs.		
Lifetime:	30 yrs.		
Land Use:	5.7 x 10 ⁻⁶ mi ² /kW		
Water Use:	0.0		
Location for Generic Design:	Regions 7, 8, and 9		
Factor Determining Regional Variation:	Relative Available Sunlight		

Source: Mitre Volume 1 op. cit.

TABLE A14

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/10% THIN FILM			PRIMARY & SECONDARY SOURCES
First Year of Operation:	1990		METREK, Westinghouse
Demand Type:	Semi-Peak		METREK, Aerospace
Nameplate Rating:	100 MW		METREK, Aerospace, Westinghouse
Capacity Factor:	0.30		Aerospace
Capital Cost Not Subject to Experience:	220 \$/kW (Power Conditioning Facility)	(+90%, -30%)	METREK, Aerospace, Westinghouse
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	12,650	620	METREK, Aerospace, Westinghouse
Storage	250	75	METREK, Aerospace
Total Modules Costs		695 \$/kW (+90%, -30%)	
O&M Costs:	40.5 \$/kW/yr (+25%, -25%)		METREK, Westinghouse
Conventional Fuel Type:	None		Westinghouse
Burn Rate:	N/A		METREK, ERDA/DSE
Construction Time:	2 yrs.		Westinghouse
Lifetime:	30 yrs.		METREK
Land Use:	9.8 x 10 ⁻⁶ mi ² /kW		METREK
Water Use:	0.0		METREK, Aerospace
Location for Generic Design:	Regions 7, 8, and 9		METREK, Aerospace
Factor Determining Regional Variation:	Relative Available Sunlight		METREK, Aerospace

Source: Mitre Volume 1 op. cit.

TABLE A15

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE--COLLECTOR/REFLECTOR/16% SILICON			PRIMARY & SECONDARY SOURCES
First Year of Operation:	1990		METREK, Westinghouse
Demand Type:	Intermediate		METREK, Aerospace
Nameplate Rating:	100 MW		METREK, Aerospace, Westinghouse
Capacity Factor:	0.45		Aerospace
Capital Cost Not Subject to Experience: 320 \$/kW (Power Conditioning Facility) (+90%, -30%)			METREK, Westinghouse
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	11,703	1400	METREK, Aerospace, Westinghouse
Storage	600 Mwh	180	
Total Modules Cost		1580 \$/kW (+90%, -30%)	METREK, Aerospace
O&M Costs: 65 \$/kW/yr (+25%, -25%)			METREK, Westinghouse
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 9 x 10 ⁻⁵ mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight			Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace

Source: Mitre Volume I; op cit.

TABLE A16

GENERIC DESIGN FOR PHOTOVOLTAIC SYSTEM WITH STORAGE - COLLECTOR/REFLECTOR/10% THIN-FILM			
First Year of Operation:	1990		PRIMARY & SECONDARY SOURCES
Demand Type:	Intermediate		METREK, Westinghouse
Nameplate Rating:	100 MW		METREK, Aerospace
Capacity Factor:	0.45		METREK, Aerospace, Westinghouse
			Aerospace
Capital Cost Not Subject to Experience:	350 \$/kW (Power Conditioning, Facility)		METREK, Westinghouse
	(+90%, -30%)		
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	20,139	990	METREK, Aerospace
Storage	600 MWh	180	Westinghouse
Total Modules Costs		1170 \$/kW	METREK, Aerospace
		(+90%, -30%)	
OM Costs:	90.3 \$/kW/yr	(±25%, -25%)	METREK, Westinghouse
Conventional Fuel Type: None			
Burn Rate: N/A			
Construction Time: 2 yrs.			Westinghouse
Lifetime: 30 yrs.			METREK, ERDA/DSE
Land Use: 1.6×10^{-5} mi ² /kW			Westinghouse
Water Use: 0.0			METREK
			METREK
Location for Generic Design: Regions 7, 8, and 9			METREK, Aerospace
Factor Determining Regional Variation: Relative Available Sunlight			METREK, Aerospace

Source: Mitre Volume I, op cit.

TABLE A17

GENERIC DESIGN FOR 10X CONCENTRATING* PHOTOVOLTAIC ARRAY SYSTEM (VERTICAL AXIS TRACKING) WITH STORAGE (SILICON CELL)																	
First Year of Operation: 1990 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.39		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK METREK															
Capital Cost Not Subject to Experience: \$200/kW (Power Conditioning, Facility)		METREK, Westinghouse															
Capital Cost Subject to Experience:																	
<table><tr><th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th><th></th></tr><tr><td>Photovoltaic Array Modules (100 M² Collector/Module)</td><td>14322</td><td>1980</td><td rowspan="3">METREK, Westinghouse</td></tr><tr><td>Storage</td><td>232 MWH</td><td>70</td></tr><tr><td></td><td></td><td>\$2050/kW (+90%, -30%)</td></tr></table>				Description	Quantity/System	Mass Produced Cost (\$/kW)		Photovoltaic Array Modules (100 M ² Collector/Module)	14322	1980	METREK, Westinghouse	Storage	232 MWH	70			\$2050/kW (+90%, -30%)
Description	Quantity/System	Mass Produced Cost (\$/kW)															
Photovoltaic Array Modules (100 M ² Collector/Module)	14322	1980	METREK, Westinghouse														
Storage	232 MWH	70															
		\$2050/kW (+90%, -30%)															
O&M Costs: \$34.5/kW/Yr. (+25%)		METREK, Westinghouse															
Conventional Fuel Type: N/A Burn Rate: N/A Construction Time: 2 Yrs. Lifetime: 30 Yrs. Land Use: 1.7 x 10 ⁻⁵ MI ² /kW Water Use: N/A		METREK, Westinghouse METREK, ERDA/DSE Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace															
Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Availability of Solar Radiation																	

*Compound Parabolic Concentrator, Factor of Ten Concentration

Source: Mitre Volume I, op cit.

TABLE A18

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER--COLLECTOR/REFLECTOR ARRAY/16% SILICON								
First Year of Operation: 1990 Demand Type: N/A Nameplate Rating: 100 MW Capacity Factor: 0.28		PRIMARY & SECONDARY SOURCES METREK, Westinghouse METREK METREK, Westinghouse METREK, Westinghouse						
Capital Cost Not Subject to Experience: 150 \$/kW (Power Conditioning Facility) (+90%, -30%)		METREK, Westinghouse						
Capital Cost Subject to Experience:								
<table> <tr> <th>Description</th><th>Quantity/System</th><th>Mass Produced Cost (\$/kW)</th></tr> <tr> <td>Solar Array Modules (100 M² Collector & Reflector)</td><td>5518</td><td>670 (+90%, -30%)</td></tr> </table>	Description	Quantity/System	Mass Produced Cost (\$/kW)	Solar Array Modules (100 M ² Collector & Reflector)	5518	670 (+90%, -30%)		METREK, Westinghouse
Description	Quantity/System	Mass Produced Cost (\$/kW)						
Solar Array Modules (100 M ² Collector & Reflector)	5518	670 (+90%, -30%)						
O&M Costs: 18.4 \$/kW/yr (+25%, -25%)		METREK, Westinghouse						
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 4.3×10^{-6} mi ² /kW Water Use: 0.0 Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse METREK, ERDA/DSB Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace						

Source: Mitre Volume I, op cit.

TABLE A19

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER--COLLECTOR/REFLECTOR ARRAY/10% THIN-FILM			
First Year of Operation:	1990	PRIMARY & SECONDARY SOURCES	
Demand Type:	N/A	METREK, Westinghouse	
Nameplate Rating:	100 MW	METREK	
Capacity Factor:	0.26	METREK, Westinghouse	
Capital Cost Not Subject to Experience: 150 \$/kW (Power Conditioning, Facility) (+90%, -30%)		METREK, Westinghouse	
Capital Cost Subject to Experience:			
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>	
Solar Array Modules (100 M ² Collector & Reflector)	8838	430 (+90%, -30%)	METREK, Westinghouse
O&M Costs: 22.3 \$/kW/yr (+25%, -25%)			
Conventional Fuel Type: None		Westinghouse; METREK	
Burn Rate: N/A		METREK, ERDA/DSB	
Construction Time: 2 years		Westinghouse	
Lifetime: 30 yrs.		METREK	
Land Use: 6.8 x 10 ⁻⁶ mi ² /kW		METREK	
Water Use: 0.0		METREK, Aerospace	
Location for Generic Design: Regions 7, 8, and 9		METREK, Aerospace	
Factor Determining Regional Variation: Relative Available Sunlight			

Source: Mitre Volume 1, op cit.

TABLE A20

GENERIC DESIGN FOR PHOTOVOLTAIC FUEL SAVER - 10XCPC*ARRAY/16% SILICON SOLAR CELLS (VERTICAL AXIS TRACKING)		
First Year of Operation:	1990	PRIMARY & SECONDARY SOURCES
Demand Type:	N/A	METREK, Westinghouse
Nameplate Rating:	100 MW	METREK
Capacity Factor:	0.30	METREK, Westinghouse
Capital Cost Not Subject to Experience:	\$160/kW (Pwr. Cond., Facility) (+90% -30%)	
Capital Cost Subject to Experience:		
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>
Solar Array Modules (108 M ² Collector)	11,218	1500 (+90%, -30%)
		METREK, Westinghouse
O&M Costs: \$20/kW/yr. (+25%)		METREK, Westinghouse
Conventional Fuel Type: None Burn Rate: N/A Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.3 x 10 ⁻⁵ mi ² /kW Water Use: N/A Location for Generic Design: Regions 7, 8, and 9 Factor Determining Regional Variation: Relative Available Sunlight		Westinghouse, METREK METREK, ERDA/DSB Westinghouse METREK METREK METREK, Aerospace METREK, Aerospace

*Factor of Ten Concentration, Compound Parabolic Concentrator (10XCPC)

Source: Mitre Volume I, op cit.

TABLE A21

GENERIC DESIGN FOR WOOD-FIRED STEAM PLANT (INTERMEDIATE)		
First Year of Operation: 1980 Demand Type: Intermediate Nameplate Rating: 100 MW Capacity Factor: 0.50		PRIMARY & SECONDARY SOURCES METREK METREK METREK METREK
Capital Cost Not Subject to Experience: 747 \$/kW (+59%, -31%)		METREK
Capital Cost Subject to Experience: N/A		
<div> <div>Description</div> <div>Quantity/System</div> <div>Mass Produced Cost (\$/kW)</div> </div>		
O&M Costs: 34.7 \$/kW/yr (+40%, -30%)		METREK
Conventional Fuel Type: Wood or Logging Residues Burn Rate: 12,000 Btu/kWh Construction Time: 2 yrs. Lifetime: 30 yrs. Land Use: 1.0×10^{-6} mi ² /yr/kW Water Use: 1.3×10^{-2} Acre-ft/yr/kW Labor: 7×10^{-3} MY/kW Location for Generic Design: All but Region 8 Factor Determining Regional Variation: Wood Availability		METREK METREK METREK METREK METREK METREK METREK METREK METREK

Source: Mitre Volume 1, op cit.

TABLE A22

GENERIC DESIGN FOR WOOD-FIRED STEAM PLANT (BASE)		
First Year of Operation:	1980	PRIMARY & SECONDARY SOURCES METREK METREK METREK METREK
Demand Type:	Baseload	
Nameplate Rating:	(1) 46 MW (2) 100 MW (3) 210 MW	
Capacity Factor:	0.80	
Capital Cost Not Subject to Experience:	(1) 1190 \$/kW (2) 747 \$/kW (3) 512 \$/kW (+ 10%)	METREK
Capital Cost Subject to Experience:		
<u>Description</u>	<u>Quantity/System</u>	<u>Mass Produced Cost (\$/kW)</u>
O&M Costs: (1) 78 \$/kW/yr; (2) 55.6 \$/kW/yr; (3) 39.1 \$/kW/yr (+15%)		METREK
Conventional Fuel Type: Wood or Logging Residues		METREK
Burn Rate: (1) 13,000 Btu/kWh; (2) 12,000 Btu/kWh; (3) 11,500 Btu/kWh		METREK
Construction Time: (1) 1.5 yr.; (2) 2.0 yr.; (3) 2.5 yr.		METREK
Lifetime: 30 yrs.		METREK
Land Use: 1.0×10^{-6} mi ² /kW		METREK
Water Use: (1) 2.5×10^{-2} Acre-ft/kW/yr; (2) 2.2×10^{-2} ; (3) 2.1×10^{-2}		METREK
Labor: (1) 10×10^{-3} ; (2) 8×10^{-3} ; (3) 7×10^{-3} MY/kW		METREK
Location for Generic Design: All but Region 8		METREK
Factor Determining Regional Variation: Wood Availability		METREK

Source: Mitre Volume I, op cit.

TABLE A23

**CAPITAL AND OPERATING COSTS COMBINED GASIFICATION
AND METHANOL SYNTHESIS PROCESSES
(COSTS IN MILLION DOLLARS)**

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Wood-biomass feed capacity, ODT/day	1700
Gasification plant output, Btu/day	2.170×10^{10}
Gasification plant capital cost, MM\$	28.64
Gasification plant annual O&M cost, MM\$	5.28
Methanol output, T/day	670
Methanol output, Btu/Day	1.310×10^{10}
<u>CAPITAL COST (METHANOL SYNTHESIS PLANT)</u>	
Syn Gas Compressor I	2.4
CO Shift	.81
Shift Conversion	
Absorber	
Regenerator	
K.O. Process	12.36
Iron Sponge Drum	
Guard Drum	
Separator	
Compressor II	.80
Compressor III	.48
Methanol Converter	1.2
Heat Exchanger	.05
Separator	.03
Flash Drum	.02
Cooling and Waste Water Treatment	.90

TABLE A23 (continued)

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION
AND METHANOL SYNTHESIS PROCESSES
(COSTS IN MILLION DOLLARS)
(continued)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Steam Plant	.18
Storage and Handling	.40
Buildings and Structures	.30
SUBTOTAL METHANOL SYNTHESIS PLANT	19.93
TOTAL GASIFICATION/METHANOL SYN- THESIS PLANTS	48.57
<u>OPERATIONS AND MAINTENANCE COST</u>	
Direct Labor Cost	.82
Labor-Related Cost	.79
Power Cost	.67
Other Utility Cost	.48
Maintenance Cost	1.41
Miscellaneous Equipment Repair Cost	.28
SUBTOTAL ANNUAL, METHANOL SYNTHESIS PLANT	4.45
TOTAL ANNUAL, GASIFICATION/METHANOL SYNTHESIS PLANTS	9.73

Source: Mitre/Metrek 1977

TABLE A24

CAPITAL AND OPERATING COSTS PUROX GASIFICATION PROCESS
FOR PRODUCING MEDIUM-BTU GAS
(COSTS IN MILLION DOLLARS)

Continued - 2

OPERATIONS AND MAINTENANCE COSTS

Direct Labor Cost	1.38
Labor-Related Cost	1.31
Power Cost	.64
Other Utility Cost	.48
Maintenance Cost	1.18
Miscellaneous Equipment Repair Cost	.29
TOTAL ANNUAL COST	5.28

Source: Mitre Volume IX, op cit.

TABLE A24

**CAPITAL AND OPERATING COSTS PUROX GASIFICATION PROCESS
FOR PRODUCING MEDIUM-BTU GAS
(COSTS IN MILLION DOLLARS)**

<u>ITEM OF COST</u>	<u>PLANT SIZE II</u>
Feed Capacity, ODT/day	1700
Plant fuel gas output, Btu/day	2.170×10^{10}
<u>CAPITAL COSTS</u>	
Front End Process	1.71
Shaft Furnace	1.00
Electrostatic Precipitator	.49
Product Gas Compressor Unit	.80
Product Gas Condensing Unit	.16
Oil Separator	.08
Oxygen Generator and Storage	12.80
General Mechanical and Plumbing	.60
Process Controls and Instrumentation	.06
Plant Services Air, Water, etc.	.04
Electric Supply and Distribution	.80
Cooling Tower and Water Treatment	.96
Buildings and Structures	.30
TOTAL	19.80

TABLE A25

**CAPITAL AND OPERATING COSTS COMBINED GASIFICATION AND METHANATION PROCESSES
FOR SUBSTITUTE NATURAL GAS PRODUCTION
(COSTS IN MILLION DOLLARS)**

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Feed capacity, ODT/day	1700
Gasification plant output, Btu/day	2.170×10^{10}
Gasification plant capital cost	28.64
Gasification plant annual O&M cost	5.28
SNG output, Btu/Day @ 800 Btu/ SCF gross	1.912×10^{10}
<u>CAPITAL COST (METHANATION PLANT)</u>	
Shift conversion	.42
Gas purification	2.016
Methanation	.513
Product gas drying	.220
Instrumentation	.238
Electrical	.822
Mechanical	1.155
Building and structure	.836
SUBTOTAL METHANATION PLANT	6.21
TOTAL GASIFICATION/METHANATION PLANTS	34.85
<u>OPERATIONS AND MAINTENANCE COSTS</u>	
Direct Labor Cost	.72
Labor-Related Cost	.68

TABLE A25. (continued)

CAPITAL AND OPERATING COSTS COMBINED GASIFICATION AND METHANATION PROCESSES
FOR SUBSTITUTE NATURAL GAS PRODUCTION
(COSTS IN MILLION DOLLARS)
(continued)

<u>PROCESS ITEM</u>	<u>PLANT SIZE II</u>
Power Cost	.6
Other Utility Cost	.4
Maintenance Cost	.46
Miscellaneous Equipment Repair Cost	.09
SUBTOTAL ANNUAL, METHANATION PLANT	2.95
TOTAL ANNUAL, GASIFICATION/ METHANATION PLANTS	8.23

Source: Mitre Volume IX, op cit.

TABLE A26

CAPITAL AND OPERATING COSTS CONVENTIONAL
WOOD-FIRED PROCESS HEAT
(COSTS IN MILLION DOLLARS)

<u>ITEM OF COST</u>	<u>PLANT SIZE I</u>	<u>PLANT SIZE II</u>	<u>PLANT SIZE III</u>
Feed capacity, ODT/day	850	1700	3400
Plant power output, MWe	46	100	210
<u>CAPITAL COSTS</u>			
Front End	1.5	1.71	3.16
Steam Generator	11.0	17.6	28.16
Water Treatment Plant	.32	.40	.50
HP/HT Valves	.22	.28	.35
Control Valves	.46	.69	1.04
Control Panels	.20	.20	.20
Transducers	1.20	1.40	1.80
Condenser	.37	.45	.58
G.P. Valves and Pumps	.12	.18	.28
Cooling Towers	1.1	1.73	2.80
Electrical	1.4	1.75	2.20
Mechanical	1.28	2.76	4.41
Supplementary Fuel Tank	.05	.07	.12
Instruments and Controls	1.28	1.6	2.00
General Construction	4.7	6.15	8.00
TOTAL	25.20	36.98	55.61

TABLE A26 (continued)

CAPITAL AND OPERATING COSTS CONVENTIONAL
WOOD-FIRED PROCESS HEAT
(COSTS IN MILLION DOLLARS)

<u>ITEM OF COST</u>	<u>PLANT SIZE I</u>	<u>PLANT SIZE II</u>	<u>PLANT SIZE III</u>
<u>OPERATING AND MAINTENANCE COSTS</u>			
Direct Labor Cost	.71	1.14	1.8
Labor-Related Cost	.67	1.07	1.7
Other Related Cost	.25	.40	.64
Maintenance Cost	1.65	2.46	3.4
Miscellaneous Equipment Repair Cost	.32	.49	.68
TOTAL ANNUAL COST	3.6	5.56	8.22

Source: Mitre Volume IX, op cit.

TABLE A27

COMMERCIAL PLANT PRODUCTION PARAMETERS AND CAPITAL COSTS
(\$/kW)

Plant No.	Capital Costs Excluding HE		Capital Costs of HE		Engineer etc. 12.25%	Capital Costs	Comments
	Materials	Labor	Materials	Labor			
1	919	267	900	330	296	2712	Production Improved Titanium Shell & Tube HE
2	827 10% Cost Red.	227 15% Labor Red.	680	370	258	2362	Enhanced Heat Transfer Titanium Shell & Tube HE
3	827	227	424	248	211	1937	Enhanced Heat Transfer. Aluminum Shell & Tube HE
4	827	216 5% Labor Red.	404	240	207	1894	Maximum Enhancement Aluminum Shell & Tube HE
5	827	216	362	212	198	1805	Aluminum Plate and Fin HE
6	827	216	202	120	167	1532	Plastic Shell & Tube HE
7	827	216	148	88	157	1436	Plastic Plate & Fin HE

Source: Mitre Volume VII, op cit.

SOLAR APPLICATION - EMPLOYMENT IMPACTS

(DATA SUMMARY)

<u>TECHNOLOGY</u>	<u>DATA AVAILABILITY</u>	<u>DATE DESCRIPTION</u>
AGRICULTURAL AND INDUSTRIAL PROCESS HEAT (A/IPH)	LIMITED	QUANTITATIVE
WIND ENERGY CONVERSION SYSTEMS (WECS)	POOR	ISOLATED FIGURES - LIMITED ANALYSIS
PHOTOVOLTAICS	LIMITED	QUANTITATIVE
HEATING (DWH, SPACE)	GOOD	ANALYTICAL
OCEAN THERMAL ENERGY CONVERSION (OTEC)	LIMITED	ESTIMATES-SOFT FIGURES
SOLAR THERMAL ELECTRIC SYSTEMS	GOOD	COMPARATIVE STUDIES
BIOMASS FUELS PRODUCTION AND CONVERSION SYSTEMS	POOR	QUALITATIVE

DIRECT AND INDIRECT EMPLOYMENT IMPACT
- NUCLEAR AND COMBINED-CYCLE OIL GENERATION OF
ELECTRICITY vs. SOLAR

NUCLEAR 1900 MW PLANT:	36,268 PERSON-YEARS (20-YEAR OPERATION)
SOLAR EQUIPMENT:	241,055 "
COMBINED-CYCLE 400 MW PLANT:	1,237 "
SOLAR EQUIVALENT:	34,835 "

SOURCE: STATEMENT OF WILSON CLARK, ASSISTANT TO THE GOVERNOR FOR
ISSUES AND PLANNING, STATE OF CALIFORNIA, "CREATING JOBS
THROUGH ENERGY POLICY," HEARINGS JOINT ECONOMIC COMMITTEE,
MARCH 16, 1978.

CUMULATIVE LABOR REQUIREMENTS

TO 2000

Solar Technology	Goods Displaced in 2000	Direct Labor Requirements Man-Years (10 ⁶)			Indirect Labor Requirements Man-Years (10 ⁶)			Total Labor Requirements Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Maximum Goods Displaced										
Solar Hot Water, Heat and Cooling	2.0	1.088	1.368	1.648	2.176	2.736	3.300	3.264	4.104	4.948
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.490	0.610	0.400	0.790	1.030
Wind	1.5	0.160	0.205	0.280	0.705	0.970	1.230	0.865	1.175	1.510
Solar-Process Heat	2.0	0.200	0.340	0.710	0.530	0.890	1.400	0.730	0.930	2.110
Solar Thermal Electric	0.5	0.185	0.180	0.205	0.490	0.515	0.530	0.675	0.705	0.735
Photovoltaics	1.5	0.645	1.110	1.645	1.470	1.755	2.610	2.115	2.865	4.275
Biomass	4.5	0.090	0.117	0.162	0.180	2.525		0.225	0.297	0.414
OTEC	0.1	0.023	0.035	0.046	0.047	0.060	0.088	0.070	0.095	0.134
Hydro	0.5		0.059			0.109			0.168	
Total	18.4		3.724			7.405			11.129	
Physical Good Limit										
Solar Hot Water, Heat and Cooling	4.0	2.176	2.736	3.296	4.352	5.472	6.600	6.528	8.208	9.896
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.490	0.610	0.400	0.790	1.030
Wind	3.0	0.320	0.410	0.560	1.410	1.940	2.460	1.730	2.350	3.020
Solar Process Heat	3.5	0.350	0.595	1.243	0.928	1.023	2.450	1.278	1.628	3.693
Solar Thermal Electric	1.5	0.555	0.570	0.615	1.470	1.545	1.990	2.025	2.115	2.205
Photovoltaic	2.5	1.075	1.850	2.775	2.450	3.825	6.350	3.525	4.775	7.125
Biomass	5.2									
OTEC	1.0	0.230	0.250	0.460	0.470	0.600	0.880	0.700	0.950	1.340
Hydro	2.0		0.236			0.436			0.672	
Total	28.5		7.847			14.441			21.488	

CUMULATIVE LABOR REQUIREMENTS

TO 2000

Solar Technology	Quads Displaced in 2000	Direct Labor Requirements			Indirect Labor Requirements			Total Labor Requirements		
		Man-Years (10 ⁶)			Man-Years (10 ⁶)			Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
<u>Low Price Scenario</u> \$18/bbl										
Solar Hot Water, Heat, Cooling	0.3	0.272	0.342	0.412	0.344	0.434	0.525	0.616	1.026	1.237
Passive Solar	0.1	0.015	0.030	0.042	0.025	0.049	0.061	0.040	0.079	0.103
Wind	0.3	0.032	0.041	0.056	0.141	0.194	0.246	0.173	0.235	0.302
Solar-Process Heat	0.2	0.020	0.034	0.071	0.053	0.059	0.140	0.073	0.093	0.211
Solar Sys-Fuels	0.1	0.002	0.003	0.007	0.003	0.006	0.011	0.005	0.009	0.019
Biomass-Process Heat	0.2	0.004	0.005	0.007	0.006	0.008	0.011	0.010	0.013	0.017
Biomass-Electric	0.1	0.022	0.026	0.031	0.071	0.094	0.118	0.093	0.120	0.149
Biomass Sys-Fuels	0.2	0.003	0.007	0.014	0.006	0.011	0.022	0.009	0.018	0.036
Total	3.5	0.370	0.488	0.640	0.849	1.105	1.434	1.219	1.593	2.075
<u>Mid Price Scenario</u> \$25/bbl										
Solar Hot Water, Heat, Cooling	1.0	0.544	0.684	0.824	1.088	1.368	1.650	1.632	2.052	2.474
Passive Solar	0.2	0.030	0.060	0.084	0.050	0.090	0.122	0.080	0.158	0.206
Wind	0.6	0.064	0.082	0.112	0.282	0.388	0.492	0.346	0.470	0.604
Solar Thermal Electric	0.1	0.037	0.038	0.041	0.098	0.103	0.106	0.135	0.141	0.147
Photovoltaic	0.1	0.043	0.074	0.111	0.098	0.117	0.174	0.141	0.191	0.285
Solar-Process Heat	1.0	0.100	0.170	0.355	0.265	0.295	0.700	0.365	0.465	1.055
Solar Sys-Fuels	0.2	0.004	0.006	0.014	0.006	0.012	0.022	0.010	0.018	0.038
Biomass-Process Heat	0.5	0.010	0.013	0.018	0.015	0.020	0.028	0.025	0.033	0.046
Biomass Electric	0.2	0.044	0.052	0.062	0.142	0.188	0.236	0.186	0.240	0.298
Biomass Sys-Fuels	0.3	0.005	0.011	0.021	0.009	0.017	0.033	0.014	0.027	0.054
Total	6.0	0.881	1.190	1.642	2.053	2.606	3.543	2.836	3.796	5.205
<u>High Price Scenario</u> \$32/bbl										
Solar Hot Water, Heat, Cooling	1.3	0.707	0.889	1.071	1.414	1.778	2.145	2.122	2.668	3.216
Passive Solar	0.3	0.045	0.090	0.136	0.075	0.147	0.183	0.120	0.237	0.309
Wind	0.9	0.096	0.123	0.168	0.423	0.582	0.738	0.519	0.705	0.906
Solar Thermal Electric	0.2	0.074	0.076	0.082	0.196	0.206	0.212	0.270	0.282	0.294
Photovoltaic	0.2	0.086	0.148	0.222	0.196	0.234	0.348	0.282	0.382	0.570
Solar-Process Heat	1.4	0.14	0.238	0.497	0.371	0.413	0.98	0.511	0.651	1.477
Solar Sys-Fuels	0.4	0.008	0.012	0.028	0.012	0.024	0.044	0.020	0.036	0.072
Biomass-Process Heat	1.0	0.020	0.026	0.036	0.030	0.040	0.056	0.050	0.066	0.092
Biomass Electric	0.6	0.132	0.156	0.186	0.426	0.564	0.708	0.558	0.720	0.894
Biomass Sys-Fuels	0.6	0.010	0.022	0.042	0.018	0.034	0.066	0.028	0.054	0.108
Total	8.7	1.318	1.780	2.456	3.141	4.027	5.480	4.479	5.801	7.938

Notes

1. 1 man-year - 1900 man-hours
2. 10,400 BTU = 1 KWH displaced
3. 3413 BTU = 1 KWH actual
4. Labor costs \$12.50/hour (1976 dollars)
5. Indirect labor = $\frac{0.053 \text{ man-years} \times 1900 \text{ man-hours}}{\$1200 \text{ 1 man-year}}$
= 0.08392 man-hours/dollar.
6. Photovoltaic, Biomass assumes 40% of capital costs is due to direct labor costs
7. Solar hot water, heating and cooling, labor estimates from:

Indirect labor assumed twice direct labor
Direct labor estimate is a weighted average based upon number of units of hot water; hot water and heating; and hot water, heating and cooling in use in 2000, as estimated by impacts panel.
8. Low, mid, high ranges due to different component mixes as well as learning effects. OTEC range based upon production of 1,4 and 7 units. Photovoltaics assumes \$500/KW for solar cells.

Residential Commercial Systems	System Costs \$/ft ²		
	Low	Mid	High
Solar Hot Water	8.50	12.00	16.00
Solar Heating, Hot Water	13.30	16.40	19.10
Solar Heating, Cooling and Hot Water	14.30	16.70	23.40

Biomass conversion system use conventional equipment. The range is based upon construction of methanol, medium BTU gas and substitute national gas plants. It does not include labor for silviculture.

Solar/A/IPH system: Initial pilot production or prototype model costs range from 2 to 5 times mass produced costs, (MITRE, Volume III, p. 82). WECS range in manpower requirements due to demand type. Rotor and tones design and fabrication subject to Rearing Curve effects.

9. Wind energy direct labor component does not include labor required to fabricate purchased components; instead, it is included in indirect labor.

UNIT LABOR REQUIREMENTS
(On displaced energy basis)

Technology	Direct Labor			Indirect Labor		
	<u>Man-Hour/MMBTU-Year</u>			<u>Man-Hour/MMBTU-Year</u>		
	Low	Mid	High	Low	Mid	High
Solar hot water,	0.667	0.933	1.233	1.334	1.866	2.466
Solar heating	1.167	1.433	1.667	2.334	2.866	3.334
Solar Cooling	1.433	1.667	2.333	2.866	3.334	4.666
Solar Aggregated Hot water, heating and cooling	1.033	1.300	1.567	2.067	2.600	3.133
Solar Electric	0.695	0.726	0.774	1.870	1.960	2.010
Photovoltaic	0.810	1.410	2.110	1.280	2.220	3.310
Wind	0.204	0.259	0.355	0.890	1.230	1.560
Solar A/IPH	0.187	0.324	0.670	0.530	0.563	1.333
Biomass Process Heat	0.035	0.045	0.064	0.055	0.072	0.107
Biomass-Syn-Fuels	0.033	0.067	0.135	0.052	0.105	0.213
Biomass-Electric	0.209	0.250	0.292	0.670	0.897	1.120
Passive Solar	0.283	0.567	0.800	0.467	0.933	1.169
OTEC	0.445	0.667	0.874	0.898	1.134	1.676
Hydroelectric ^a		0.234			0.414	

^aBechtel Estimate

Source: Unit labor estimates computed from data presented in:

- a - Systems Description and Engineering Costs for Solar-Related Technologies, Volume I, Summary. The Mitre Corporation, Metrek Division, June 1977.
- b - Systems Description and Engineering Costs for Solar-Related Technologies, Volume III, Agricultural and Industrial Process Heat. The MITRE Corporation, Metrek Division, June 1977.
- c - Escalation in the Costs of Manpower, Materials, and Equipment Needed for Energy Facilities, the Bechtel Corporation, October 1977. Resource Requirements, Impacts, and Potential Constraints Associated with various energy futures. Bechtel National, Inc., March 1978.
- d - Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume VII, Ocean Thermal Energy Conversion. The MITRE Corporation, Metrek Division, June 1977.
- e - Systems Description and Engineering Costs for Solar Related Technologies, Volume IX, Biomass Fuels Production and Conversion System, The MITRE Corporation, Metrek Division, June 1977.

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
b	100-150°F hot air plastic curing	29,565 MMBTU				0.670	26.48	15.89	1.33
c	Hydroelectric dam, and power plant	Baseload	0.981 x 10 ⁹ KWH			0.234	8.46	4.93	0.414
d	OTEC 4 plants	Baseload	266.5	0.61		0.974	33.28	19.97	1.676
d	OTEC 7 plants	Baseload	264.5	0.61		0.445	17.83	10.70	0.898
e	Biomass-Methanol		3.82 x 10 ⁶ MMBTU			0.135	4.23	0.213	
e	Biomass-Medium Btu gas		6.34 x 10 ⁶ MMBTU			0.33	1.03	0.62	0.052
e	Biomass-Substitute Natural gas		5.58 x 10 ⁶ MMBTU			0.066	2.09	1.25	0.105
e	Biomass-Process Heat 850 ODT/day	Steam	3.86 x 10 ⁶ MMBTU			0.064	2.01	1.20	0.101
	1700 ODT/day	Steam	8.40 x 10 ⁶ MMBTU			0.045	1.43	0.88	0.072
	3400 ODT/day	Steam	17.64 x 10 ⁶ MMBTU			0.035	1.09	0.66	0.055

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	WECS with Hydroelectric hybrid	Intermed.	100	0.48 18 mph	0.0054*	0.235	17.96	15.02	1.26
a	Advance WECS with gas turbine	Intermed.	100	0.49 14 mph	0.0050*	0.226	21.08	18.26	1.53
	Advanced WECS with combined cycle	Baseload	100	0.87 18mph	0.0085*	0.204	13.58	11.03	0.93
a	WECS	Fuel Sav.	1.5 (22.4 mph)	0.30	0.0051*	0.355	23.02	18.58	1.56
a	Advanced WECS	Fuel Sav.	1.5 (17.1 mph)	0.65	0.0085	0.273	14.04	10.63	0.89
a	Wood Fired Steam Plant	Intermed.	100	0.50	0.007	0.292	17.05	13.25	1.12
a	Wood Fired Steam Plant	Baseload	100	0.80	0.008	0.209	10.65	8.04	0.67
b	Solar Heated Textile Processing Water		68,750 MMBTU			0.330	8.73	9.00	0.50
b	50-100°F Hot air grain Dryer		70,200 MMBTU			0.219	9.85	7.11	0.59
b	50-100°F Hot water can washing system		38,250 MMBTU			0.187	9.22	6.88	0.57

Source	Technology	Demand Type	Plant Capacity	Capacity Factor	Fabrication/Shipping/Install.		Capital Costs	Material Costs	Indirect Labor
			MW		MY/KW	MHR/MMBTU	\$/MMBTU	\$/MMBTU	MHR/MMBTU
a	Solar Thermal Central Receiver, 3 hour storage	Semi Peak	100	0.35	0.013	0.774	31.93	22.26	1.87
a	Solar Thermal Central Receiver, 6 hour storage	Semi Peak	100	0.50	0.017	0.708	32.69	23.84	2.00
a	Solar Thermal Central Receiver	Fuel Saver	100	0.30	0.010	0.695	32.69	24.00	2.01
a	PV with Storage Collector/Reflector 16% Si	Semi Peak	100	0.30	0.025	1.418	44.33	26.57	2.23
a	PV with Storage Collector/Reflector 10% Thin Film	Semi Peak	100	0.30	0.041	1.110	34.82	20.85	1.75
a	PV with Storage Collector/Reflector/16% silicon	Intermed.	100	0.45	0.04	1.540	48.20	28.96	2.43
a	PV with Storage Collector/Reflector/10% Thin Film	Intermed.	100	0.45	0.067	1.230	38.56	23.12	1.94
a	PV with Storage IOX Concentrating/Verticle Tracking	Intermed.	100	0.45	0.045	2.110	65.86	39.44	3.31
a	PV Collector/Reflector/16% Silicon	Fuel Saver	100	0.28	0.017	1.070	33.43	20.02	1.68
a	PV Collector/Reflector/10% Thin Film	Fuel Saver	100	0.26	0.027	0.810	25.46	15.25	1.28
a	PV 10XCPC/16% Silicon	Fuel Saver	100	0.30	0.035	2.020	63.17	37.89	3.18

TO 2000

Solar Technology	Quads Displaced in 2000	Direct Labor Requirements			Indirect Labor Requirements			Total Labor Requirements		
		Man-Years (10 ⁶)			Man-Years (10 ⁶)			Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Maximum Quads Displaced										
Solar Hot Water, Heat and Cooling	2.0	1.088	1.368	1.648	2.176	2.736	3.300	3.264	4.104	4.948
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.490	0.610	0.400	0.790	1.030
Wind	1.5	0.160	0.205	0.280	0.705	0.970	1.230	0.865	1.175	1.510
Solar-Process Heat	2.0	0.200	0.340	0.710	0.530	0.590	1.400	0.730	0.930	2.110
Solar Thermal Electric	0.5	0.185	0.190	0.205	0.490	0.515	0.530	0.675	0.705	0.735
Photovoltaics	1.5	0.645	1.110	1.665	1.470	1.755	2.610	2.115	2.865	4.275
Biomass	4.5	0.090	0.117	0.162	0.135	0.180	0.252	0.225	0.297	0.410
OTEC	0.1	0.023	0.035	0.046	0.047	0.060	0.088	0.070	0.095	0.134
Hydro	0.5		0.059			0.109			0.168	
Total	18.4		3.724			7.405			11.129	

Physical Quad Limit

Solar Hot Water, Heat and Cooling	4.0	2.176	2.736	3.296	4.352	5.472	6.000	6.528	8.208	9.896
Passive Solar	1.0	0.150	0.300	0.420	0.250	0.490	0.610	0.400	0.790	1.030
Wind	3.0	0.320	0.410	0.560	1.410	1.940	2.460	1.730	2.350	3.020
Solar Process Heat	3.5	0.350	0.595	1.243	0.928	1.033	2.450	1.278	1.628	3.693
Solar Thermal Electric	1.5	0.555	0.570	0.615	1.470	1.545	1.590	2.025	2.115	2.205
Photovoltaic	2.5	1.075	1.850	2.775	2.450	2.925	6.350	3.525	4.775	7.125
Biomass	5.2	0.104	0.135	0.187	0.156	0.208	0.291	0.260	0.343	0.478
OTEC	1.0	0.230	0.350	0.460	0.470	0.600	0.880	0.700	0.950	1.340
Hydro	2.0		0.236			0.436			0.672	
Total	28.5		7.182			14.649			21.831	

CUMULATIVE LABOR REQUIREMENTS

TO 2000

Solar Technology	Quads Displaced in 2000	Direct Labor Requirements			Indirect Labor Requirements			Total Labor Requirements		
		Man-Years (10 ⁶)			Man-Years (10 ⁶)			Man-Years (10 ⁶)		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Low Price Scenario \$18/bbl										
Solar Hot Water, Heat, Cooling	0.5	0.272	0.342	0.412	0.544	0.684	0.825	0.816	1.026	1.237
Passive Solar	0.1	0.015	0.030	0.042	0.025	0.049	0.061	0.040	0.079	0.103
Wind	0.3	0.032	0.041	0.056	0.141	0.194	0.246	0.173	0.235	0.302
Solar-Process Heat	0.2	0.020	0.034	0.071	0.053	0.059	0.140	0.073	0.093	0.211
Solar Syn-Fuels	0.1	0.002	0.003	0.007	0.003	0.006	0.011	0.005	0.009	0.019
Biomass-Process Heat	0.2	0.004	0.005	0.007	0.006	0.008	0.011	0.010	0.013	0.017
Biomass-Electric	0.1	0.022	0.026	0.031	0.071	0.094	0.118	0.093	0.120	0.149
Biomass Syn-Fuels	0.2	0.003	0.007	0.014	0.006	0.011	0.022	0.009	0.018	0.036
Total	3.5	0.370	0.488	0.640	0.849	1.105	1.434	1.219	1.593	2.075
Mid Price Scenario \$25/bbl										
Solar Hot Water, Heat, Cooling	1.0	0.544	0.684	0.824	1.088	1.368	1.650	1.632	2.052	2.474
Passive Solar	0.2	0.030	0.060	0.084	0.050	0.098	0.122	0.080	0.158	0.206
Wind	0.6	0.064	0.082	0.112	0.282	0.388	0.492	0.346	0.470	0.604
Solar Thermal Electric	0.1	0.037	0.038	0.041	0.098	0.103	0.106	0.135	0.141	0.147
Photovoltaic	0.1	0.043	0.074	0.111	0.098	0.117	0.174	0.141	0.191	0.285
Solar-Process Heat	1.0	0.100	0.170	0.355	0.265	0.295	0.700	0.365	0.465	1.055
Solar Syn-Fuels	0.2	0.004	0.006	0.014	0.006	0.012	0.022	0.010	0.018	0.038
Biomass-Process Heat	0.5	0.010	0.013	0.018	0.015	0.020	0.028	0.025	0.032	0.046
Biomass Electric	0.2	0.044	0.052	0.062	0.142	0.188	0.236	0.186	0.240	0.298
Biomass Syn-Fuels	0.3	0.005	0.011	0.021	0.009	0.017	0.033	0.014	0.027	0.054
Total	6.0	0.881	1.190	1.642	2.053	2.606	3.563	2.836	3.796	5.205
High Price Scenario \$32/bbl										
Solar Hot Water, Heat, Cooling	1.3	0.707	0.889	1.071	1.414	1.778	2.145	2.122	2.668	3.216
Passive Solar	0.3	0.045	0.090	0.126	0.075	0.147	0.183	0.120	0.237	0.309
Wind	0.9	0.096	0.123	0.168	0.423	0.582	0.738	0.519	0.705	0.906
Solar Thermal Electric	0.2	0.074	0.076	0.082	0.196	0.206	0.212	0.270	0.282	0.294
Photovoltaic	0.2	0.086	0.148	0.222	0.196	0.234	0.348	0.282	0.382	0.570
Solar-Process Heat	1.4	0.14	0.238	0.497	0.371	0.413	0.98	0.511	0.651	1.477
Solar Syn-Fuels	0.4	0.008	0.012	0.028	0.012	0.024	0.044	0.020	0.036	0.072
Biomass-Process Heat	1.0	0.020	0.026	0.036	0.030	0.040	0.056	0.050	0.066	0.092
Biomass Electric	0.6	0.132	0.156	0.186	0.426	0.564	0.708	0.558	0.720	0.894
Biomass Syn-Fuels	0.6	0.010	0.022	0.042	0.018	0.034	0.066	0.028	0.054	0.108
Total	8.7	1.318	1.780	2.458	3.161	4.022	5.480	4.479	5.801	7.938

PRELIMINARY ESTIMATES OF LABOR COEFFICIENTS FOR SOLAR ENERGY TECHNOLOGIES

DPR Solar Impacts Panel: Employment Impacts Group

Table I presents preliminary results on coefficients for direct (design and construction) and indirect (labor required to produce installed capital) for 5 technology types. Another component, operation and maintenance labor, is omitted due to the lack of operating experience with most of these technologies. (It appears to constitute about 5 percent of the direct requirements for the heat and hot water technologies).

Construction
Related

Table I
Labor Hours per MMBTU of Annual Output (Fossil Equivalents)
(Range of Uncertainty is $\pm$ Factor of 2)

	<u>Direct</u>	<u>Indirect</u>	<u>Total</u>
Solar Hot Water	4.2	9.3	12.5
Solar Heat/Hot Water	4.9	12.9	17.8
OTEC	1.3	2.9	4.2
Solar Thermal	1.3	1.9	3.2
Wind	1.0	2.7	3.7

The table indicates that there are two divisions to the technologies. The flat-plate collector types, hot water and hot water/space heat, seem to require a good deal more labor and capital per BTU than the others. It is not known at this stage whether this reflects the economies of scale involved in energy production or simply the considerable error ranges which must be attached to these estimates. The first two technologies represent reasonable averages taken from the welter of design studies and actual reported experience available

on solar heat and hot water installations. Enough variation exists among these data to justify easily a range on the order of a factor of two. The other coefficients are based on engineering studies primarily and until actual experience is available, greater variation than we attached to the first two technologies must be assumed.

Other Technologies

Gross labor coefficient estimates have been obtained for Agricultural and Industrial Process Heat, Biomass conversion, and Photovoltaic, but they are still so rough that they are not shown here. We expect to have these refined to more reasonable limits within a few days.

Considerable work has been done on the amorphous area of passive solar. We have identified a set of material which seems to characterize most recent passive solar applications. Although the magnitudes are not definite, there seems to be additional labor input required for passive, particularly in the architectural or design phase. There may also be additional construction labor requirements, but these do not seem to be of a qualitatively different sort than now required by conventional construction.

We are in the process of checking these estimates with other analysts such as Bob Herendeen of the Center for Advanced Computation and comparing them with similar measures for conventional energy production for consistency and reasonableness.

"Labor Costing" the Base Case

We have received computer runs from Bechtel in San Francisco on the direct labor and capital requirements for the conventional technologies assumed in the three scenarios constituting our base case. Indirect labor requirements are being calculated and these data will be merged with the estimates we are deriving for solar technologies to complete the assessment of labor demands implied by the base case. We will also ask Bechtel to run some 1-quad changes in conventional energy production for selected conventional sources to facilitate the "conventional offset" analysis of solar expansion options.

BACKGROUND PAPER:

Solar Financing

The Solar Domestic Policy Review identified three generic classes of financial barriers which hinder the use and acceptance of solar technology in residential commercial and industrial markets. The three categories are

- Risk: According to results developed by the DPR, purchasers of solar equipment are denied adequate credit on favorable terms for solar equipment because of the risks associated with the technology. This risk impairs the credit-worthiness of potential solar loans. Additionally, there is a market risk borne by the user due to the newness of the technology.
- Liquidity:
Purchasers of solar equipment do not have access to adequate capital to meet needs.
- Subsidy:
In order to overcome the high initial capital cost of solar equipment, subsidies may be necessary to stimulate the demand for solar equipment.

Specific financial barriers such as credit terms for new solar homes, public and private appraisal policies, and loan capital cost ceilings fall within these generic classes of financial barriers.

A number of government programs and institutions have been designed to overcome the same set of barriers (i.e. risk, subsidy, liquidity) in the housing market. These program^(s) and institutions are described briefly in Attachment I. An important part of the policy debate on how to overcome financing barriers for solar is whether or not the existing financial institutions serving the housing market (e.g. FHA, FNMA) can be used to overcome the financing barriers which hinder the use of solar technology. That is, can or should these programs and institutions be expanded to include solar initiatives? Or, alternatively, should a new institution be set up to deal with solar financing problems?

Policy initiatives advanced to remove the barriers described above have focused on changes in two sets of financial activities (private and public):

- Direct lending programs operated by the government or by private banks.
- Secondary financing organizations (i.e. FNMA, GNMA) which provide liquidity and security to mortgage lenders.

These policy initiatives have concentrated on achieving the following objectives:

- changing financing practices in the residential sector by forcing consideration of energy factors in lending decisions (e.g. changing appraisal practices).
- providing subsidies to purchasers of solar equipment by lowering interest rates and increasing amortization periods.

ATTACHMENT I

How Current Institutions Help Overcome

Housing Market Financial Barriers

Barrier	Organization	Method
Risk	FHA	Insures mortgages, home improvement loans
	VA	Guarantee
	GNMA	Guarantee
	MGIC, PMI (etc)	Insures mortgages
Liquidity	FNMA, GNMA, FHLMC	Operates secondary market
Subsidy	HUD - FHA - GNMA	<ul style="list-style-type: none"> Below market interest rates for mortgage/home improvement loans (subsidy goes to developer/owner) Direct payments for rent made to owner-operator FHA insurance, VA guarantees extend term of loan, lower down payment requirements

- increasing the liquidity for lenders who lend on solar equipment.
- assuming, through governmental guarantees, the risks of lending on solar systems.

There have been three broad classes of policy options considered to accomplish the above objectives:

1. Modify existing governmental programs and institutions (e.g., GNMA, FNMA) so that these institutions more effectively promote the use of solar
2. Create a new and separate institution to undertake a number of financing functions, primarily as a secondary financing entity (but with standby direct lending authority). Such an institution would encourage lending for solar systems and homes by existing lenders.
3. Create a direct federal loan program.

Each option can mitigate each of three generic barriers to a greater or lesser degree (See Attachment 2: "Examples of How Options Would Overcome Barriers" on following page). Each option, however, has its own set of relative strengths, weaknesses and costs. For example:

- Option 3 (direct lending) offers the surest and fastest means of providing funds directly to solar users. Use of direct lending, however, would mean large federal outlays, federal preemption of private lending functions, and creation of a large federal bureaucracy.

ATTACHMENT 2

EXAMPLES OF HOW OPTIONS WOULD OVERCOME BARRIERS

BARRIER	OPTION 1 (Modify Existing Programs)	OPTION 2 (New Federal Institution)	OPTION 3 (Direct Federal Lending)
Risk:	FHA guarantees rules modified to give special consideration to solar loans	Solar bank guarantees solar loans made by private lenders	Federal Government assumes risk of lending to solar users
Liquidity:	FNMA, GNMA, FHLMC facilities used with appropriate modifications	Solar bank operates new secondary market for solar loans	Federal Government borrows at its costs lends directly to solar users at a rate set by government policy makers
Subsidy:	Use of NEA tax credits	Solar bank subsidizes below market interest rate mortgage and .	Federal Government lending rate can be set at any level thought necessary to stimulate solar demand

- Option 1 would use existing institutions and would therefore cost less than Option 3 but would require legislative and administrative changes which could be time consuming to achieve.

In evaluating these options, therefore, it is important to thoroughly understand:

- the barriers to be overcome in each market segment (e.g., residential hot water, residential heating and cooling, commercial and industrial use).
- the effectiveness of policy tools available to overcome these barriers (e.g., tax credits, direct loans, interest subsidies).
- the costs (administrative and direct) of implementing each option.

Current Situation

Many solar groups strongly favor creating a separate Solar Bank which would perform some of the financing functions currently performed by institutions such as FNMA and GMA, as well as new functions. The purpose of the bank would be to overcome the generic financial barriers cited by the DPR. A separate bank is thought necessary because:

- it would be a highly visible entity and symbol of federal commitment
- it could channel capital to solar without large federal outlays

- it could rapidly develop the necessary lending policy standards and procedures necessary to get solar into the marketplace.
- it could independently develop and implement innovative lending programs necessary for solar commercialization without having to integrate such programs into existing Federal programs.

Two major arguments have been made for not using existing institutions and programs:

1. Existing institutions and programs may be limited, by legislation, charter or regulation, in their ability to rapidly and adequately address solar financing needs. Changing legislative and regulatory authorities may be time consuming.
2. Existing institutions have a broad range of concerns (financing housing construction, providing loan guarantees for subsidized housing), therefore, they may not be willing to give solar the high policy priority it may require.

Analysis of Issues in the Current Policy Debate

As pointed out above, the principal issue in the solar financing debate is whether or not existing programs and institutions designed primarily to serve the housing market can be modified to effectively overcome the financial barriers faced by solar. The alternative to modifying these institutions and programs is to create a new institution to specifically overcome the financial barriers identified by the DPR. Initial analysis indicates that a number of questions outlined below remain, as yet, unanswered.

These questions include:

1. Is the entire range of solar uses uniformly affected by all three generic categories of barriers? Or, does each market segment representing a specific form of solar use (e.g. solar hot water heating) face a unique set of barriers which require a tailored set of actions to overcome?
2. How would each policy option affect the barrier in each market segment and at what cost?
3. Is it necessary to segregate lending to solar equipped homes from other residential lending? Can such lending be done within existing institutions?
4. Do existing institutions have the capability to meet current and projected loan demands, or, will a new solar-related institution be required?
5. Are there other policy tools available which could be used to overcome the barriers cited at lower cost, with greater effectiveness, and in less time?
6. Will the creation of a new institution be disruptive or conflict with existing financial institutions?
7. Will the creation of a separate organization specifically designed for solar financing hinder the ultimate acceptance of solar as a viable energy alternative (i.e., will solar continue to be viewed as an exotic energy form if it is necessary to have special financing devices necessary to assure its use)?

8. Is it necessary to create a large broad-scale organization to address the broad range of solar financing problems?
Or, can more targeted and focused programs address specific problems?
9. Can, or should solar financing programs designed to serve the housing market be merged with or separated from programs designed to serve the commercial/industrial market?

Because these questions are unanswered at this time, there is no good analytical basis for choosing which broad class of options should be used to overcome the financial barriers to solar. Despite this lack of specific information as to the comparative costs/benefits and impacts of each class of options, there is a strong demand for immediate action. This demand, particularly among solar advocate groups, focuses on the need to create a separate solar development bank which would have a broad range of functions (See Attachment 3 for a summary of the functions to be performed under the Option 2 solar development bank). As pointed out above, however, this option may:

- be more costly than modifying existing programs
- create a new and cumbersome institution and set of processes which will have to interface with existing institutions anyway
- be disruptive to existing programs
- potentially impede the acceptance of solar
- not be as cost/effective as other possible/potential options

Recommendations

In light of the concerns discussed above, it may be appropriate to recommend that more analysis of the cost/benefit and impacts of Options 1 and 2 be undertaken. If the decision is made to select Option 2, decisions as to the specific functions and status of the new organization should be deferred, pending further interagency study and analysis.

Attachment 3

Proposed Functions of the Solar Development Bank

(Option #2)

The Solar Development Bank would establish six programs to meet solar needs, as identified by the DPR. The proposed program would create:

1. An FHA subsidized home improvement loan purchase program.
2. An FHA and conventional home improvement loan purchase program.
3. A solar refinanced conventional and FHA/VA insured mortgage purchase program.
4. A lending program for solar refinanced conventional and FHA/VA insured mortgages and new conventional and FHA/VA insured mortgages.
5. A conventional solar mortgage purchase program.
6. An FHA/VA insured solar mortgage purchase program.

APPENDIX

Functions and Participants in the Secondary Mortgage Market

Functions of the Secondary Mortgage Market

The creation and function of the secondary mortgage market grew out of an inability, by private lending institutions, to keep pace with a growing national demand for mortgage money. The existence of a secondary market has served to help address the supply - demand imbalance by providing an opportunity to mortgage lenders, to recoup lost liquidity (lendable funds) by selling their mortgages in the secondary market to either government institutions or private investors. This access to liquidity permits the lending institution to make a greater number of loans than would otherwise be possible in the absence of a secondary market. This is because the secondary market frees lenders from making mortgage loans in direct proportion to savings deposits. Moreover, the presence of a secondary market permits organizations such as mortgage bankers, to make loans even in the absence of savings deposits. In addition, the secondary market has had a stabilizing influence on the residential construction industry. That is, it has helped assure a constant, though changing, flow of funds into the residential construction industry by assuring an adequate supply of lendable funds for construction purposes.

It is important to point out, however, that the mortgage lender gains more than just liquidity when he sells a mortgage in the secondary market. For example, lenders usually charge an "originating fee" plus a "service fee" when loans are sold. The originating fee is simply to compensate for the initial paper work, etc.; the service fee is to pay for subsequent collections and disbursements of monthly mortgage payments. Thus, the

combination of access to liquidity and potential fee income serve as strong inducements to the mortgage lender to participate in the secondary market.

Institutional Participants

There are several institutions which operate in the secondary mortgage market; however, for the purposes of this paper, only three are discussed in brief: Federal National Mortgage Association (FNMA-"Fannie Mae"), Government National Mortgage Association (GNMA-"Gennie Mae"), and the Federal Home Loan Corporation (FHLMC-"Freddie Mac").

Federal National Mortgage Association

The Federal National Mortgage Association has the authority to purchase and sell several different types of mortgages. These include:

- Federal Housing Administration (FHA) insured mortgages
- Veterans Administration (VA) guaranteed loans
- Mortgages backed by securities guaranteed by the government National Mortgage Association (GNMA)
- Conventional mortgages not federally underwritten

Typically, these loans are purchased from savings and loan associations, insurance companies, and banks or large mortgage bankers. The purchase prices are determined through a "Free Market System Auction," conducted biweekly at prevailing secondary market rates. Lenders may submit bids for consideration, either at a competitive price or at the mortgage price of the auction day. If a lender sells a mortgage to FNMA, he may qualify as an eligible servicer by the Association's standards, sign a servicing agreement,

and continue to service the loan. If not, he will provide FNMA with an acceptable service agreement. Although the major emphasis has been in the area of mortgage purchases, at times an equally important function may be mortgage sales. Inherent in the performance of secondary market functions is that under certain conditions it is in the best interest of an orderly market that FNMA be a seller as well as a buyer. Sales from the portfolio of the secondary market operations are made at prices based on prevailing prices for similar classes of mortgages in the general secondary market.

Government National Mortgage Association

The government National Mortgage Association has three primary functions. The first function is to purchase or make commitments to purchase, service, and sell any mortgages offered to it by HUD where the Secretary has deemed their acquisition to be in the best interest of efficient management and liquidation. The second function is to provide special assistance in connection with certain residential mortgages when the President determines that such assistance is in the best public interest. This assistance usually takes the form of purchases or commitments to purchase loans made on houses in underdeveloped areas, pending the establishment of their marketability.

The third primary function is to guarantee the timely payment of the principal and interest on securities that are based on or backed by a pool of mortgages insured by the FHA or the Farmers

Administration or those guaranteed by the VA. The Department of Justice has rendered an opinion that the GNMA guarantee constitutes the full faith and credit of the United States and the Treasury has ruled that GNMA may properly borrow from the Treasury to meet its obligations.

Federal Home Loan Mortgage Corporation

"Freddie Mac" is designated to serve as a secondary market facility for real estate mortgages under the sponsorship of the Federal Home Loan Bank System. The FHLMC has the authority to buy and sell FHA and VA loans, conventional loans, and mortgage participations. It was created to improve secondary market facilities for residential conventional mortgages which have not had the benefit of federal insurance or guarantees.

	PURPOSE	SOURCE OF FINANCING	FUNCTIONS
<p>FNMA est. 1938</p>	<p>1) Provide secondary market for federally insured mortgages.</p>	<p>1) Original capital and surplus (\$10 m) (\$1 m) 2) Issuance of FNMA debentures and short term notes. 3) Issuance of long term subordinate notes. 4) Issuance and marketing of securities backed by pools of mortgages.</p>	<p>1) Buy and sell both federally insured or guaranteed mortgages and conventional mortgages. 2) Direct lending on FHA-insured first mortgages. 3) Buy and sell loans for construction and modernization of hospitals. 4) Absorb losses from ownership and disposition of federally insured mortgages.</p>
<p>GNMA est. 1968</p>	<p>1) Management and liquidation of mortgages held. 2) Special assistance lending in support of federal programs. 3) Guarantee eligible mortgages.</p>	<p>1) Borrowing from US Treasury. 2) Interest from mortgages held. 3) Purchase and marketing fees. 4) Issuance of debentures.</p>	<p>1) Review all applications for issuance of certificates on pools of mortgages. 2) Purchase and sale of FHA/VA mortgages in cooperation with FNMA. 3) Backing of certificates for interest rate futures options. 4) Guarantees securities issued by FHA, Farmers Home Administration or VA.</p>
<p>FHLMC est. 1970</p>	<p>1) Provide secondary market for mortgages sponsored by Federal Home Loan Bank System 2) Particularly to provide for residential <u>conventional</u> mortgage secondary market.</p>	<p>1) Federal Home Loan Bank Capital Shares (\$100 m). 2) Borrowing from FHLB. 3) Issuance of GNMA-guaranteed mortgage-backed bonds. 4) Issuance of participation sale certificates. 5) Direct sale of mortgages held.</p>	<p>1) Over-the-counter continuous purchase and sale of mortgages and securities backed by mortgages. 2) Establishment of AMMNET (Automated Mortgage Market Information Network). 3) Offering commitments to purchase mortgages.</p>

Alteration of the NEPA Process to Ensure that Renewable
and Conservation Alternatives are Given Appropriate
Consideration

Statement of Need/Opportunity

Title I of the National Environmental Policy Act (NEPA) requires both a detailed statement of alternatives to major proposed federal actions within the context of an environmental impact assessment (Sec. 102.2 Ciii) and the study, development, and description of alternatives where unresolved conflicts concerning use of available resources are involved (Sec. 102.2E). Compliance with the spirit of these provisions clearly requires detailed consideration of the extent to which conservation policies and programs and the use of renewable energy sources are viable and cost-effective alternatives to proposals that utilize conventional energy sources (e.g., siting of LNG import facilities, construction of oil pipelines, granting of coal mining leases, siting of electric power plants, licensing of nuclear fuel cycle facilities). Yet the full range of conservation and renewable options are not always considered in such decisions, in part because of the lack of a reliable data base and in part because of a lack of initiative among the concerned decision-makers to explore the full spectrum of renewable and conservation strategies possible using state-of-the-art technology. The Council on Environmental Quality (CEQ) has recently promulgated a set of proposed regulations to implement the procedural provisions of NEPA (40 CFR 1500-1508, Federal Register Vol. 43, No. 112, June 9, 1978). These proposed regulations make several references to the consideration of alternatives, in particular: reiteration of the NEPA mandate to study, develop, and describe alternatives where

conflicts concerning resource use exist (1501.2c, 1507.2d); an exhortation for agencies to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for such elimination" (1502.14a); and specifications that energy requirements, natural or depletable resource requirements, and both energy and resource conservation potential of the proposed action and alternatives be analysed (1502.15e,f). The proposed regulations also instruct federal agencies to adopt implementation procedures within eight months after their final adoption. Thus an excellent opportunity presently exists to increase the level of consideration given to renewable and conservation options by either: (a) specifying the nature of the treatment of these alternatives in the agencies' implementing procedures; or (b) suggesting revision of the CEQ regulations themselves to add more specific statements concerning the consideration of renewable energy sources and conservation.

Background

Until very recently, conservation and renewable energy sources have not been routinely considered as alternatives to increased supplies of conventional energy sources in energy supply planning. This situation is rapidly changing for a number of reasons:

- increased fuel prices;
- increasing problems with availability of conventional sources;
- environmental difficulties with fossil fuels and socio-political problems with nuclear energy;

- increased R&D on conservation and renewables, leading to improvements in the technical and economic status of these options; and
- increased public awareness of and interest in conservation and renewables.

As a result, the use of improved conservation measures (e.g., more fuel-efficient cars, better insulated and more tightly constructed buildings) and certain solar technologies (e.g., hot water and space heating in some regions, energy from paper and pulp waste) has been steadily increasing in applications where these techniques have been shown to be cost-effective. An interesting case is that of hydropower, where the changed economic, political, and institutional situation has led to plans for the reactivation of dams that were retired from electricity production in the past era of falling energy prices, the consideration of expansion of hydropower facilities at many existing dams as a cost-effective way of producing electricity, and a groundswell of local interest, especially in New England, in a variety of small hydroelectric projects.

Despite these advances, in many cases conservation and renewable alternatives are simply not considered or are dismissed out of hand when expansion of conventional supplies are considered. In some cases the conservation or renewable options are not competitive from an overall cost point of view. But in others their non-viability is incorrectly inferred because of, e.g., the use of out-of-date technical or economic analyses; improper assumptions concerning the need for infrastructure or institutional

adjustments; or unwarranted assumptions about the social acceptability of specific methods of energy conservation, production, transportation, storage, or end use. This field is rapidly developing, and the number of cases in which conservation and renewable alternatives will be cost-effective when compared with proposals to develop conventional sources will be increasing in the future. The purpose of the options described below is to ensure that proper consideration is given to these rapidly evolving alternatives so that in every case where their adoption is cost-effective it is actually made. The options should be viewed as attempts to facilitate the earliest possible adoption of cost-effective conservation and renewable alternatives, i.e., as speeding up a process that would eventually occur, but might otherwise take very much longer.

Description of Options

Option A: Specify that the agency implementing procedures required by CEQ's proposed NEPA regulations at a minimum include in their treatment of alternatives:

- 1) A requirement to develop a framework for the analysis of alternatives that specifies the amenities or end uses that will result from the energy supplied by or other aspects of the proposed federal action. All reasonable alternative means of providing these amenities or end uses must then be considered as to: their efficiency of use of energy and resources; their overall cost-effectiveness, including social and environmental costs; their requirements for the use of depletable resources; their overall flexibility and vulnerability; and their effect on existing

federal, state and local conservation programs, as well as those embodied in executive and legislative proposals in existence at the time at federal, state, and local levels. These alternatives will explicitly include state-of-the-art conservation and renewable options. The framework for analysis of alternatives will be developed in advance of the scoping process required by Section 1501.7 of the proposed CEQ regulations, so that all interested agencies and persons can have the opportunity to contribute to the identification of reasonable alternative means of providing the desired amenities or end uses.

2) A requirement that in the consideration and evaluation of alternatives the latest state-of-the-art technical and economic data and social, institutional, and political analyses be used. The data for evaluation of conservation and renewable alternatives should include: the latest results of government-sponsored studies; all available National Laboratory analyses; the work of independent University and research laboratory groups; the statements and assessments of public interest and intervenor organizations; and all available state, local and regional studies. In addition, the NEPA requirements (Section 102.2A,B) to utilize a systematic interdisciplinary approach that integrates natural and social sciences and the environmental design arts and to develop methods and procedures to ensure that unquantified environmental amenities and values are given appropriate consideration will be implicitly obeyed in the evaluation.

3) For those alternatives that are eliminated as non-viable, in keeping with the spirit of Section 1502.14 of the proposed CEQ

regulations, a requirement to provide a specific statement of the manner in which the determination of non-viability was arrived at. This statement should include an identification of the major factors in the determination (e.g., economics, social acceptability, infrastructure or institutional problems), the sources of data used in the determination, and a convincing description of the logic used in arriving at the result. It should also estimate the potential for changes in these major factors on a timescale consistent with the lead time required for the proposed action.

Option B: Make the following changes to the proposed CEQ regulations:

- 1) Add as Section 1501.7a9: Consider ways in which conservation measures and the use of renewable energy sources could compete with the proposed action and obtain the views of all interested participants in the scoping process on this subject.

- 2) Revise Section 1502.14a to read as follows: Rigorously explore and objectively evaluate all reasonable alternatives, including conservation measures and the use of renewable energy sources, and for alternatives which were eliminated from detailed study, provide a statement that describes the specific reasons for such elimination. This statement should include an identification of the major factors involved in the decision, the sources of data relied upon, and the logic used in arriving at the result. It should also estimate the potential for changes in these major factors on a timescale consistent with the lead time for the proposed action.

Item (1) expands the instructions for the initial scoping process to ensure that conservation and renewable options are

considered as possible alternatives at the outset of the NEPA process. Item (2) adds specific language concerning conservation and renewables to the instructions to explore alternatives and strengthens and makes more specific the requirement to explain the reasons for eliminating alternatives from detailed consideration (the proposed regulations only require that the agencies "briefly discuss" these reasons).

Discussion of Options

Neither of these options requires any legislation. Option A could be accomplished either through an Executive Order to the agencies or through a CEQ Guideline concerning implementation of the proposed regulations. Option B could be accomplished simply through amendment by CEQ of the proposed regulations. Neither option leads explicitly to any budget requirements, although both have the potential for expanding the NEPA process in a way that could lead to increased expenditures. A counter force to this is that the proposed regulations are in fact designed to reduce overall paperwork and delay in NEPA implementation. These options are not inconsistent with each other, and could be implemented either separately or together. Some important aspects of Option A would not be covered by the implementation of Option B alone, e.g., the focus on amenities and end uses and the requirement to seek out and use the full state-of-the-art data base in the evaluation of conservation and renewable alternatives.

Anticipated Impacts

The potential impacts of these options are extremely difficult to quantify for two reasons. First, NEPA applies only to federal actions, so that the effect of altering the NEPA process on important actors such as industries, utilities, or state and local regulators has to be traced through a two or three step, or even longer, process, thus making accurate estimation of the impact difficult. The effect is real, however, and should not be ignored. For example:

- state and local governments often use the federal approach as a model in designing their own procedures, and adopt the results of federal evaluations and impact assessments;
- federal regulators must often provide explicit instructions to potential licensees or to organizations that must adhere to federal guidelines or standards as to the methodology and data to use in making impact evaluations; and
- federal funding of R,D&D programs can often be used as a "handle" to require applicants to utilize specified techniques, methods, and procedures for impact evaluation and mitigation, and to consider a broad spectrum of alternatives.

The second factor that makes the quantitative assessment of impacts difficult is that the impact of these options depends to a great extent on future developments, both in the cost-effectiveness of conservation and solar alternatives and in the range of proposed actions that fall under the purview of NEPA. However, while one cannot describe in detail their actual impacts, it is clear that

these options can serve to accelerate the implementation of state-of-the-art conservation and renewable alternatives to the increased use of conventional energy sources by forcing detailed comparisons at an early stage of the NEPA process that might not otherwise take place until much later, if at all.

Advantages and Disadvantages

The principal advantage of these options is stated above-- improved penetration of conservation and renewable energy sources resulting from the requirement that they be fully considered as alternatives in the NEPA process. Disadvantages are that the options could lead to increased efforts to evaluate alternatives that are not viable, overblown assessments and comparisons, or lengthy and potentially unproductive discussions of the reasons for elimination of certain alternatives. These could in turn lead to increased paperwork and delay of the NEPA process, exactly the things that the proposed CEQ regulations are intended to avoid. However, these are the standard risks taken when any requirements are added to the NEPA (or any other) implementation process, and they can be reduced substantially if the selection and evaluation of alternatives is performed in a careful and forthright manner.

Topic 3: What recommendations for an overall solar strategy should the Administration make?

Undertaking a vigorous solar strategy is well within the present capabilities of the Nation. The Domestic Policy Review has identified a number of areas where the initiatives of the National Energy Act can be expanded and enhanced. These include federal, state and private efforts that can either be revised and refocused and new activities that should be initiated.

A federal strategy to advance solar must be structured differently than previous "crash" national efforts, since its eventual goal is to promote the use of a number of specific technologies in a free-market environment. The strategy should strive to eliminate the economic advantages given to competing energy sources, to expedite dissemination of the information required by consumers to make reasoned energy-use decisions, and to establish an institutional framework in which states and local governments can work with the federal government to resolve the institutional issues that could infringe on solar development.

Although the long-term viability of solar energy depends upon business, industry, utilities, and governments working with minimal federal involvement, there are clearly several areas where federal attention is needed now. During the course of the DPR, it became clear that these could be addressed in numerous ways; the specifics of each depending upon the nature of the solar strategy selected. First, a strategy constrained by budgetary considerations would include:

- Restructuring of existing financing mechanisms (VA and FHA loan programs) to encourage solar financing.
- Improved technical information programs, including funding development of reliable, widely applicable solar designs and providing technical assistance to solar buyers through existing or imminent programs.
- Shift solar R&D emphasis away from electricity to heat and fuel production
- Focus R&D on cost-reductions in several areas (wind, biomass, and photovoltaics in particular)
- Revise federal cost-effectiveness criteria and procurement practices to reflect solar's unique advantages and to stimulate market development.
- Use federal utilities and power generating authorities as vehicles to initiate and test innovative utility roles in promoting solar.

Second, a strategy marked by a willingness and/or desire to promote solar through a significant federal budgetary expenditure could include all of the elements described above as well as several other components, such as:

- Financial incentives to homeowners and businesses purchasing solar beyond those proposed under the N.E.P.
- Establishment of quasi-public or federal corporations to finance the solar equipment manufacturers and purchasers.
- Extensive solarization of federal buildings
- Extensive purchases of biomass-derived fuels for federal vehicles

- Financial assistance to state and local governments for resolution of utility, building code, and zoning issues.
- Support early solar purchasers through federally-backed warranty programs.

Third, a solar strategy might include elements that reflect an intense federal desire to change the institutional environment of the energy marketplace. This would involve a Congressional and Administrative willingness to revamp existing federal regulatory practices and to intervene in cases where individual states and localities do not act to expedite solar use. This would require additional policy elements, such as:

- Removal of federal subsidies to conventional fuels that solar must compete against
- Vigorous enforcement of existing authority (e.g., under NEPA) to ensure that all solar opportunities are considered before conventional energy facilities are constructed.
- Requiring states to develop utility rates and roles that expedite solar use and to assure that building codes, land use patterns, zoning laws, and business practices allow full development of the solar potential.

Each set of strategy elements clearly has unique advantages and shortcomings. Choosing the best mix of policy options requires a frank assessment of federal budgetary constraints, the prospects for increasing federal regulation, and the ability of the federal government to make better choices than it represents. It is clear that an overall strategy to develop solar is but the sum of numerous components, each of which must be developed and implemented on its own. The final formulation of a solar strategy from these components must be based upon the perceived urgency of accelerating solar use.

DRAFT

**CONSUMER PROTECTION WARRANTY
ASSURANCE PROTECTION OPTIONS**

**Solar Energy Domestic Policy Review
Barrier and Incentives Panel**

September 15, 1978

Statement of the Problem

Growth and evolution of the solar industry has been marked by certain peculiarities. The nature of these peculiarities is such that attention is needed in the area of consumer protection and the resultant relationship between manufacturers and consumers, an interaction frequently defined by the terms of warranty protection plans manufacturers provide. There are several cogent reasons justifying government attention to this aspect of the solar market place.

First, solar is one of the few consumer product markets which has been actively developed and encouraged with the full participation of the Federal Government. As a result of this intervention, individuals have been encouraged to purchase and install solar, for purposes of public as well as private benefit. This federal encouragement/intervention carries with it the attendant responsibility of helping to protect the public from potential industry abuses.

Second, due to governmental involvement, the normal time span for growth and development of the solar industry has been compressed, and the usual process of product improvement has been altered. In some cases, it has been advanced, but in others impeded. Thus, early purchasers may be subject to a greater number of imperfectly designed systems than would otherwise have been the case.

Third, the very nature of solar leaves room for potential problems. For example, it is difficult for even a sophisticated consumer to evaluate a typical system's mechanical operation.

Proposals are usually designed to address two major issues:

- a) manufacturer reluctance to offer warranties judged to be comprehensive enough to adequately protect consumers, and
- b) manufacturers' ability to honor their warranties.

By providing this dual protection, warranty assurance programs would help mitigate consumer reluctance to the extent that current and future homeowners will buy solar systems knowing that they will have meaningful recourse should problems, which are related to manufactured components, arise. Having removed this reluctance, the domestic solar industry should enjoy greater growth than might otherwise be the case.

The purpose of warranty assurance for solar manufacturers is therefore two-fold: 1) to help manufacturers bear the cost of securing insurance to cover liabilities they incur as a result of offering more comprehensive warranties, and 2) to provide consumers with added protection in those cases where manufacturers do not or can no longer, honor their warranty commitments.

Why Warranty Assurance Protection is Needed

The Real Estate Research Corp. recently surveyed a group of individuals who had recently purchased homes with solar systems-- 40 percent had concerns regarding the presence of the solar system, of which 59 percent were related to possible breakdowns and 17 percent routine maintenance. This concern is further supported by the fact that the absolute number of solar collector manufacturers has declined by roughly 12 percent in the last year.

(This is a net number which takes into account new entrants as well as dropouts. As such, the 12 percent figure belies the true number of firms that have either gone bankrupt or have discontinued this line of production.) Moreover, the fact that many solar installers are still learning the trade, and many installation-related mistakes have been documented, has also contributed to both consumer reluctance to buy and a slower rate of industry growth.

Another element of concern exists where warranties are offered, but review judged them to be seriously inadequate when it came to meeting real or perceived risk levels. One such review of "5-year" solar warranties indicated that, in many cases, the homeowners would be required to: a) remove the collector from the roof at owner's expense (leaving roof exposed); b) ship the collector to the factory also at owner's expense; c) leave to the manufacturer's discretion if a warrantable defect existed; d) pay return shipping costs; and e) assume all responsibility for reinstallation. In addition, installers' warranties appeared to be vague or non-existent.

Definitions/Precedents

Before a formal discussion of the options is undertaken, a review of key insurance definitions is warranted. We feel that this brief digression will avoid confusion in the usage of terms.

Assurance

Assurance programs are primarily designed to encourage consumer confidence in a particular product, often through guarantees regarding performance over some period of time, that is through warranties.

Insurance

Insurance is basically a contract binding a company to indemnify an insured party against specified loss in return for premiums paid.

Co-insurance

Co-insurance is a form of insurance in which the insured accepts a share of the risk. For example, deductible automobile insurance policy options are a form of co-insurance since the owner can choose to pay for the loss on some portion of the risk.

Reinsurance

Reinsurance means essentially insuring by contracting to transfer in whole or in part a risk or contingent liability already covered under an existing contract. For example, insurance companies with large liability exposure will find other insurers to cover their ability to adequately handle the policy.

Federal intervention into the insurance marketplace is not new. Major precedents exist for government assistance in insuring against certain types of risks/accidents. Examples include protection from nuclear accidents (Price - Anderson Act), damage from civil disturbances (FIA Riot Insurance), danger that investment property will be damaged or expropriated (War Risk Assurance), or destroyed by natural causes (Federal Crop Insurance).

Proposed Options

A series of basic assumptions were identified as having important bearing on examination of the various options available to the solar industry. These basic assumptions are as follows:

- Option should protect both the consumers and manufacturers.
- General subsidization should be avoided.
- Any subsidies which are given should be of a short duration, for example, until a performance data base is developed.
- Program design must provide for early phase out.
- Program should maximize private sector participation.

- Program should avoid the creation of a new federal, permanent bureaucracy.
- Program should not inhibit competition among manufacturers.

1) A Non-Profit Assurance Corporation

One such option proposed to assist solar energy equipment manufacturing companies in providing more comprehensive warranty protection for consumers would be the creation of a private, non-profit corporation to act as an intermediary between private insurance carriers and the solar companies. Such a corporation would function to secure two types of "insurance" covering solar energy equipment and consumers:

- 1) A reasonably priced policy for companies that covers the liability level incurred by the warranties the companies issue.
- 2) Insolvency coverage for consumers who find that equipment they bought is no longer covered because the manufacturer either refused to honor the warranty, but should have, or went bankrupt.

As a pre-requisite for membership in the corporation, solar companies would have to demonstrate that their equipment and warranty coverage meet existing solar industry standards that are acceptable to the corporation. The solar energy companies would also have to offer specified minimum warranty terms for the equipment covered.

This option calls for voluntary participation by solar manufacturers. The Panel feels that this approach has several advantages. First, it "softens" the argument that the Federal Government is once again intruding into the workings of the private

sector, and that the solar industry is being singled out from among the various producers of energy. Second, the decision of whether or not to join would lie with the individual manufacturer; they would have to decide if they wanted or needed the protection provided by the warranty assurance program. Third, the voluntary program would give the manufacturers the option of either joining or dropping out at a later date.

The corporation would cover its costs of operation through membership insurance fees and federal funding. For the corporation to effectively operate, the Federal Government would have to bear the cost of administrative "start-up" and for a limited time subsidize the insurance premium payment program.

The Solar Warranty Assurance Corporation would determine a "reasonably priced" premium for the coverage desired. This premium would be based on a prudently optimistic, rather than worst case, assessment of anticipated equipment failures. The formulas devised to determine the premiums would also try to account for the expected costs of covering warranty liability, and solar company bankruptcy rates. It is anticipated that the limited knowledge about such factors as durability and cost of repair would make the initial premium rate selected subject to considerable error.

In the final analysis, the goal would be to attempt to make these calculations with the objective of keeping costs as low as possible for the participating solar companies. Because of the newness of the technology and insurance industry caution, the

initial premium levels for the risk demanded by the carriers could well be higher than the premium level a warranty corporation would set for its members. In this case, the Federal Government would ultimately pay the difference, thereby providing an initial subsidy to the solar equipment manufacturing industry. For the Federal Government, the greatest risk occurs if too much optimism governs assessments of what is a reasonable premium.

Under this plan, actual data would be used to readjust, every two years, the premiums charged. If the premium levels need to be increased, industry would be charged more. At the same time, the Federal Government subsidy of the difference between the actual premium industry pays and what is paid for the private carrier insurance will decrease. After more adjustments over the next four years, the Federal Government subsidy of the insurance premiums would be ended, and industry would bear the full cost of the insurance program.

The Warranty Assurance Program may be criticized for having competent solar energy companies supporting "weaker" companies with poorer quality components or inadequate quality control. At the outset, this situation may be unavoidable. As the corporation evaluates its members' performance, however, premiums can be adjusted to reflect demonstrated performance shortcomings. As a result, certain companies would pay more for their membership.

The existence of a warranty assurance corporation should raise consumer confidence in the solar energy industry in view of the proposed guarantee to honor any warranty obligation

should a manufacturer become insolvent.

This particular guarantee, however, again raises a concern about "good" companies subsidizing weak ones, since part of the corporation's financial responsibility would be to cover valid warranty claims made against insolvent solar companies. If bankruptcy rates are high, the remaining solar companies in the corporation would be paying higher premiums and the Federal Government might have to intervene to relieve the burden placed on those companies.

The assurance corporation will also benefit the relatively smaller but reputable manufacturers because they will be in the position to offer the consumer a better warranty and therefore be able to compete with the larger manufacturers on an equal footing.

The above benefits notwithstanding, it is crucial that any program explicitly limits Federal Government financial participation to a short period of time, and incorporates a method for that participation to be phased out as the industry matures. In fact, this concept leaves open an option for the corporation itself to disappear if the industry matures to the point where it can secure desired insurance without need for an intermediary: or, like many other industries, it finds that warranty insurance is not desirable.

Before discussing other options considered in the course of this review, the Panel wishes to comment on one particular problem

area, installation or system performance warranties.

By not including system performance warranties or installation warranties, the option previously described fails to address some important issues. This is crucial since many consumer complaints may be related to how well a system is functioning and not to specific component failures.

The panel's hesitancy about a national program dealing with performance and installation warranties was influenced by certain of the guiding assumptions listed on page 4, and some other technical considerations related to system performance. A system's performance is a function of four distinct components: 1) design, 2) quality of fabricated components, 3) quality of installation, and 4) use and maintenance. Problems with any one of these affect the others and can severely impact the system's overall performance, which may give rise to a consumer complaint. Another problem exists regarding performance calculations. To date, industry has no widely accepted standard or measure of what constitutes acceptable "performance" of a solar system. Clearly, there could be as many measures of performance as there are generic types of solar energy heating and cooling systems.

The current distribution/marketing system presents additional complications. Solar energy systems reach consumers in a number of ways. Some manufacturers sell them directly to installers, and have created their own dealer/installer network. Others use dealers, but also work through distributors who wholesale to installers and builders, or retail directly to the public.

When the manufacturer has created his own dealer network, he has the potential to control how his product is installed. Where a middleman such as a wholesaler is involved, this opportunity is usually lost.

Another key consideration for the panel was a pronounced unwillingness to see the Federal Government create a situation where thousands of independent HVAC contractors, plumbers, and solar specialists felt they had to belong to a national non-profit corporation to be in the solar energy business.

Finally, some positive considerations about other programs in the installation area helped convince the Panel to reject an installers warranty protection program for any nationally oriented program. Private institutions, associations and government have been funding programs to assist the training of solar installers. Industry's certification of equipment should also assist installers select better components and help solve some of these problems. Some states have already developed installer certification and/or licensing programs of their own. These and other similar programs should upgrade the general quality of solar installations. Together they could obviate the need for a nationally organized solar warranty assurance program which extends down to the independent dealer/installer.

Finally the panel feels it will be difficult to determine in many cases whether a performance or installation warranty has been violated, and for what reason. Trying to deal with these kinds of installer-related concerns with a nationally organized corporation just does not appear to be a sound approach.

Accepting the panel's view does not preclude the Federal Government from approaching the installer-related problem in

different ways. To start, the Panel feels the warranty assurance corporation can have a positive effect if it is seen as a single part of a supporting foundation being constructed for the solar heating and cooling industry. It helps by giving consumers and installers better warranties to work with, and a guarantee of an available follow-up mechanism. As such, this initiative could be accompanied by, (or have substituted for it) broad-based support for general programs aimed at increasing installer competency and requiring better warranties. The broader approach would have the Federal Government continue to encourage manufacturers to increase their warranty coverage using other mechanisms.

These alternative choices include:

- Continued pressure through federal procurement or subsidy programs, with the Federal Government insisting on a desired minimum warranty.
- Consumer education programs that emphasize warranty coverage.
- Support for state programs designed to increase installer competency which may also include installer warranties.
- Support for private industry initiatives, which could include funding for educational and technical assistance on warranties for manufacturers and identification of marketing advantages inherent in more comprehensive coverage.

The remainder of this section presents more information and discussion of these and other options. Some were rejected, others are just listed for the reader's information. The Panel organized these into federal, state, and private industry categories.

2) Federal Government Options

a) The Federal Government would reimburse, in full, solar manufacturers for insurance premiums on policies which would be written by private insurance firms. The major drawback to such a plan would be temptation by the insurance industry to inflate rates knowing the Federal Government would cover the premium payments.

b) The Federal Government would act as the reinsuring agent for policies written by private carriers covering manufacturers' warranties.

This option may not be feasible if the insurance industry would prefer to deal with an entity which represented all participating solar manufacturers rather than individual firms themselves. Moreover, the very nature of reinsurance dictates that the insured item be of a large dollar magnitude in the terms of cash value, e.g., a supertanker. While the aggregate of solar warranties may be large by company standards, they would be too small to be of any interest to firms who are in the reinsuring business. Finally, there is no demonstrated insurance industry activity for the Federal Government to reinsure.

c) The Federal Government would set up a federal agency to directly insure warranties of the solar manufacturers.

Due to public disdain towards the creation of yet another bureaucratic "watchdog" and the panel's objective to include private sector participation, this proposal would not be a viable option for the solar industry.

3) State Level Options

Warranty assurance programs available on the state level may be vitally important because they allow more attention to be paid to installation warranties through establishment of local programs. Two such plans have been proposed in California, one at the instigation of the California Energy Commission in the form of legislation submitted to the State Assembly, and another proposed by the California Solar Energy Industry Association. Both of these programs involved specific warranty assurance programs.

a) California Solar Energy Consumer Warranty Insurance Authority

During the 1977-78 session of the California legislature, a bill (AB 2982) was introduced to enact the Solar Energy Consumer Warranty Authority Act and establish the Solar Energy Consumer Warranty Insurance Association. The proposal provided for the following:

- a non-profit corporation;
- required membership for firms whose equipment meets state standards and qualifies for state tax credits;
- a membership fee of 2% of sales to capitalize the fund;
- payment to consumers for repairs;
- reporting on member performance.

(See Appendix C for a more detailed description of this plan.)

b) CAL-SEAL Warranty Assurance Program

Under the CAL-SEAL Warranty Assurance Program, qualified solar systems bearing the CAL-SEAL label would be assured of industry and state backing if necessary to uphold the fundamental warranty requirements of the "guidelines and criteria" set in the California Solar Energy Tax Credit Bill (AB 1558).

Funds would only be expended as a last resort and if spent would require that the warrantor responsible be dropped from the CAL-SEAL labeling program and his installations or components would no longer qualify for the Sales Tax Credit nor for the Warranty Assurance.

The warranty assurance program will be administered by the CAL-SEAL Program Director through the CAL-SEAL Program, utilizing CAL-SEAL resources, facilities and personnel.

Eligibility of warranty assurance is limited to:

1. Installations for solar systems (as defined by the Guidelines) that bear the CAL-SEAL Label and are installed by a licensed contractor who is registered with and participating in the CAL-SEAL program.

2. Solar components manufactured for resale to the general public and are within the purview of the Guidelines and subject to certification.

Both of these programs have the distinct advantage of including installations warranties. The California State Assembly Bill designated a period of time for installer responsibility followed by a manufacturer's obligation.

c) Florida Certification Program

In Florida, a more general approach to resolve the same problems has been proposed. Working together, the Florida Solar Energy Center and the Florida Solar Energy Industries Association (SEIA) plan to require that beginning in 1980, all solar energy heating and cooling equipment installed in Florida will have to be certified.

To support compliance with this requirement, the state, again working with the Florida SEIA, plans to establish minimum competency guidelines and a testing program for installers. Two additional support mechanisms are also envisioned, a public awareness program so that consumers know they should look for the state certificate seal, and a program to train and certify system inspectors.

No warranty assurance program is apparently contemplated in Florida at the present. An industry association spokesman feels the program outlined above is going to upgrade the quality of installations and that reputable firms will not require an insurance program to provide warranty backup for consumers.

d) State Warranty Option

In addition to those state level options described above, a program might be created involving a warranty/inspection system where consumers and installers (or either), could request a technical inspection of an installation to certify that it meets existing installation standards. When an inspection finds the solar system acceptable, the installer would offer a full warranty for a

specified period of time. This program could be completely voluntary, or might be included as part of a state program mandating certain requirements for solar energy businesses.

Federal Government subsidy (along with state funding) could be limited to the training of inspectors. The inspection could be handled by existing building code officials. Department of Energy regional Solar Energy Research Centers could provide technical and educational support, which is probably necessary since building code inspections have traditionally been health and safety oriented. Installers would pay a fee for the inspections, the cost of which could then be passed on to the consumer.

This program addresses the installation problem on the state level, but has the same drawbacks relative to a bureaucratic "watch-dog" agency. Although the program described above does not address the issue of insolvency, provisions for establishing such coverage could also be an added feature of the program.

At this stage in the development of the solar industry, the creation of a pilot manufacturer warranty assurance program on the state level may only be counter-productive. It would delay any nationally-oriented program. If every state was encouraged to set minimum manufacturer warranties, solar companies would be faced by the monumental task of complying with numerous and varying state standards. Finally, it would be difficult to properly generalize locally obtained data for the larger national program.

4) Private Sector Options

In the event private insurance carriers do become interested in providing coverage for solar heating and cooling components, warranties, or service contracts, the Federal Government could assist

by commissioning research projects designed to answer major insurance industry concerns and make technical know-how available through its solar energy laboratories.

The Solar Energy Industry Association and Solar Energy Research and Education Foundation are attempting to advance collector standards and certification programs. Additional Federal Government support for such efforts which would help industry self-regulate and improve product quality should alleviate certain technical problems in the market and encourage companies to offer more comprehensive warranties. The Federal Government may also want to consider supporting an association for solar installers which deals with installation technology and directly addresses problems with training and education aids.

Implementation Issues

A wide spectrum of issues surround implementation of the various options as examined by the Panel. Problems concerning the "state of art" development for standards, assessment of manufacturer warranty versus installer problems, the role of private insurance companies and federal involvement in this sector, and the effect on the competitive atmosphere for solar energy companies will be reviewed.

For purposes of this report the implementation issues are grouped under four main headings:

Insurance Industry Issues

Consumer Issues

Solar Energy Industry Issues

Government Intervention Issues

Insurance Industry Issues

- The insurance industry does not write much warranty assurance coverage; it is considered a surplus line.

Discussion: Insurance representatives contacted said that there had been some experiments in the past with regard to warranty insurance, but difficulties involving overlap between manufacturing and installation prompted the companies to back away from such policies. Moreover, manufacturing companies offering warranties seem to generally be operating in a "self-insurance" mode. They usually make a contingent liability entry in their accounting records similar to a bad debt entry. These liabilities are then cleared through cash payments, labor and materials allocations, or lack of claims. In some cases, companies set aside amounts in interest accounts to cover warranty obligations, and hence, are self-insured. These observations indicate therefore that the creation of warranty assurance programs may run counter to general practices in both the insurance and manufacturing industries and would be likely to run into firm opposition from many solar energy companies.

- The private insurance carriers may have a difficult time deciding on proper premium levels, and will want to adopt a "worst case" posture in most cases.

Discussion: Rates do not generally depend on the type of business involved or the length of time a business has been in existence. The range of cost premiums depend primarily on the business and consumer climate in various regions of the country, where, for example, a state may be considered claim conscious by the insurance industry.

Moreover, because the insurance industry already underwrite policies covering manufactured items that are subsequently assembled into a larger item, difficulty in developing a similar line for manufacturers of those component parts which go into solar collectors may not even arise.

- At present, solar heating and cooling systems are covered by the Magnuson-Moss--Federal Trade Commission Improvement Act.

The Act provides minimum disclosure standards for written consumer product warranties and defines federal content standards for such warranties. Moreover, the Act contains "redress" provisions to aid consumers in bringing suit for failure to honor warranties or service contracts.

For the purposes of discussion, a warranty is generally part of the sales contract for a particular product. Therefore, the consumer, as buyer, is primarily concerned that the seller of this product honor such a warranty should the product fail to perform. Although the Magnuson-Moss Act focuses on legal redress when the seller fails to honor his contractual agreement to "replace, repair, or refund", it also addresses the issue of tort liability when personal or economic injury is incurred by

the consumer because of product failures. Thus, when a seller "breaches" his duty to honor a warranty, it is not only a violation of a sales contract, but can also be a tortious wrong, suable by the consumer against the seller, distributor, or manufacturer, regardless of any contractual agreement among the parties.

Therefore, estimating the cost of warranty insurance coverage should not be limited to "repair and replace" cost figure, but also to what reserves may be needed to cover the losses when personal and or economic injury is incurred by the consumer. Bearing in mind the FTC provision for legal redress under "failure to honor warranty" theory and recent reports of solar system malfunctions resulting in minor property damage, a review of the availability and extent of product liability insurance coverage should also be made before steps are taken to estimate the cost of creating a separate warranty insurance program. (see Appendix A for a more complete discussion of the Magnuson-Moss Act, warranty coverage and consumer rights to bring suit)

Consumer Issues

- Warranty assurance programs could actually delay consumer acceptance of solar energy because the consumer might feel the solar industry needs special insurance programs because it is not technically ready.
- Unscrupulous firms could use membership in an association to disarm consumer wariness.
- Solar companies may raise prices to cover costs of the insurance.

Discussion: Those companies participating in a warranty assurance program could avoid an outlay of funds by self-insuring. If they

join an assurance corporation, however, they would probably pass on added costs to the consumer. There is a possibility consumers might find added costs coming from a completely different set of circumstances if costs for warranty liability coverage are quite low, but manufacturers could pass on the cost to them of an expensive national program that anticipated high costs. This situation raises serious questions about the general premise, that solar manufacturers do not offer more extensive warranty coverage because they cannot afford to. It may be a case where the companies do not know they can afford to offer more warranty coverage. If they did so, they might actually increase business turnover to more than offset the added costs. This argument should be extensively examined.

- The creation of warranty assurance programs for solar manufacturers may not resolve the problems inherent in the marketing of solar products, namely consumer confidence in system performance and installation warranties (See discussion pp. ____).
- This program may depend heavily on the existence of accepted standards, which will have to be used to govern membership in the program. These standards do not exist industry-wide at present, and they may vary regionally for a certain period of time.
- The weeding-out process could be delayed.

Discussion: Any government supported warranty/risk assurance program could be a detriment to the consumer over the long-run, because it may hinder the normal sorting out process which occurs when new industries are in a nascent stage of development. Firms that would have disappeared in a normally evolving competitive atmosphere may survive and continue to sell products which are of lesser quality than might otherwise be the case. In the long-run,

the consumer ultimately suffers when the marginal products are allowed to remain on the market. Thus, even though such a program helps the consumer in the short-term, the long-term implications are not so favorable.

Before resolving this issue, another short-term benefit should be weighed against longer term disadvantages, namely the consumer might benefit from a delay in the weeding-out process since small companies with high quality products could be assisted by the existence of a warranty assurance SWAC program. In this case, government sharing of warranty liability would reduce near-term costs and help the smaller quality companies compete.

- Anti-competitive problems may be created because of the purpose behind these warranty assurance options.

Discussion: The various options examined are specifically designed to provide meaningful benefits to manufacturers of medium temperature flat plate liquid or air type collectors, or special liquid collectors, due to the nature of the problems addressed. Low temperature, low technology, or passive design technology manufacturers may not materially benefit from a warranty assurance program. This may result in providing an unfair competitive advantage to a certain segment of the solar manufacturing industry. The extent to which this may distort the market should be carefully considered.

Solar Energy Industry Issues

- Solar companies dispute necessary warranty levels.
- Very little data is known about the many factors that will determine the cost to solar companies for warranty coverage.

Discussion: Some company representatives feel that the cost of covering their warranty liability to date has been "meaningless". This impression is only based on a few years of experience. Other companies have been complaining vociferously about government mandated warranty requirements governing participation in federal programs. They have cited these warranty requirements as the main reason behind significant price increases. This whole area needs close attention.

- The solar market is quite price competitive, and companies may object strongly to added costs (i.e., the insurance premium, however small) when they are demonstrably cash short.
- "Good" solar companies may legitimately object to the fact that they are subsidizing companies with poor equipment.

Discussion: Industry leaders that have built sales on existence of a strong warranty may be concerned that smaller weaker companies are able to offer the same coverage because the Federal Government may be willing to subsidize a warranty assurance program. (see pp. 10) These and other anti-competitive aspects, as noted above, need to be carefully reviewed.

Federal Issues

- Establishing warranty assurance programs may be considered a government giveaway to industry and could lead to requests from other alternative energy industries for similar plans.

- The Federal Government would be paying risk insurance for private companies which, in many cases, is a normal business expense.
- The Government would be in a position where it can mandate, through its participation in these warranty assurance programs, minimum warranties for the solar industry.
- Government intervention in the industry at this stage for this reason may retard natural maturation of mechanisms that alleviate the problem. The Government may inadvertently create a new bureaucracy which would sustain itself, assume long-term market power, and adopt a regulatory role.
- Potential exists for unanticipated costs to the Government over the short-term, and there is a danger that it will be difficult to terminate a subsidy program after the designated phase-out period.
- Government places itself in a liability situation where it has little direct bargaining power with the private insurers.
- With the Government sharing liability, there may be no incentive for solar companies to try harder to improve their products.

APPENDIX A

MAGNUSON-MOSS ACT CONSIDERATIONS AND HUD WARRANTY

Consumer Protection Warranty Assurance Protection Options

The following terms are defined within the Magnuson-Moss Act:

Consumer - means a buyer (other than for purposes of resale) of any consumer product who is entitled by the terms of such warranty (or service contract) to enforce against the warrantor (or service contractor) the obligation of the warranty (or service contract).

Supplier - means any person engaged in the business of making a product directly or indirectly available to consumers.

Warrantor - means any supplier or other person who gives or offers to give a written warranty or who is or may be obligated under an implied warranty.

Written Warranty - (a) any written affirmation of fact made in connection with the sale of a consumer product by a supplier to a buyer which relates to the nature of the material or workmanship and affirms or promises that such material or workmanship is defect-free or will meet a specified level of performance over a specified period of time, or (b) any undertaking in writing in connection with the sale by a supplier of a consumer product to refund, repair, replace or take other remedial action with respect to such product in the event that such product fails to meet the specifications set forth in the undertaking.

Service Contract - means a contract in writing to perform over a fixed period of time or for a specified duration, services relating to the maintenance or repair (or both of a consumer product).

"Remedy" - means whichever of the following actions the warrantor elects:

- a) repair
- b) replacement, or
- c) refund

except that the warrantor may not elect refund unless (i) the warrantor is unable to provide replacement and repair is not commercially practicable or cannot be timely made, or (ii) the consumer is willing to accept such refund.

Private Consumer Remedies Under the Act

A consumer can sue for personal or economic injury due to:

- 1) failure to honor a written warranty;
- 2) failure to honor a service contract agreement;
- 3) failure to honor any implied warranty created by state law (e.g., warranties of merchantability or fitness for a particular use under the U.C.C.);
- 4) violation or failure to comply with a requirement of the Act.

Under the Act, the following persons (or companies) can be sued:

- 1) Under a written warranty only the person (or company) "actually making" the written warranty. (Consider those circumstances where one company is deemed to have "adopted" a warranty of another company as its own).
- 2) Under an implied warranty, anyone who is liable under state law.
- 3) Under a service contract, anyone who is obligated, under the contract (as determined by state law).

- 3) For violation or failure to comply with the requirements of the ACT (warrantor, service contractor and seller--under presale contract--are covered under this rule.)

Nevertheless, before bringing suit under the Act for breach of warranty or service contract, a consumer must give the person obligated a reasonable opportunity to perform (cure the breach). If the person does not meet this obligation within a reasonable amount of time, a number of remedies are generally available to the consumer (e.g., recovery of purchase price, market price of a replacement, or loss in value due to the problem). Moreover, the Act contains a "lemon" clause applicable only to "full" warranties. This provision entitles the consumer to a choice of a full refund or a new replacement producer if the warrantor fails to remedy defects after a reasonable number of attempts.

4. Minimum Solar System Warranty Requirements

include in the Application copies of the warranties which the builder / developer, solar system and/or collector manufacturer and installer will extend to the owners of existing buildings or to purchasers of new buildings. These warranties must be reasonable and, at a minimum:

- a. Comply with all applicable provisions of the Magnuson-Moss Warranty Act of 1975 (12 U.S.C. 2301 et. seq.) which establishes Federal disclosure terms and substantive and enforcement provisions for written warranties on consumer products;
- b. Include a one year warranty from the installer against failure of the solar system, any component, or assembly where such failure is caused by a defect in materials, manufacture or installation. The warranty shall cover the full costs of parts and labor required to remedy the defect, including, if necessary, replacement at the site, and shall run from the date of installation completion. The warranty shall also include provision for field inspection at no charge to the consumer, to verify failure, establish probable cause, and determine corrective action required. NOTE: The installer's warranty may include pass-through warranties provided by his supplier or the manufacturer.
- c. Include a five (5) year collector manufacturer's warranty which shall include:
 - (1) A five (5) year warranty against defects in materials or manufacture. The warranty shall cover the full costs of parts and labor required to remedy the defect, including, if necessary, replacement at the site, and shall run from the date of installation completion.
 - (2) A five (5) year warranty against corrosion of the absorber plate and other coolant passage. This corrosion warranty shall cover, for the first year, full costs of parts and labor required to remedy the defect including, if necessary, replacement at the site. For the remainder of the warranty period, the corrosion warranty shall cover the cost of all parts, delivered to the site, necessary to remedy the corrosion defect, including the cost of furnishing new collectors, if necessary. The corrosion warranty shall run from the date of installation completion.
- d. The manufacturer's warranty shall also include provision for a field inspection at no charge to the consumer to verify failure, establish probable cause, and determine corrective action required. NOTE: The manufacturer is not required to warrant against system failure caused by defective or faulty installation.
- e. All warranties may specify reasonable installation and maintenance procedures for the warranty to be effective. However, no warranty shall be voided or in any way reduced by conditions that may occur in normal operation of the system.
- f. HUD also expects the manufacturers of other major system components such as heat exchangers and storage tanks to reasonably warrant their products in accordance with established industry standards.

APPENDIX B

Consumer Protection Warranty Assurance Protection Options

Sample Insurance Programs

1. Federal Disaster Assistance Administration

Yearly appropriations \$200,000,000 of which \$6,000,000 (or 3%) overhead. 168 personnel (75% professional; 25% clerical). This program is somewhat difficult to budget for as it is based solely on historical experience and if in any given year, more disasters occur, the program merely receives supplemental funding.

2. Federal Insurance Administration

This administration is divided into a number of insurance sectors: crime insurance, flood insurance, etc. Difficulty with using this program's cost figures is that there is no reliance on appropriations (as of now) but rather on profits made in another sector. Using the flood insurance program as an example, one finds 1.3 million policies in force with a cost of administering these policies at \$15 million or approximately \$10.00 per policy. Approximately 400 persons work exclusively in the flood insurance sector (under the \$15 million budget).

3. California Warranty Assurance Corporation and Cal-Seal

The start up costs for proposed creation of a Solar Energy Consumer Warranty Insurance Association in California were estimated to be \$250,000. For the California SEIA Cal-Seal Program costs were estimated at \$125,000. (see the main text and Appendix C for description of these programs)

4. Homeowners Warranty Corporation

The Homeowners Warranty Corporation is the first 10 year nationally-insured protection plan for home buyers. The Corp-

ration is a wholly-owned subsidiary of the National Association of Home Builders and is seen as a viable alternative to federally-supported warranty programs. The program applies only to new homes where the builder gives a 1-2 year warranty: one year warranty against defects in workmanship and material; a two year warranty against certain limited defects in plumbing, heating, etc. and a two year warranty against major structural defects. From years 3-10, a major insurance company will provide direct insurance protection against major structural defects (also for years 1-2 should the builder refuse or be unable to honor his warranty.)

Basically, each builder enrolls as a participant by meeting certain standards for technical competence. The plan costs \$2.00 per \$1000 of the final sale price of the home. From this \$2.00, \$1.00 goes to the national insurer, 50¢ goes to the National HOW Office and 50¢ goes to the local state office.

When the insurance company receives its payment (after year 1 or 2) it takes 15% of it for overhead-the maximum allowed); the number of claims are calculated (usually 5%). The rest of the subscription payment goes to the National HOW Office and is subsequently distributed as a rebate to local offices.

In the National Office, there are 40 staff personnel, (25 executive; 15 clerical). The Virginia local office operates on a budget of \$50,000 per year overhead of about \$5,000 a month for everything). It is an average size office with 2 secretaries and 3 executives.

APPENDIX C

California Solar Energy Consumer Warranty Insurance Authority

During the 1977-78 session of the California legislature, a bill (AB 2982) was introduced to enact the Solar Energy Consumer Warranty Authority Act and establish the Solar Energy Consumer Warranty Insurance Association. The proposal provided for the following:

1. A non-profit corporation would be created under the Insurance Commissioner's office which would function as an insurance pool for the expressed warranties of manufacturers and installers.
2. Any manufacturer or installer whose systems have been tested and certified by the Energy Commission and whose systems have qualified for the tax credit shall be required to be members of this pool.
3. Each company shall pay 2% of the price of each system sold to provide full capitalization of the insurance fund. The cost to the company, shall be prorated by the extent and term of coverage offered.
4. The corporation shall be organized with a Board of Directors consisting of a majority of members from the industry, with public members from the Energy Commission and the Dept. of Consumer Affairs.
5. The corporation shall cover the cost of system repairs in the event of failure of a company within the warranty period or refusal of a company to honor its warranty. It shall provide the consumer with the full dollar amount he/she would have received if the warranty were honored. It shall also refer

the consumer to qualified companies capable of performing the repairs within the consumers service area.

6. The corporation shall have the power to expel members who fail consistently to live up to their warranties. They shall also inform the testing and certification program of the Energy Commission where substantial system and warranty failures are occurring. The industry version rejected some of the main precepts of the legislation described above by lessening some warranty requirements provided by the state and attempting to ensure that industry had absolute control over the program. This particular program has been closely linked with a proposed certification plan for equipment, CAL-SEAL, a mission delegated to the California SEIA.

MEMORANDUM

TO: Mike Power
Dave Engle
THRU: Joel Rosenblatt
FROM: C. La Porta, J. Schutz, & D. Lowe
Subject: Transmittal of Consumer Protection Options Papers

Date: September 26, 1978

Please find attached copies of "Consumer Portection Warranty Assurance Protection Options" prepared for the Barriers and Incentives Panel of the Domestic Policy Review on Solar Energy.

As we agreed, the options are briefly discussed, with emphasis on the warranty assurance corporation plan. The cost analysis was only done once with a single set of general assumptions.

Regarding the Warranty Assurance Corporation proposed, we feel many issues have been raised which deserve more analysis. It is understood, for example, that installer-related problems are a major concern, and that this option does not deal directly with that issue. We feel the paper submitted, however, does discuss other ways to deal with the situation.

We also have additional concerns about: liability claims that might be made against the Solar Warranty Assurance Corporation; the creation of a mechanism which goes against standard industry practices for dealing with warranties; the addition of unnecessary business costs to the solar energy industry; and the danger of over-regulating an industry which feels it suffers from too much government attention.

CONSUMER PROTECTION WARRANTY
ASSURANCE PROTECTION OPTION

Solar Energy Domestic Policy Review
Barrier and Incentives Panel

September 15, 1978

Statement of the Problem

Growth and evolution of the solar industry can be characterized as having certain peculiarities. The nature of these peculiarities is such that attention is needed in the area of consumer protection and the resultant relationship between manufacturers and consumers, an interaction frequently defined by the terms of warranty protection plans manufacturers provide. There are several cogent reasons justifying government attention to this aspect of the solar market place.

First, solar is one of the few markets which has been actively developed and encouraged with the full participation of the Federal Government. As a result of this intervention, individuals have been encouraged to purchase and install solar, for purposes of public as well as private benefit. This federal encouragement/intervention carries with it the attendant responsibility of helping to protect the public from potential industry abuses.

Second, due to governmental involvement, the normal time span for growth and development of the solar industry has been compressed and the usual process of product improvement has been altered. In some cases, it has been advanced, but in others impeded. Thus, early purchasers may be subject to a greater number of imperfectly designed systems than would otherwise have been the case.

Third, the very nature of solar leaves room for potential problems. For example, it is difficult for even a sophisticated consumer to evaluate a typical system's mechanical operation.

This initiative is designed to address two major issues, a) manufacturer reluctance to offer warranties judged to be comprehensive enough to both adequately protect consumers as well as address consumer reluctance to purchase solar systems, and due to uncertainty regarding the system's overall reliability and long-run durability, and b) manufacturers' ability to honor their warranties. The option described consists, therefore, of two main elements. One is designed to help manufacturers bear the cost of securing insurance covering liabilities they incur as a result of offering more comprehensive warranties. The second is to provide consumers with added protection in those cases where manufacturers do not or can no longer honor their warranty commitments.

The general purpose of this initiative, then, is to mitigate consumer reluctance to the extent that current and future homeowners will buy solar systems knowing that they will have meaningful recourse should problems, which are related to manufactured components, arise. Having removed this reluctance, the domestic solar industry should enjoy greater growth than might otherwise be the case.

Recent studies indicate that among the major reasons that consumers are reluctant to purchase solar systems is a concern that a manufacturer of the system will: 1) not honor written warranties governing the system's components; 2) the manufacturer will not be in business for the life of the warranty. In a recent survey by the Real Estate Research Corp. of individuals who had recently purchased homes with solar systems, 40 percent had concerns

regarding the presence of the solar system, of which 59 percent were related to possible breakdowns and 17 percent routine maintenance. This concern is further supported by the fact that the number of solar collector manufacturers has declined by roughly 12 percent in the last year. While there have been new entrants in the field, the number is outweighed by firms that have either gone bankrupt or have discontinued this line of production. Consumer reluctance, added to the fact that many solar installers are still learning the trade, and many installation-related mistakes have been documented, has slowed industry growth.

Another element of concern exists where warranties have been offered, but were judged inadequate by government reviewers when it came to meeting real or perceived risk levels. One such review of "5-year" warranties indicated that, in many cases, the homeowners would be required to: a) remove the collector from the roof at owner's expense (leaving roof exposed); b) ship the collector to the factory also at owner's expense; c) fully leave to the manufacturer's determination if a warrantable defect existed; d) pay shipping costs back; and e) reinstallation. In addition, installers' warranties appeared to be vague or non-existent.

Proposed Option

A series of basic assumptions were identified as having important bearing on the choice of the option described below. These basic assumptions are as follows:

- Option must protect consumer and assist manufacturer.
- General subsidation should be avoided.

- Any subsidies which are given should be of a short duration, for example, until a performance data base is developed.
- Program design must provide for early phase out.
- Program should maximize private sector participation.
- Should avoid the creation of a new federal, permanent bureaucracy or program.
- Should not inhibit competition among manufacturers.

To assist solar energy equipment manufacturing companies provide more comprehensive warranty protection for consumers, a private non-profit corporation is proposed to act as an intermediary between private insurance carriers and the solar companies. A Solar Warranty Assurance Corporation would be organized to be the main agent in securing two types of "insurance" covering solar energy equipment and consumers:

- 1) A reasonably priced policy for companies that covers the liability level incurred by the warranties the companies issue.
- 2) Insolvency coverage for consumers who find that companies warranting the equipment they have purchased have disappeared, or refuse to honor the warranty.

In essence, this plan creates insurance for assurance programs. Such a solar Warranty Assurance Corporation (SWAC) could be created as a completely independent body, or as an affiliate of some established institution.

The Solar Warranty Assurance Corporation will maintain a membership of solar manufacturers participating in its insurance program. Solar companies that join will have to demonstrate that equipment to be covered by the insurance program meets

existing, generally accepted solar industry standards the SWAC selects as governing its program. The solar energy companies will also have to offer specified minimum warranty terms for the equipment covered. SWAC will also establish a maximum level of coverage that it will honor in the event it has to make good on a consumer complaint. SWAC member companies would be free to offer warranties without SWAC assistance that extends beyond the maximum, if they desire. The minimum and maximum warranty levels will be determined by the SWAC organization with appropriate guidance from industry and other interested parties.

In the proposed option no coverage of solar energy system performance warranties, or installation warranties is foreseen. This could be an extremely important omission. First, many consumer complaints about solar energy systems will be related to how well the system is functioning, and not to specific component failures. Second, experience has clearly demonstrated installer-related problems have often figured prominently in system failures documented thus far. In each of these areas, warranted component performance will be called into question, however, clear cut determination of fault will be hard to pinpoint.

The panel feels that there is no way at present to devise a plan to adequately address these problems on a national level.

The SWAC should cover its costs of operations through member paid insurance fees and funds granted to it by the Federal Government. It is expected that start up costs and administrative costs for the first two years will be borne by the Federal Government.

The Federal Government should also be making a financial contribution in the insurance premium payment program; however, this funding requirement is to be phased out within a six year period, as described in the operational mechanics below.

The Solar Warranty Assurance Corporation will be charged with determining a "reasonably priced" premium for the coverage desired. This premium should be based on the most accurate assessments available of anticipated equipment failures, expected costs of covering warranty liability, and company failure rates. It is anticipated that the limited knowledge about such factors as durability and cost of repair will make the initial premium rate selected subject to considerable error. SWAC will attempt, however, to estimate these factors so that the lowest cost possible can be established for the solar companies participating in the program.

At this point the Solar Warranty Assurance Corporation will have assembled a "pool" of warranty liability from all its members, and should seek one or several private insurance carriers to cover the risk. More than likely, the premium levels for the risk demanded by the carriers could be higher than the premium level the SWAC has set for its members. In this case, SWAC will pay for the difference, thereby providing an initial subsidy to the solar equipment manufacturing industry. The funds to cover this early subsidy will be granted to SWAC by the Federal Government.

Every two years under this plan SWAC will use actual data to readjust the premium it charges its members. In this way the premiums should gradually reflect with greater accuracy the cost for the risk insurance. If the premium levels are in fact increased to match costs more closely and approach the premium

SWAC must actually pay the carrier, then industry will be charged more for its membership in SWAC. At the same time, the Federal Government subsidy of the difference between the actual premium industry pays to SWAC and what SWAC pays will decrease. After more adjustments over the next four years, the Federal Government subsidy of the insurance premiums will be ended, and industry members of SWAC will bear the full cost of the insurance program.

Solar Warranty Assurance Corporation Functions

A board of directors appointed from the private sector will oversee management of SWAC. Representatives from the solar industry, consumer organizations, standards institutions, and other interested and relevant groups will be selected to make up the initial board.

The SWAC will monitor the insurance coverage program and performance of its members. A professional staff will evaluate performance of solar energy systems, the instances of warranty related problems, and costs of satisfying them in order to gather necessary data to adjust the premium rates. A review board would be designated to consider cases where particular manufacturers may have to have their membership status reviewed because of performance problems.

It is conceivable that SWAC, in the initial near-term period of its existence, may create a division of inspectors to provide expert assistance to the insurance carrier and impartial adjudication or arbitration of claim disputes. This particular function could lead to a rather large permanent staff, and may have severe drawbacks, and should be considered carefully.

In those cases where warranties are not honored because a member firm has become insolvent, consumers can appeal to SWAC for such a determination, whereupon SWAC can designate an agent to take whatever steps are necessary to satisfy the complaint.

In summary, SWAC will be providing the solar manufacturing industry assistance in obtaining insurance designed to cover the liabilities solar companies incur as a result of offering more comprehensive warranties. When it is determined that a particular company needs to plan on a certain expenditure as a result of the warranty coverage it offers, this liability is translated into insured risk. Through its membership in SWAC, however, the company will not have to pay the full cost of the business risk. The lessened obligation will help the company through that near-term period of uncertainty in market development when costs of providing such coverage are unclear.

A second benefit of the proposed plan involves assuring potential and actual consumers of solar energy equipment that manufacturers belonging to the Solar Warranty Assurance Corporation will be able to financially cover the warranty obligation given to the consumer. And in the event the company a consumer purchases his solar energy equipment from disappears, the consumer will still have recourse to satisfy any warranty complaints he may have.

It is crucial that any program explicitly limits Federal Government financial participation to a short period of time, and incorporates a method for that participation to be phased out as the industry matures. In fact this concept leaves open an option

for the Solar Warranty Assurance Corporation itself to disappear if the industry matures to the point where it can secure desired insurance without need for an intermediary, or it finds that, like many other industries, warranty insurance is not desirable.

Other Options

Other options were considered but dismissed for various reasons. Among the alternative options considered were the following:

(1) The Federal Government would reimburse, in full, solar manufacturers for insurance premiums on policies which would be written by private insurance firms.

This was eliminated for two reasons. First, there is not a sufficient performance data base on which to realistically base insurance premiums. Hence, rates could be expected to reflect "worst case" scenarios. Second, providing "free" warranty insurance for solar manufacturers would be a bad precedent for the Federal Government to set. This would be tantamount to opening up the government to accusations of "favoritism" and requests for equal treatment. In addition, general subsidies of solar energy can be more adequately handled by tax credits, or other more direct aid programs.

(2) The Federal Government would act as the reinsuring agent for policies that were written by private carriers, to cover manufacturers' warranties.

Here again, there is no performance data, or claims record, on which realistic premiums could be set. The resulting "worst case" premium would be high, perhaps even too high for solar

manufacturers enjoying a more favorable cash flow situation. The result could be bankruptcy for a number of weaker firms.

(3) The Federal Government would set up a Federal agency to directly insure warranties of the solar manufacturers.

" This was eliminated because it would be a clear usurpation of a private sector function, i.e., insuring commercial risks which are not related to natural disasters, acts of war, civil disorder, or acts of God. Additionally, claims of "favoritism" would certainly rise to protest this initiative, along with demands for equal coverage. Finally, it is feared a whole new Federal bureaucracy would be created which would strongly resist its termination as foreseen in the overall scheme.

IMPLEMENTATION ISSUES

A wide spectrum of issues surround implementation of such an option as the one described in detail above. They involve concerns about the state of standards development, assessment of warranty verses performance problems with systems, role of private insurance companies and federal involvement in this sector, the effect on the competitive atmosphere for solar energy companies, etc. In this section many of these issues will be identified, and in some cases limited discussion will be included.

For purposes of this report the implementation issues are grouped under four main headings:

Insurance Industry and Private Commercial Concerns

Consumer Concerns

Solar Energy Industry Concerns

Government Intervention Concerns

Insurance Industry and Private Commercial Concerns

- The insurance industry does not write much warranty assurance coverage, it is considered a surplus line.

Discussion: Insurance representatives contacted said that there had been some experiments in the past with regard to warranty insurance, however the companies were concerned about the difficulties involving the overlap between manufacturing and installation, and backed away from such policies. Private companies offering warranties seem to generally be operating in a "self-insurance" mode. They usually make a contingent liability entry in their accounting records: this is carried much

like bad debt entries. These liabilities are cleared through cash payments labor and materials allocations, or lack of claims. In the case of labor and materials allocations, such a program as the option detailed could have some difficulty in determining cash value for the in-kind expenditures assigned to solving warranty problems. In some cases companies do set aside amounts in interest accounts to cover warranty obligations.

- The private insurance carriers may have a difficult time deciding on proper premium levels, and will want to adopt a "worst case" posture in most cases.

Discussion: This problem is due to the lack of data. The Solar Warranty Assurance Corporation could have the same difficulty. In addition, it may be difficult to figure in the many variables due to climatic and geographic variables which affect system design and performance. Moreover, it may be difficult to determine exactly what should be covered, that is, just major components, or should the relation between components and overall system performance be linked.

- When the insurance industry does write warranty insurance it is related to the type of product, and is generally set so uniform rates apply to like products.

Discussion: Premiums are determined for various products that are components in subsequently assembled systems, in order to provide warranty insurance. Rates do not generally depend on the type of business involved or the length of time a business has been in existence. When premiums vary, they tend to do so based on assessments of the business and consumer climate in various regions of the country. For example, some states may be considered claim conscious by the insurance industry. Thus, the insurance industry may have necessary experience with the products that go into solar systems, and only need

additional time to begin writing such policies.

- The insurance industry may be reluctant to be involved because legal considerations appear to favor homeowner breach of contract suits.

Discussion: Careful attention should be given to the issue of warranty assurance all along the distribution network: will the ultimate consumer (i.e. homeowner) be adequately protected unless the component part manufacturer and the solar system distributor as well as the installer provide some type of guarantee. The warranty issue is not simply one of "parts and labor" or "repair and replacement" but also extends to problems in defective product design and faulty installation.

These problems have legal implications when, for example, the homeowner's system fails and the warranty is not honored by anyone. Depending on the particular manufacturer and the language of a purchasing and installation contract, an express warranty is not simply an added bonus to the package but is usually part and parcel of the contract bargain. Thus, if the manufacturer or installer fails to honor the warranty, the homeowner should have an excellent chance to recover for breach of contract.

Consumer Concerns

- This program may actually delay consumer acceptance of solar energy because the consumer may feel the solar industry needs special insurance programs because it is not technically ready.
- A mechanism is being created that unscrupulous firms could use to their advantage by disarming consumer wariness through membership in the association.
- Solar companies may raise prices to cover costs of the insurance.
- The weeding out process could be delayed.

Discussion: A government supported warranty/risk insurance program could be a detriment to the consumer over the long run, because the program will hinder the normal sorting out process which occurs when new industries are in a nascent stage of development. Firms that would have disappeared in a normally evolving competitive atmosphere may survive and continue to sell products which are of lesser quality than might otherwise be the case. In the long-run, the consumer suffers the longer marginal products remain on the market. Thus, even though such a program helps the consumer in the short term, the long-term implications are not so favorable.

- Costs for warranty liability coverage may be quite low, but consumers could find themselves bearing the cost of an expensive national program that anticipated high costs.

Discussion: This concern attacks one of the main premises for this option, that solar companies do not offer more extensive warranty coverage because they cannot afford to. It may be a case where the companies do not know they can afford to offer more warranty coverage,

and to do so will increase business turnover to more than offset the added costs. This argument should be extensively examined.

- Such a program could create barriers for entry of new companies that may offer the consumer alternative choices, such as low technology systems that cannot meet warranty requirements, but may make economic sense.

Discussion: Although this presents a particular problem for small companies, it is not something new. Debate about standards development has included many of the same concerns and the selected design may be adjusted over time to follow the path taken by the standards implementation process. It should be pointed out, however, that this option may actually help small companies remain competitive with assistance from the subsidy.

- Anti-competitive problems may be created because of the focus of this option program.

Discussion: This option appears to be specifically designed to provide meaningful benefits to manufacturers of medium temperature flat plate liquid or air type collectors, or special liquid collectors, due to the nature of the problems addressed. Low temperature, low technology, or passive design technology manufacturers may not materially benefit from the program. As a result, the program may provide an unfair competitive advantage to a certain segment of the solar manufacturing industry. The extent to which this may distort the market should be carefully considered.

Solar Energy Industry Concerns

- Solar companies dispute necessary warranty levels.
- Very little data is known about the many factors that will determine the cost to solar companies of warranty coverage.

Discussion: Some company representatives feel that the cost of covering their warranty liability to date has been "meaningless." This impression is only based on a few years of experience. Other companies have been complaining vociferously about government mandated warranty requirements governing participation in Federal programs. They have cited these warranty requirements as the main reason behind significant price increases. This whole area needs close attention.

- The solar market is quite price competitive, and companies may object strongly to added costs, i.e. the insurance premium, however small, when they are demonstrably cash short.

Discussion: "Good" solar companies can legitimately object to the fact that they are subsidizing poor companies with poor equipment. Industry leaders that have built sales on existence of a strong warranty may be concerned that smaller weaker companies are able to offer the same coverage because the Federal Government is offering the subsidy. These and other anti-competitive aspects need to be carefully reviewed.

- This program may depend heavily on existence of accepted standards, which will have to be used to govern membership in the program. These standards do not exist industry-wide at present, and they may vary regionally for a certain period of time.
- Many problems with solar energy systems are due to poor installation, whether due to poorly trained, or just sloppy

craftsmanship. The program, as proposed, would not cover

installation or maintenance problems.

Discussion: An additional concern here is that the Assurance Corporation may have to gather together a large staff of experts to mediate disputes about the warranty covered defects in parts and labor, and other system defects due to improper installation.

Government Intervention Concerns

- This program may be considered a government giveaway to industry, and the funds might be better spent on alternative market development strategies.
- The Federal Government will be paying business risk insurance for private companies.
- Should the Government be in a position where it can mandate, through its participation in the Warranty Assurance Corporation, minimum warranties for the solar industry.
- Government intervention may support a program that large companies can readily use, while smaller companies may find it hard to enter.
- Government intervention in the industry at this stage could only retard natural maturation and industry creation of such a program on its own.
- The Government may be responsible for creating a very large new bureaucracy which would be self-sustaining and assumes unto itself a certain market power and regulatory role.
- Potential exists for runaway cost to the Government over the short term, and strong arguments may be made to continue the subsidy program after the designated termination point.
- Government places itself in a liability situation where it has little bargaining power with the private insurers.
- With the Government sharing liability, there may be no incentive for solar companies to try harder to improve their performance
- This program could lead to requests from other alternative energy industries for similar plans.

COSTS

A number of factors will determine the dollar cost of the option detailed above. These include:

- The number of solar manufacturers participating in the program
- Annual sales of the firms participating
- Number of claims made against solar manufacturers
- Nature of insurance provided and degree of coverage
- Length of warranty coverage
- Content of the warranty coverage
- Failure rate of solar manufacturing firms
- Physical and personnel requirements of the Solar Warranty Assurance Corporation.
- Additional functions, such as data collection, assigned to the Solar Warranty Assurance Corporation

Determining values for these variables should involve some very complex calculations. For some categories only rough estimates may be possible, and any subsequent computations would then depend on the general parameters selected. DPR Impacts Panel revisions are being used to try and calculate some of their costs, and the process is now under way.

4. Minimum Solar System Warranty Requirements

Include in the Application copies of the warranties which the builder/ developer, solar system and/or collector manufacturer and installer will extend to the owners of existing buildings or to purchasers of new buildings. These warranties must be reasonable and, at a minimum:

- a. Comply with all applicable provisions of the Magnuson-Moss Warranty Act of 1975 (12 U.S.C. 2301 ~~et. seq.~~) which establishes Federal disclosure terms and substantive and enforcement provisions for written warranties on consumer products;
- b. Include a one year warranty from the installer against failure of the solar system, any component, or assembly where such failure is caused by a defect in materials, manufacture or installation. The warranty shall cover the full costs of parts and labor required to remedy the defect, including, if necessary, replacement at the site, and shall run from the date of installation completion. The warranty shall also include provision for field inspection at no charge to the consumer, to verify failure, establish probable cause, and determine corrective action required. NOTE: The installer's warranty may include pass-through warranties provided by his supplier or the manufacturer.
- c. Include a five (5) year collector manufacturer's warranty which shall include:
 - (1) A five (5) year warranty against defects in materials or manufacture. The warranty shall cover the full costs of parts and labor required to remedy the defect, including, if necessary, replacement at the site, and shall run from the date of installation completion.
 - (2) A five (5) year warranty against corrosion of the absorber plate and other coolant passages. This corrosion warranty shall cover, for the first year, full costs of parts and labor required to remedy the defect including, if necessary, replacement at the site. For the remainder of the warranty period, the corrosion warranty shall cover the cost of all parts, delivered to the site, necessary to remedy the corrosion defect, including the cost of furnishing new collectors, if necessary. The corrosion warranty shall run from the date of installation completion.
- d. The manufacturer's warranty shall also include provision for a field inspection at no charge to the consumer to verify failure, establish probable cause, and determine corrective action required. NOTE: The manufacturer is not required to warrant against system failure caused by defective or faulty installation.
- e. All warranties may specify reasonable installation and maintenance procedures for the warranty to be effective. However, no warranty shall be voided or in any way reduced by conditions that may occur in normal operation of the system.
- f. HUD also expects the manufacturers of other major system components such as heat exchangers and storage tanks to reasonably warrant their products in accordance with established industry standards.

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