InterTechnology Corporation
Proposed
Test and Evaluation Plan
Commercial Buildings
National Solar Demonstration Program

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PREFACE

The InterTechnology Corporation (ITC) was one of two companies who received awards to conduct studies and analyses for the Energy Research and Development Administration (ERDA) in support of the National Solar Heating and Cooling Demonstration Program. This report was prepared as part of the requirements under contract E(11-1)-2688. It is not intended to reflect an ERDA plan or position. It is expected to be used by ERDA in the development of their plans for implementing the Solar Heating and Cooling Demonstration Program.

FOREWORD

All sections of the Test and Evaluation Plan except Section VIII, were prepared by The Singer Company, Corporate R & D Laboratory. Section VIII dealing with societal and environmental considerations, was prepared by Mueller Associates, Inc., with assistance from Development Sciences, Inc.

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Section I Introduction

A. . Overview

The Energy Research and Development Administration is conducting a national program to demonstrate the economic effectiveness of solar energy as an alternative energy source. Part of the program addresses the heating and cooling of building. The present contract is concerned with planning that part of the National Demonstration Program (NDP) devoted to the heating and cooling of non-residential buildings. A detailed presentation of the system level plan was published recently*.

This report describes the test and evaluation procedures which are needed to document the results of the national demonstration. Specifically, this report presents a Test and Evaluation Plan which is intended to capture, record, process and interpret the data necessary to support that part of the NDP described in the system level plan*.

The Test and Evaluation Plan must encompass those technical, economic, social and environmental factors which provide the basis for showing the role that solar energy can play in providing a viable economic alternative.

The primary focus is on commercial structures and this plan is tailored to a directed number of 200 sites to be utilized over a three year time frame to demonstrate both the heating and the heating and cooling of buildings.

The plan envisions a hierarchy of automatic data collection subsystems to treat the technical factors. Many of these will be intelligent units located at the demonstration sites to record and initially process engineering data which is later forwarded via the telephone network to a

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centralized data base for subsequent processing and interpretation. The plan envisions a variety of manual systems to collect and initially process the economic, social and environmental data. These will be appropriately merged with the technical data in the centralized data base. Compatibility with other Demonstration program activities will be accomplished at the data base level by data storage and formatting constraints.

B. Report Structure

This report has three major parts. The first of these, Section II to Section VI, derives the requirements for the T&E plan from the System Level Plan which is summarized in Section II. The second part contains the proposed plan to fill these requirements and includes hardware and software recommendations as well as procedures and management considerations. Primary emphasis has been given to the remote site because this is the area in which the commercial part of the demonstration is most unique.

Finally, Section XI and XII describe some pre-demonstration activities. The pilot program is intended to resolve a number of issues which arose in the course of the Test and Evaluation Plan. These relate to choice of scan frequencies, compression algorithms, etc. It is also intended to confirm performance and cost effectiveness of the site data collection package. The base line measurements of attitudes, etc. provide a reference mark against which we can measure the non-technical effectiveness of the demonstration program.

Section II System Level Plan

A. General

The primary goal of the National Demonstration Program (NDP) is to show the ultimate economic viability of solar heating and cooling. The relation between this primary goal and the other goals of the NDP as well as with the intermediate objectives has been set forth in the System Level Plan (SLP) which is summarized here.

B. Goals and Strategies

1. There are three principal goals which the System Level Plan seeks to achieve for the NDP:
 - a) Demonstrate the long-term economic viability of solar energy systems for the heating and cooling of buildings.
 - b) Contribute to the creation of a viable commercial and industrial capability to produce, distribute, install and maintain solar heating and cooling systems.
 - c) Stimulate the market to accept solar energy as a cost effective energy alternative and accelerate its use.
2. To achieve these demonstration goals in a timely and cost-effective manner, the System Level Plan must have clearly defined strategies in three key areas: the technical, economic and institutional.

a) Technical Strategy

To succeed, the demonstration program must describe the engineering footing on which the observed performance is based, with sufficient detail to make possible the extrapolation of future performance as well as sufficient system

understanding to permit both system and sub-system optimization. This will require documentation of the various technical parameters describing the solar heating and cooling system, the building, its load and climate.

b) Economic Strategy

The demonstration program must provide an understanding of the present and projected economics of solar energy systems in sufficient detail to permit reliable forecasting of the time of ultimate economic viability of different solar energy system types for different applications in different regions. This implies the need to choose cost-effective sites, to explore learning curves and economies of scale and to understand and exploit various financial incentives and opportunities.

c) Institutional Strategy

The demonstration program must identify and, to the extent possible, mitigate or remove the potential institutional barriers which may arise to slow or limit the spread of solar energy as a viable energy alternative. These barriers include but are not limited to legal barriers (building codes, zoning laws and "sun rights"), labor barriers (training of personnel, jurisdictional arrangements), psychological barriers (acceptance to a new technology by both the building community and its customers) and others (impact on utilities, protection of the consumer).

These strategies can be related in various ways to the program goals enunciated at the start of this section. One such relation is shown in the attached matrix of strategies and goals (Fig. II-1) which attempts to portray some first order interrelations.

Fig. II-1

STRATEGY/GOAL MATRIX

GOAL STRATEGY	PREDICT LONG TERM ECONOMIC VIABILITY	STIMULATE MARKET	CREATE INDUSTRY
TECHNICAL	DETERMINE TECHNICAL PARAMETERS	CLARIFY SYSTEM DESIGN PROCEDURE	IDENTIFY MOST PROMISING DESIGNS
ECONOMIC	DETERMINE ECONOMIC PARAMETERS	EVALUATE FINANCIAL INCENTIVES	EXPLOIT NEAR TERM ECONOMIC VIABILITY
INSTITUTIONAL	DETERMINE COSTS OF REMOVING OR MITIGATING BARRIERS	PROTECTION OF CONSUMER	ACCEPTANCE BY BUILDING COMMUNITY

C. Composition of the Demonstration

The full set of 200 sites can be decomposed into subsets of sites, each subset being the focus of a particular study. These are graphically shown in Fig. II-2.

1. Parametric Study

This group of sites is the heart of the demonstration for they are chosen primarily to document the engineering performance in enough detail to determine,

- a) the performance of the overall systems in terms of energy usage,
- b) the performance of major subsystems so as to permit verification of design rules and evaluation of components.

This engineering performance together with the other technical data is to permit the selection and validation of the parametric solar model outlined in Appendix A. Together with economic data and forecasts, the parametric study forms the experimental nucleus of the demonstration. This is the subset on which forecasts of ultimate economic viability are essentially based and it includes about 67 sites.

2. Technical Studies

This group of sites is addressed to the other technical factors that need study. These include newer technologies in the fields of collectors, cooling systems, passive units, etc. Some 28 sites are involved.

Fig. II-2 . COMPOSITION OF THE NDP
DEMONSTRATION

3. Economic Studies

There are some 41 sites devoted to a demonstration of certain other economic factors such as economy of scale, construction learning curves and the effects of area saturation.

4. Institutional Studies

The remaining 64 sites are chosen to assure adequate coverage of the spectrum of possible institutional factors such as labor-management relations, zoning and building codes, etc.

D. Implication for the Test and Evaluation Plan

The System Level Plan, as summarized above, sets certain goals for the Test and Evaluation Plan. What is required is a data collection procedure which is accurate, consistent, timely and cost effective. This procedure will:

1. Provide adequate documentation at the end of the demonstration for,
 - a) the technical and economic data needed to predict ultimate economic viability.
 - b) the clarification of system design rules which minimize the cost/performance ratios for SHAC systems in different applications.
 - c) the identification of those subsystems and components which offer best design and manufacturing opportunities.
 - d) the evaluation of the social and environmental impacts of the NDP, and
 - e) the preparation and publication of final reports on each site and on the entire demonstration.

2. Permit corrective action during the conduct of the demonstration by analyzing,
 - a) the effectiveness of the demonstration as a whole in achieving the goals of the NDP,
 - b) the on-line performance of individual systems and subsystems, and
 - c) the effectiveness of various mechanisms for the identification and removal of various institutional barriers.

Section III Philosophy of the Test and Evaluation Plan

A. Background

To carry out these objectives, the T&E Plan requires adequate instrumentation at each site to measure and record the appropriate engineering data. It also requires a national center to collect and process the site data.

Specifically, the T&E plan must offer a cost-effective solution to meet the following needs:

- 1) An on-site data collection package to assure the accurate, timely and complete collection of data from geographically scattered site locations.
- 2) A central point for storing and processing the data necessary to describe and evaluate the engineering and economic performance of the SHAC System.
- 3) A monitoring of each site and of the entire demonstration, comparing predicted and actual performance.
- 4) Prompt identification of any operation problems at a site at the subsystem or component level.

This solution must also be compatible with other aspects of the solar demonstration program such as the Residential Program and various NASA and DOD programs.

B. Assumptions

The following assumptions have been made in deriving the details of the proposed T&E plan.

- 1) The load provided by the building will be measured indirectly through the energy supplied by the HVAC

system. Some pertinent parameters of the controlled space (e.g., temperature) will be monitored directly.

- 2) Only normal building maintenance personnel will be available at each site on a full time basis. T&E maintenance personnel will be assigned on a regional basis.
- 3) Commercial structures and their HVAC systems exhibit much more variety than do single family residences and this will affect the data collection effort. In addition, the environment in which the systems must operate in are considerably more hostile than that found in a home.
- 4) These data collection packages and the central data processing systems will be required to be in place and in operation within approximately a six month time frame.

C. Basic Data Requirements

1) Classification of Demonstrations

It is convenient to define three possible levels of instrumentation in order to classify the data requirements. These are defined in response to the needs of the System Level Plan and are to be assigned priorities in light of that plan. Generally, we have defined three such levels; a MACRO level which examines total system energy balances, a MICRO level, which looks at subsystem performances and a Laboratory level which involves a detailed study of subsystems and components.

2) MACRO Instrumentation

The purpose of the MACRO instrumentation is to provide basic data on the total system energy balance.

It is intended to show how much energy was used to heat or cool the building and what part of this was provided by the solar energy system. Consequently,

it might yield only four numbers in a year. This is the minimal level of instrumentation for any site and is the one most subject to undetected error.

An extended MACRO level may be appropriate in some cases. The extension may include a measurement of the energies actually delivered to the HVAC system as well as a minimal weather and insolation measuring station. Such extensions may be required at certain sites if the errors likely to occur otherwise are unacceptable. The elements to be measured are shown in Table III-1.

3) MICRO Instrumentation

The purpose of the MICRO instrumentation is to determine the heat or energy flow across the boundaries that might be set up to surround the major subsystem elements such as those enumerated in Table III-2. These elements will be treated as "black boxes" where the instrumentation provides only the data needed to measure energy flows in and out.

To be reasonably accurate in characterizing the performance of these subsystems, it is necessary to recognize the fact that they cycle on and off and to collect the data accordingly. This implies data sampling rates of at least one or two per hour, a requirement several orders of magnitude greater than at the MACRO level.

4) Laboratory Instrumentation

This class of instrumentation is concerned with a detailed study of a selected subsystem such as might be desired by the manufacturer of that element in order to determine the differences between performances in a real environment as opposed to those in a laboratory. In general, the content of such an experiment would be far more detailed than the preceding levels because of the need to explore transient behaviour of a number of elements within

TABLE III-1

MACRO EXPERIMENT ELEMENTS

Solar Energy System
Auxiliary Heater
Auxiliary Cooling
Weather Factors (degree days, insolation, wind velocity)

TABLE III-2

MICRO EXPERIMENT ELEMENTS

Solar Energy System
Collector
Storage Unit
Heat Exchanger
Pumps
Auxiliary Heater (Central)
Auxiliary Cooling (Central)
Water Tower
Centrifugal Chiller
Absorption Chiller
Distribution System
Pumps
Incremental Heat/Cool Units
Weather Factors
Ambient Temperatures
Humidity
Insolations (Horizontal, Tilted, Diffuse, etc.)
Wind Speed and Direction

the subsystem. There is considerably more data involved here because of the complexity of certain components, (.e.g, an absorption air-conditioner) and because of the potential need to record transient performance of variables whose time constants may be the order of seconds.

5) Basic Assumptions

The basic purpose for collecting data at the various sites is to verify the performance of the SHAC system where verification will be interpreted in the following way. As shown in Figure III-1, the design phase for a demonstration site involves predicting SHAC system performance via a computer simulation. Weather data for a typical or characteristic year is used together with a computerized model of the building and the SHAC System (such as TRANSYS Program of the University of Wisconsin) to dynamically simulate the behaviour of the components over the year determining how much energy is obtained from the SHAC system. The actual site will later be constructed with some possible variation from the original design and will be operated in accordance with the demands of the actual weather at the site. The actual performance at the site will be measured and recorded by the Test and Evaluation equipment.

It is clear that the earlier performance predictions are no longer appropriate reference points because of the changes in the building design and in the weather. However, if the building and the SHAC models are adjusted (insofar as this is possible) to incorporate the variations found in the actual site and if the actual weather as recorded by the T&E equipment is used in conjunction with this adjusted computer model, then the resulting simulated performance should be a meaningful reference against which to validate the measured performance.

It is to be expected that the measured and simulated performance numbers will differ. This difference can come from the following sources:

- 1) variations in performance of SHAC components,

FIGURE III-1 PERFORMANCE VALIDATION

DESIGN PHASE

VALIDATION PHASE

- 2) difference between simulated and actual control strategies,
- 3) problems in system operations,
- 4) approximations in the computer simulation model, and
- 5) errors in the T&E measurements.

The contributions from these last two sources should be made small enough as to have no effect on our ability to identify any of the first three sources as the cause of any real difference between measured and simulated performance detected during the monthly performance assessments described in Section VI-D.

The implications for the T&E Plan are three-fold.

- a) The site data collection package must measure those parameters likely to be needed in identifying sources of discrepancies as noted above. Practically speaking, it should measure those parameters required in the computer simulations of the SHAC Systems.
- b) The parameters must be measured at least as often as is required to validate results at the minimum time step used in the simulation programs. Typically, this is the order of one half hour or an hour.
- c) The measurement accuracies must be adequate as noted above. The convenient rule of thumb is that the errors should be approximately equal to those inherent in the simulation results which typically are the order of 1%.

With this general framework in mind, let us now turn to a discussion of the appropriate level of instrumentation.

It will be assumed that the Laboratory level of instrumentation will play no role in the NDP. Research and development efforts which need such instrumentation will be conducted by NASA and its contractors or by the equipment manufacturer. In either event, such instrumentation falls outside the scope of the ERDA NDP.

The MICRO level of instrumentation is appropriate for the sites in the parametric study as well as those in the technical study. It is also possible that some of the sites in the economic study warrant this level of instrumentation. For example, it seems desirable to assure that performance does not suffer as a result of the changes in installation techniques that may be part of the construction learning curve. This implies approximately 110 sites at this MICRO level.

The MACRO level of instrumentation is appropriate for the remaining 90 sites in the economic and institutional studies. The extended MACRO level might be appropriate for some small fraction ($\sim 1/3$) of these sites.

D. Basic Decisions

1) Sampling Frequency

A key decision is the frequency with which measurements are to be made. This decision must be made in light of the phenomenon being measured and the use to which the measurements will be put. Some of the variables to be measured change significantly over an hour and may even vary within minutes. Examples are the temperatures of the collectors and the incident solar energy (insolation). Similarly, it is known that some computer simulation programs require data at time intervals of less than one hour.

It is not clear at this time what the proper sampling frequency is. Resolution of this point is one of the major purposes of the pilot program discussed in Section XI.

2) Data Compression

If there are many variables to be measured many times in a hour, the data storage requirements will become excessive, making it very desirable to reduce or compress the data. Furthermore, in the normal environments there will be random variables affecting these measurements and the net effect of the random contributions (noise) can be reduced by certain data smoothing techniques. For these reasons, data compression will be used to reduce the amount of data. Measurements will be made perhaps as often as every twenty seconds and data compression techniques will be used to reduce this to a smaller set of numbers which describe the performance over an hourly interval with interpolation as needed.

The hourly description will vary from component to component. In some cases, it will be a single number representing the average of all the readings over the hour. In other cases, a polynomial will be fit through the data points, and only the coefficients in the polynomial will be stored. In this case, a second order fit would compress all the points down to three. And finally, there will be some measurements for which in addition to the smoothed values, there is need to record the scatter of the data so that the standard deviation of the measurements would also be recorded. The latter may be appropriate for things such as insolation measurements, which will fluctuate significantly within an hour on a windy day when there are many small clouds passing between the collector and the sun.

3) On-Site Intelligence

In order to assure that the data collection system has a high level of reliability and is reasonably certain of collecting a fairly complete set of data, we believe it is necessary to have some intelligence present at the remote site. This intelligence can be utilized to verify the performance of the remainder of the system by running through diagnostic checks on e.g., a daily basis. In addition to these reliability considerations, we have chosen to distribute intelligence about these sites because of the need for flexibility. This flexibility relates in part to the ease in installing the differing configurations that will be required from one site to another, as well as to the need to vary the data compression requirements at a given site during the course of that demonstration. We believe that the only way to meet these requirements is through the modularity and flexibility associated with software in an intelligent controller. In addition, the presence of such intelligence makes it easy to satisfy the requirements imposed by the next decision, namely to support the implied telecommunication requirements.

4) Data collection via telecommunications

There is a large amount of data that will be collected at each site, and efficient operation of the entire demonstration requires that the data capture techniques be highly automated. In addition, the existence of many records in different places implies the need to minimize potential human errors by automating this again as far as possible. Finally, there is need for reasonably short delays in getting site data to

some central facility for analysis and modification of the demonstration to correct operational problems that have been detected. For these reasons, we believe the most cost-effective solution is to poll the remote sites by telephone on a daily basis. An economic comparison of the alternatives is outlined in Appendix B.

5) Compatibility

It is clearly necessary for the commercial side of the demonstration and the residential side of the demonstration to provide compatible and comparable results. This can be achieved in several ways, ranging from complete hardware compatibility at the site level up through compatibility of records in some centralized data base. Because of our preceding decisions, the compatibility which seems most appropriate to us is the latter, namely compatibility of records at some centralized data base. Use of telecommunications networks provides the appropriate interface for site subsystems of different manufacture and configuration to deposit in the central data bank records describing their site performance which are compatible with the overall framework of the data base. It is clear that the records will be different in length and conceivably different in the type of description provided for each of the parameters measured. Therefore, we have proceeded on the assumption that providing a format compatible record to a centralized data facility over telecommunications networks is adequate to meet the needs of the compatibility requirements.

Section IV National Requirements

A. Functional Requirements

To carry out the above solutions, a number of tasks devolve on the national agency in the T&E Plan.

1. Post Demonstration Documentation

a) Ultimate Economic Viability

To demonstrate the ultimate economic viability of solar energy for the demonstration as a whole, it is necessary to combine the energy equation (discussed in Appendix A) with the collected economic factors to make a prediction of the economic savings. To carry this out, it is necessary to select that model of the energy equation which best fits the data collected at the MICRO level and then refined to include MACRO level data as well, resulting in a choice of various coefficients in the equations. Furthermore, the varying economic scenarios deemed appropriate for consideration must be detailed adequately for the forecasts to be made. This will require the collection of economic statistics in a number of areas.

b) System Design Rules

One of the elements aiding in the creation of a market is the emergence of accepted set of design rules for solar energy systems. The T&E plan will contribute to this by examining the spectrum of system designs included in the NDP and characterizing their technical and economic performance, thereby indicating the optimal solution and fostering the adoption of the most successful of these.

c) Subsystems Evaluations

In a similar way, the subsystems and components will be evaluated. It should be possible to indicate the more successful subsystems as well

as identifying those elements for which further development is indicated.

2. Mid-Demonstration Analysis

a) Entire Demonstration Effectiveness

It is desirable at any time during the demonstration to anticipate the effectiveness of the demonstration so far. This can be done by employing the actual history to that point and the predictions for the remainder of the time. Forecasts of energy savings will depend on the model employed as noted above. An initial selection (based entirely on predictions) and modified annually (on the basis of actual experience) is the recommended procedure. Similar updating can be employed with the economic scenarios. In this way, the T&E Plan will provide a continuing estimate of the effectiveness of the demonstration as a whole.

b) Individual System Performance

By collecting the appropriate engineering data, the T&E Plan makes it possible to monitor the performance of individual sites. Comparing the simulated and actual performances of subsystems and components will permit identification of incipient problems early enough to minimize their impact on the demonstration.

3. Institutional Barriers

Through its monitoring of the attempts to overcome the various barriers encountered in the course of the demonstrations, the more successful solutions may be identified soon enough in the demonstration to significantly improve the later sites in the demonstration as well as to contribute to the creation of a future market.

B. Data Processing

The data flow shown in Figure IV-1 provides a schematic presentation of the above requirements in a way that allows transition from requirements at a national level to those at the site. It is clear that achievement of the final objectives requires four basic activities.

1. Collection of engineering, operation and economic data on the SHAC system and components as well as appropriate data on the building and climate to define the thermodynamics, economics and operational history of this site. This will be discussed further in a subsequent paragraph.
2. Generation of appropriate economic scenarios with timely updating to permit realistic forecasts of economic viability.
3. Prediction of cost and performance improvements in SHAC equipment due to mass production and reliability enhancements.
4. Formation of the statistical data base necessary in the prediction of ultimate economic viability. This will include not only regional building statistics but also appropriate insolation and weather data to describe ultimate national impact.

The remainder of this report focuses on the first activity. Those enumerated in the last paragraphs are quite necessary but lie outside the scope of the current work, and are included only for estimates of resource requirements.

Fig. VI-1 TEST & EVALUATION PLAN:

DATA FLOW

Section V- Local Site Requirements

A. General

The preceding discussion implies that at the local site, provision must be made to collect the engineering, operational, and economic data necessary to define the thermodynamic, economic and operational history of the site to whatever level of detail is appropriate.

These requirements fall into two classes: variables to be measured, and records to be examined. The variables must be measured by sensors in the data acquisition subsystem, and subsequently relayed in an automatic fashion to the central data base. The records must be examined by T&E personnel, the needed material must be extracted, and then forwarded to the central site for subsequent incorporation into the data base..

B. MACRO Level Sites

1. Measurements

The variables to be measured on a MACRO site are the energy delivered by the solar energy system (2 to 3 channels) plus the conventional energy supplied by the HVAC devices (number of channels here vary from 1 per site to 1 per conventional device). A daily interrogation of these variables is the most frequent reading that might be required in order that heating and cooling be properly separated.

2. Records

The records to be examined relate to the costs of fuel, maintenance and other operating costs, as well as to equipment failure and malfunction. Conventional utility meters will be read where appropriate. For sites without weather stations, the U.S. Weather Service records covering temperature and insolation must also be obtained.

3. Configuration

For sites with extended MACRO level instrumentation, there are an additional three channels for measurements of temperature, insolation and wind, plus another two or three channels to measure the solar energy actually delivered for the heating and cooling of the building. This raises the total channel count to a maximum of nine. For purposes of estimation, it will be assumed that the MACRO level system has five analogue channels and two digital channels and that the extended MACRO level system has 12 analogue and three digital channels. As the data requirement is probably 1 measurement or coefficient per hour per channel the total daily data generated is approximately 250 coefficients.

C. MICRO Level Systems

1. Measurements

The variables to be measured for this level of instrumentation are determined primarily by the solar energy and HVAC subsystems present in the site design. An enumeration of possible subsystem elements is given in Appendix C together with the type instrumentation required. A summary of the required data together with their characteristics are given in the following Table V-1.

2. Records

The records to be examined must provide the following information:

- a) Costs for conventional energy used along with a basis for properly apportioning shares to the solar and conventional contributions to the heating and cooling of the building.
- b) Costs of other consumables such as water (in cooling towers) filters, etc.

TABLE V-1

GENERAL DATA CHARACTERISTICS

<u>Variable</u>	<u>Range</u>	<u>Accuracy</u> *
Weather Station		
Ambient Temperature	-40° to 150°F	± 2%
Humidity	0% to 100%	± 3%
Insolation	0 to 350 BTU/ ft ²	± 2%
Wind Speed	0 to 80 MPH	5%
Wind Direction	0° to 360°	5%
SHAC Components		
Fluid Flows	0 to 200 GPM	2%
Fluid Temperature	20° to 200°F	Varied
Air Flows	0 to 10 ⁴ ft ³ /min.	2%
Air Temperature	-30° to 200°F	Varied
Surface Temperature	-40° to 400°F	5%

* The accuracies cited are preliminary assessments subject to confirmation by comparison with validated simulation programs.

- c) Other operating costs, including
 - 1) Labor
 - 2) Floor space charges
 - 3) Taxes and insurance
 - 4) Equipment maintenance and repair
- d) Maintenance logs
- e) Failure data on SHAC equipment to include failure analysis and raw data for meantime before failure (MTBF) and meantime to repair (MTTR) calculations.

3. Configuration

The general implications of the above are conveniently discussed in terms of the schematics of Fig. V-1 and 2 for nominal and maximum site configurations. Using the sensor counts shown in the schematics and allowing 10% for electric power meters and 10% redundancy for the nominal system and 20% for the maximum, the channel requirements are as follows.

	Nominal	Maximum
Analogue	34	81
Digital	7	15

For purposes of estimates we will assume a nominal site has 30 analogue channels and 10 digital ones and a maximum sized site will have 80 analogue channels and 20 digital ones.

The transmission and storage requirements must be based on the maximum site configuration. The maximum instrumentation shown in Fig. V-2 generates 150 to 200 coefficients per hour. This is based on an assumed mix of data compression fits and assumed cycle frequencies. It implies the need to store 4K to 5K coefficients each day, where a coefficient involves a sign, a two digit characteristic and a six digit mantissa, which will require two eight bit words.

Fig. V-2 TYPICAL SHAC CONFIGURATION
FOR MAXIMUM CHANNEL ESTIMATE
(No redundancy included)

CHANNEL REQUIREMENTS

SYSTEM	Temperature	38
	Flow Rate	16
WEATHER	Temperature	2
	Insolation	3
	Humidity	1
	Wind	2
		<u>62</u>

29

Channel Requirements

SYSTEM	Temp. Sensor	13
	Flow Sensor	7
WEATHER	Temp. Sensors	2
	Insolation	3
	Humidity	1
	Wind	2
		<u>28</u>

Fig. V-3 NOMINAL SHAC CHANNEL CONFIGURATION
(No Redundancy Included)

Section VI Data Processing Tasks

A. General

This section marks the end of the derivation of requirements for the Test & Evaluation Plan. It consists of a summary of the various data processing tasks which must be carried out. These tasks are grouped in terms of their frequency of occurrence, from hourly to yearly. The software configuration task, which must be done at the inception of each demonstration, is discussed under yearly tasks.

B. Hourly Tasks

1. The tasks that must be performed at least once every hour include the scanning of the data channels, the initial processing of the data and the hourly (or per cycle) compression of the data.
2. Channel Scan. The data collection effort begins with the scanning of the various analogue and digital channels whose measurements are to be recorded. The frequency with which these channels are scanned depends on the level of instrumentation. At the MACRO level, the data on energy usage must be taken often enough so that any sampling involved contributes no significant error. For the solar collector system, this probably means 10 to 20 scans per hour.

At the MICRO level, the data on the various subsystems must be recorded in enough detail to permit accurate dynamic simulation of these subsystems. Because of the non-linearities in the performance of these subsystems, the required scan frequency is largely determined by the time constants of the subsystems. As noted earlier, the basic

scan frequency will be chosen based on the results of the pilot study. In any event, it should be less than 4 per minute.

3. The initial processing includes some noise reduction, conversion to engineering units and performance of some checks.
 - a) Some noise reduction can be accomplished by averaging. If there are less than 200 channels per site to be sampled say every 20 seconds, then the resulting rate (10 samples/sec.) is well below the rates of typical A/D converters, (e.g., 10-20 KHz). This excess capability can be used to generate ten or more raw data points at, say, a 10 KHz rate which can then be averaged to yield one smooth point. This averaging will reduce the effect of high frequency electrical noise. Furthermore, judicious choice of the sample can yield substantial attenuation of 60 Hz signals and their harmonically related components. This is important because of the potential effect on the power line of the various non-linear elements in the building.
 - b) To convert this smooth data point into proper engineering units requires calibration data for that channel. This data is stored on site at the time of initial configuration. The conversion may require table look-up and interpolation or merely algebraic manipulation.

Providing this arithmetic capability at the site makes it possible to generate derived channels, e.g., the heat flow from a unit which is a flow rate times a temperature difference. In addition to providing directly some implicit engineering items, these derived channels may also contribute some further data compression.

- c) Two checks can be made to verify each smooth point after its conversion to engineering units.

The first check is a high-low limit check and is intended to identify system or sensor malfunction. At the time the system is initially configured, normal operating ranges are defined for the variable monitored in each analogue channel. A reading outside this range indicates a potential problem.

A second check can be made if any of the more important variables are being monitored by more than one channel. Comparing these redundant channels provides another opportunity to detect malfunction.

4. Data Compression is clearly required to reduce the mass of recorded data to that which is fundamentally required. For some variables such as the conventional energy consumed, a cumulative integration is appropriate. For others such as a flow rate, an average over the basic time interval is adequate. For still others, such as tank temperature, a trend may be required (i.e., a linear fit). Finally, to properly describe the energy delivered from a collector, a higher order fit (e.g., a second or third order curve) may be necessary. One of the purposes of the pilot study (Section XI) is to recommend specific algorithms for specific variables.

This spectrum of requirements can be satisfied by a set of compression algorithms such as that enumerated in Table VI-1. At the time of initial configuration, the algorithm desired for each channel can be specified as well as the basic interval of data to be compressed. At least two choices for this interval appear needed.

- a) Daily compression appears necessary for the MACRO Instrumentation.
- b) Hourly compression at the MICRO level appears needed for those subsystems which are essentially "on" all the time. For those subsystems which

TABLE VI-1

COMPRESSION ALGORITHMS

Code	Resulting Fit	Number of Coefficients per hour/cycle
0	Average and Standard Deviation	2
1	Average value	1
2	Linear fit of interval	2
3	Quadratic fit of interval	3
4	Exponential fit of interval	4
5	Linear fit plus corrected variance	3
6	Integrated value over period or cycle	1
7	Cumulative integration of variable	1 (per day)

cycle on and off; compression should be carried out separately over each state. The duration of the "on" state and the data should be recorded in the hour during which the state ended.

5. Further checks are possible with the compressed data because of the reduced effects of noise and the reduced quantity of data.
 - a) Derived relations provide further opportunity to identify malfunction. Since intra-channel relations can be specified at the time of configuration, this implicit redundancy can be used to verify that various channels agree to within some predetermined amount.
 - b) Trends can be observed in things such as flow rates and when statistically significant deviations occur (due for example to build-up of constrictions in the plumbing) these can be noted and flagged.
 - c) Cycling limits will be required for each subsystem of this type to establish data storage requirements. If a cumulative sum is kept of the number of times the subsystem cycled on and off during a day, then excessive cycling can be detected and flagged.
6. Preparation of the preamble to the report forwarded to the central data base must be largely done before the remote site is actually polled. Since the exact time of the call is not known, the preamble must be updated hourly. Further details are given below.

C. Daily Tasks

1. Additional Tasks are performed each day by the remote site unit in order to transfer its daily records to the central data base. These include

response to the central site diagnostic interrogation, completion of the preamble, transmission of the data records and daily reinitializing. The central site carries out the polling program, collecting data from each site and storing it after some initial processing.

2. When a remote site is polled, the interaction between the two machines begins with a "handshaking" routine which should be expanded beyond the usual telecommunication protocol to permit the central site to verify some minimal level of operation of the remote site machine. This diagnostic interrogation will call for a brief diagnostic routine stored at the remote site which is intended to exercise those components whose performance cannot be otherwise monitored at the site.
3. The result of the diagnostic routine will be included in the preamble, which is that part of the transmission to the central site where the remote site identifies itself and gives a status report. The identification included the site number and the essence of the current configuration (to include channel calibration) in order to permit the central site to make proper verification and keep its records up to date. The status report includes the result of the diagnostic routine check on the main machine, as well as all malfunctions detected in the various checks. Power failures and component outages will also be included.
4. The second part of the transmission contains the data for the day. It is the set of coefficients generated by the compression algorithms. It is anticipated that the transmission will be a character at a time in ASCII format (with parity) and will include some additional error control characters for the preamble and each block of data.
5. Reinitializing is required when the transmission is completed, in order reset malfunction flags, etc.

6. The central data base has some initial processing to perform on the transmitted data before adding it to the data base. From the preamble, the central site machine can confirm the site identity and verify that it has the latest version of the configuration program. The preamble is also the source of malfunction alerts, which are collected and directed to the attention of supervisory personnel for action. Finally, when all this has been accomplished, the day's record is added to the data base.

D. Monthly Tasks

1. The remaining tasks all relate to the central site. The monthly tasks fall into two categories, technical and operational.
2. The technical tasks are twofold. The first amounts to cleaning up the record (i.e., filling in missing data through interpolation or other means) and systemetizing the data base for that month's data so that it can be used by other agencies. The second task is concerned with performance analysis. It begins with a search for trends by comparing this month's data with its predecessor. It includes a comparison of the actual performance with that predicted from a dynamic simulation model, as discussed earlier in Section III-C. Finally, it may include recommendations on modifications to configurations, control strategies or other elements under the control of the demonstration program.

In addition to the evaluation of each site, there should be a monthly evaluation of the demonstration as a whole. The basic demonstration program will have been evaluated for effectiveness based on calculated results derived from simulation programs and simulated weather conditions. As the demonstration program proceeds, simulated data can be replaced by actual data and a monthly update of the forecasted effectiveness of the demonstration can be made.

3. The operational tasks to be undertaken each month are needed to complete the description of the demonstration. This data must be collected, verified and entered into the data base in a consistent fashion.
 - a) Cost information must be collected regarding the installation, operation and maintenance of the SHAC system. Of particular interest are the costs of conventional energy forms.
 - b) Reliability, maintainability and failure analysis data must be collected and statistically analyzed as part of the program to evaluate the performance of the various SHAC subsystems.
 - c) Data on the social, institutional and environmental impacts should be incorporated in the data base in a consistent and usable fashion.

E. Annual Tasks

1. Annual tasks include two which relate to the individual site (initial configuration and final report) and two which relate to the demonstration as a whole (building an economic data base and forecasting the fuel and dollar savings offered by solar energy systems).
2. The initial configuration at each site is accomplished with the aid of a computer program called the Configuration program which is described in some detail in Appendix D. This program provides the central site engineers with a concise definition of each remote site. It aids the installers at the remote site in configuring the instrumentation system and assists in the calibration maintenance and servicing. The specific program results for each site are stored at the central facility for use in daily verification and reinitializing if that becomes necessary.

3. At the completion of the year demonstration at a site, a final report covering the technical and non-technical aspects must be prepared. This should include a life cycle cost analysis, projected fuel and dollar savings under different economic scenarios, a comparison of predicted and actual performance, comments on the design rules, installation and maintenance procedures control strategies, component performance, etc. The social, institutional and environmental impacts must be discussed and any contributions to the solutions of these various problems needs careful discussion.
4. At the end of a year, approximately one-third of the demonstrations will have been completed and it is appropriate to summarize the status of the demonstration as a whole. Enough data should be available to solve the basic parametric model (cf. Appendix A) and to permit a forecast of the energy and total dollars which the nation could save through use of solar energy.
5. To accomplish this forecast requires a solid data base describing the fundamental economic scenarios as well as the projected technical and institutional advances likely in the future. These are required for the annual forecast, but must be built up over the year.

FIGURE VII-1 SITE DATA ACQUISITION SUBSYSTEM

Section VII - Remote Site Hardware

A. General

The two previous sections have presented a set of functional requirements that are to be met by the equipment at the remote site. Two levels have been described: A MACRO and a MICRO level of instrumentation. The first of these requires a Site Data Acquisition Subsystem (SDAS) which is very similar to that required for the residential demonstration and a possible implementation is outlined in Appendix E. The MICRO level of instrumentation requires a more complex SDAS such as that shown in Fig. VII-1, and is discussed in this Section.

The site itself is, of course, not part of the SDAS; rather it represents the collection of variables to be monitored. The other elements in the order of presentation are:

1. Sensors and transducers which convert the monitored variables into electrical signals.
2. Transducer interface which couples the transducer and sensors in an appropriate way to the on-site intelligence.
3. Local storage of data prior to forwarding to a central data collection facility.
4. On-site intelligence in the form of a small computer to monitor and control the SDAS and compress the raw data for storage, and
5. Communications interface to permit transmission of data from local storage to the central facility.

B. Sensors and Transducers

Sensors and transducers produce electrical signals which represent the variables to be measured, and are to be chosen so as to meet the requirements on the measured data given in Table V-1. An extensive evaluation of

sensors is beyond the scope of the present study, but a preliminary assessment is part of the pilot program and a discussion of the sensors used there will be found in Section XI.

The selection of sensors is important because they represent a major portion of the individual site costs. To illustrate this point, Table VII-1 summarizes the cost estimate of a particular site considered in this program, one that is configured much as the system in Figure V-1. Assuming that final installation and calibration costs about \$80 for a digital (state) line and \$120 for an analogue line, the total cost of the installed sensors is just above \$10,000.

In addition to the usual cost and performance criteria in selecting sensors, certain operational factors should be kept in mind. Where possible, temperature sensors should be chosen so that they can be easily installed (in wells) after site construction is completed. It is also important to identify those critical sensors which need to be replaced periodically for maintenance or recalibration.

It seems appropriate here to point out the need for adequate liaison between the T&E personnel and the site design and construction people, for there are many interactions that need to be expedited. For example, the mechanical bed package should include sensor wiring as well as installation of certain key sensors such as fluid flow meters or temperature sensors in pressurized vessels. Accessibility of sensors for later installation and calibration often needs attention at the design stage. Many problems can arise if this liaison is not properly carried out.

C. Transducer Interface

The transducer interface is the instrumentation front end and connects the sensors and transducers to the input/output structure of the on-site intelligence. The accuracy requirements set forth in Section V together

TABLE VII-1 COST ESTIMATE FOR TRANSDUCER
SET FOR A NOMINAL SITE*

<u>Sensor</u>	<u>Number</u>	<u>Unit Cost</u>	<u>Extension</u>	<u>% Discount</u>	<u>Net Extension</u>
<u>Collector</u>					
Fluid flow	1	600	600	15	510
Fluid temp.	2	60	120	20	96
Air temp.	1	20	20	20	16
State (pump)	1	15	15	20	12
Surface temp.**	2	160	320	15	272
<u>Weather</u>					
Insolation	2	570	1140	10	1026
Air temp.	2	50	100	20	80
Humidity	1	50	50	10	45
Wind direction	1				
Wind speed	1	125	125	15	110
<u>Storage Tank</u>					
Fluid flow	2	600	1200	15	1020
Fluid temp.	6	60	360	20	288
Air temp.	1	50	50	20	40
State (pump)	2	15	30	20	24
<u>Auxiliary Heater</u>					
Fluid temp.	1	60	60	20	48
Flow rate	1	600	600	15	510
State (pump)	1	15	15	20	12
<u>Auxiliary Chiller</u>					
Fluid flow	1	600	600	15	510
Fluid temp.	1	60	60	20	48
State (pump)	1	15	15	20	12
<u>Tower</u>					
Fluid flow	2	600	1200	15	1020
Fluid temp.	1	60	60	20	48
State (pump)	1	15	15	20	12
<u>Electric Power Meters</u>	4	150	600	10	540
<u>Site totals</u>					
Analog	33		7283		6299
Digital	6				
Installation Costs		33 x 120			3690
		6 x 80			480
					<u>4170</u>

* No allowance has been made for special power supply costs.

** Reflects shared amplifier costs.

with the desired range suggests the need of $10^{-2} \times 10^{-2} = 10^{-4}$ accuracy in the analogue to digital (A-to-D) converter. To provide some reserve, a 12 bit (1/4096) A-to-D converter was chosen.

Because of the number of channels involved, it is more economical to share one good A-to-D converter among many channels using multiplex (time sharing) techniques. This then leads to a choice of a programmable interface which will provide, under computer control,

1. Programmable addressing of channels,
2. Programmable gain control to compensate for the differences in the output levels of various transducers,
3. Reading of analogue signals and analogue to digital conversion, and
4. Direct reading of digital signals.

There are several pieces of available equipment which appear to meet the basic requirements set down for the transducer interface, viz a programmable machine, 12 bit output, expandable to 80 analogue channels with scan rates high enough (e.g., 10 KHZ) to provide multiple hits per sample (to analytically remove 60 Hz noise and its harmonics).

These fall into two categories. One is the interface unit designed for use with customary minicomputers such as DEC PDP-11's or D.G. Nova 1200 machines. These interfaces have the necessary program interrupt interfaces and the requisite speeds to provide an effective interface for these minicomputers. Units available from Adac or Analogic are typically in the \$2000 to \$2500 price range.

A second class of interface is the newly emerging group intended to interface with the simpler and slower micro-computer based systems. Adac offers Model 600-LSI-II

based machines. It is a 16 to 64 channel multiplexed 12 bit A-to-D converter with 35 KHZ throughput and programmable gain. Most attractively, it is priced in the 64 channel version at about \$1300.

Two configurations questions need to be recognized. One concerns physical configuration and the other electrical configuration. Physically, the transducer interface can be placed in the same cabinet as the minicomputer mainframe. This is cost-effective because power supplies, ventilation and cabinetry are shared. However, since the transducers tend to be deployed in small subgroups (e.g., in the boiler room and at the collectors) it is necessary to run long lengths of wire carrying unamplified signals. This will be unacceptable in noisy environments, where another solution is to distribute the transducer interface in field cabinets near the transducers so that the only strong digital signals need be sent over long noisy runs. This latter has proven a very effective noise control technique in communications applications, but is a somewhat more costly one. Proper choice of physical configuration obviously requires some detailed knowledge of the site*.

The question concerning electrical configuration involves the manner in which each channel is connected to the interface; single ended, differential and psuedo-differential. Single ended connections are the simplest and cheapest. Differential channels employ amplifiers which reject common mode signals (CMR) through additional wiring. Consequently, although the most costly option, the differential amplifier channels provide the best interference rejection and signal-to-noise ratios. Psuedo-differential connections are hybrid solution, attempting to achieve common mode rejection through the use of building ground circuits. The last is the most attractive solution, but not all sites will have the proper ground circuits. Again building details are needed for proper selection.

D. Local Storage

1. Local storage must be large enough to store the

* The pilot program will use main frame mounting. The cost estimates assume field cabinets.

coefficients resulting from compression, the basic computer programs and some utility programs.

The coefficient file is sized by the configuration and the reserve capacity required. The configuration maximum is 80 analogue channels and the various mixtures of sensors, compression choices and cycling frequencies we have examined suggest a maximum of 3 coefficients per channel per hour. Digital channels require less than 2 coefficients per hour on the average so that if a coefficient requires two 16 bit words for storage, then $(80 \times 3 + 20 \times 2) \times 24 \times 2 = 13,440$ words/day will be required in the coefficient file.

Because of possible network and mainframe problems at the central site, it is likely that polling may be interrupted for up to a day. Allowing an additional day for the central site to catch up, it seems advisable to have at least three days storage at the site. With this reserve, the total coefficient file size is about 40K words.

The size of the basic computer program and the utility packages, to be stored at the site (e.g., the configuration program and the local reporting program) is not yet certain. If preliminary estimates are correct, this total should be less than 50K words.

In summary, the local storage requirement appears to be about 90K words, which is convenient since most tape cassette units have 100K word capability, while floppy disks may have 128K words (single drive).

Equipment is generally available from the computer supplier to provide local storage both as a tape cassette and as a disk at essentially the same price. The added storage in the disk is offset by its lower reliability. Unless a configuration is in significant danger of exceeding the cassette storage capability, the cassette is the preferred solution.

E. On-Site Intelligence

The requirements enumerated above imply the need of a small 16 bit word minicomputer. This follows from the size of the A-D output word needed for accuracy, and the general processing tasks of monitoring, scanning and compressing, which significantly outstrip the capabilities of the available 8 bit microprocessors. A summary of requirements follow.

1. A 16 bit Central Processing Unit (CPU),
2. Internal memory (16K words) for storage of operating programs and intermediate data,
3. Provisions for connections with
 - a) Transducer interfaces both analogue and digital,
 - b) Local storage interface,
 - c) Communication interface,
 - d) Local teletype interface,
4. Automatic power fail restart feature,
5. Real Time Clock

In addition to these functional requirements on the hardware, it is important to impose additional requirements on the vendor, primarily system responsibility and nationwide servicing. These latter two are most important for the operation of a widely dispersed set of installations.

In this context, we wish to select a system with a 16 bit CPU, 16K memory, cassette storage, transducer and telecommunications interface. There are a number of vendors offering such equipment, but the most outstanding are Digital Equipment Corp. and Data General. A comparison of their offerings is given in Table VII-2.

The price differential between these is enlarged by the fact that the Adac transducer interface is currently usable

Table VII-2 Comparison of Remote
Site Processors

DEC PDP 11/03

CPU, 4K RAM, Auto Restart	
Teletype interface, Real time clock	\$2,495
Additional RAM modules (3 at 4K words each)	1,875
Parallel interface (2)	390
Cassette drive	3,000
Expansion module and connectors	1,300
	<hr/>
	\$9,060

at 34% Quantity buy discount \$5,980

Data General Nova 3/12

CPU, 16K core, expansion module	\$6,200
Auto power restart	470
I/O Card	500
Teletype Interface	350
Real time clock	400
Cassette drive	3,000
	<hr/>
	\$10,920

at 37% quantity buy discount \$6,880

only with the PDP 11/03.

F. Communications Interface

As will be shown in Section IX, the data flowing to the Central Data Processing facility from the remote sites can be accomplished using asynchronous communications at 1200 baud. The communications interface at the local site provides the automatic answering, the initializing of the conversation ("handshaking"), line protocol and control buffering and timing. It is provided by the computer vendor.

The advisability of built-in modems is questionable at the moment, given the variety of interconnect regulations and their state of flux.

G. Summary of Costs

The cost of a nominal site with the transducers in Table VII-1, an Adac 600-LSI-II interface with a PDP 11/03 system installed at the site, costs about \$18,000 (exclusive of transportation) as summarized below.

Transducers	\$6,200
Installation and Calibration	4,200
Interface	1,300
Local Storage	2,000
On-Site Intelligence	4,000
	<hr/>
	\$17,700

Section VIII Societal Impact Evaluation

A. Introduction

Unlike other broad studies which try to access the potential impact of SHACOB in the future - 20 to 30 years hence - this evaluation methodology was developed specifically to determine the impact of ERDA's National Demonstration Program. The distinctive character of this method is that, unlike broad studies of social impact, it centers on the demonstration projects themselves and the attitudes of persons --actors--participating in or near the demonstration situation, both before and after a demonstration project is implemented. The "actors" are the decision makers associated with the specific demonstration and those which can be expected to become involved in similar future solar projects.

The narrowness of this focus assures that the findings will be (1) credible for the issues developed; (2) applicable to market research for extending solar applications; (3) complete with reference to impacts surrounding the demonstrations; and (4) capable of comparing and contrasting the pre-demonstration and post-demonstration situations around the project itself as well as among other situations and regions.

B. Objectives and Orientation

Due to the unprecedented nature of the Solar Demonstration Program, it was realized that unusual societal assessment opportunities were present. An evaluation of the opportunities lead to the identification of four

overall objectives: (1) fostering ERDA goals of useful research leading to the development of a market for solar; (2) enhancement of the credibility of societal impacts research regarding solar energy utilization through derivation of findings from specific non-residential solar energy demonstrations; (3) capability of bridging the gap between the findings of the "before" demonstration findings and the need for findings applicable to the solar market place, and (4) completeness. Completeness in this context refers to completeness in the factors which are considered important to achieve a solar energy market, completeness in identifying all the parties involved in a solar decision, and completeness in identifying the issues raised as important to the solar decision.

A great range of approaches could be taken for an assessment of societal impacts of solar energy applications, depending on the definition of "societal impacts". The "societal impacts" with which we are concerned are defined by ERDA interest in development of a solar market. In focusing on factors involved in solar acceptance, the relevant "societal impacts" are therefore found in those attitudes and impacts which will (or will not) make solar marketable. By assessing peoples' attitudes about solar energy we will learn about both the magnitude of solar development and the areas where it will likely impact. Approaches to societal impacts assessment seeking to establish credibility could rely on the relevance of the discipline of the researcher. For instance: An engineer can look at solar technology for its performance capability and its technical acceptability in competition with existing energy technologies; he might also look at past experiences in the construction industry with innovative technologies and derive some

conclusions regarding magnitude and direction of impact. An economist might look at comparative economic history and forecast the potential of solar finding a place in future energy economics. A lawyer can look at the effect of government regulation and draw conclusions about the scope of legislative involvement in the energy field and what legislative changes would be necessary for solar acceptance in that field. The environmentalist might weigh the pros and cons of solar energy as compared to alternative energy forms. A sociologist might look at the characteristics of societal attitudes and responses which have attended other successful technological innovations, and seek evidence that such attitudes might trigger successful responses to solar. The market analyst might rely on his well established combination of the above disciplines for testing new product potential.

To date, no matter what the discipline of the researcher, because of the preoccupation with proving of technology in present solar energy demonstrations, the researcher has been largely limited in the technique of his study to observation and analysis after the fact on non-market-designed solar applications. He has had to rely in large measure on his own good experience and intuitions, the resources of his library and a yet-untried marketplace. Forays with survey techniques have been highly dependent on the respondent's frequently limited solar understanding, descriptions of hypothetical applications, and the interviewer's creativity in applying essentially non-solar responses to his solar information needs.

It is important to maintain an interdisciplinary approach to the subject, and because this methodology described here is firmly anchored in the substance of demonstration projects and

limits its conclusions to those which can be derived from this empirical evidence, it will not incur many of the insecurities inherent in the conclusions of past studies.^{1,2,3} There will not be the need to attempt national solar market forecasts in a market beset with problems of fuel cost fluctuations and threatened fuel supplies and in a recession market in which any long-term forecast is problematic and government response uncertain to predict. Demonstration regions will be characterized by specific levels of vulnerability to prices and shortages in present fuels and "if...then" judgments in forecasting will be in the context of specific regional economic and political climates. Neither will it be necessary to extrapolate solar conclusions from non-solar experiences or to assume the technical efficiency of hypothetical solar applications. The demonstration projects, with their before and after testing, will give real-world evidence and not all of the concepts can be expected to prove out. The demonstration projects will permit consideration of not only the specific technology, but the specific marketplace of its demonstration; comparisons will be possible among the different demonstrations and their immediate marketplaces; and conclusions can be made about a national marketplace for the different applications which are examined. Nor will it be necessary to attempt projections of social behavior from past behavior patterns using a science which is itself questioning its own capabilities. In this study, the actors will be there in the demonstration milieu for consideration both before and after the demonstration is in operation.

The study opportunities offered by the National Demonstrations Program in this area will allow giant steps in the direction of credibility in analysis and prediction of responses to solar energy and were recognized and utilized

to their fullest in the research design developed. The insights which have been gained from the earlier work will, however, assist substantially in determining the scope of responses sought, both in issues addressed and actors involved.

The research design developed also fosters the overall goals of the ERDA National Plan for Solar Heating and Cooling, which is a positive plan, intended to stimulate a solar heating and cooling industry and market. This can be done through a positive style of approach: a solar information program integrated with the baseline societal impacts analysis efforts in the various communities to reflect the preliminary analysis findings. An awareness of this goal is important in designing the research to yield useful industry and market information for future applications, markets, planning, and legislative and policy design. The information gained by this study must be market-applicable in the specific instances of the study. For it is in these demonstrations that the root stock of many marketable solar products will be developed, and it is in these analyses of the demonstrations that the relationships and substance of many later assumptions will be formed -- be they assumptions about the workings of the solar marketplace, the policies which will foster solar applications, or the institutional resistances which must be broken down or sidestepped.

We have suggested above that two requirements which this study must meet are (1) fostering of the ERDA goal of development of a market for solar, and (2) enhancement of the credibility of societal impacts research regarding solar through careful derivation of findings from specific solar energy demonstrations. A third requirement is completeness -- completeness in the number of factors which

are considered important to achieve a solar energy market, completeness in the actors considered as parties to the solar decision, and completeness in the issues raised as important to the solar decision. Not only does this requirement demand completeness in scope in these categories, but also that the categories be allowed to speak for themselves: we must not assume a role in a future marketplace for an actor, for there remain too many uncertainties. Nor should a few experiences be allowed to mold our expectations of an actor -- as has occurred with, for instance, Labor, an actor for whom every social historian worrying about Labor's intransigence to change ⁷ is countered by a would-be producer of solar technology who anticipates no problems ⁸. Moreover, completeness of data will be meaningless if the data is not capable of cross-site and cross-regional comparisons which are meaningful, and comparisons among similar and dissimilar projects both on technical and actors' and issues' similarities and differences.

As a fourth and final requirement, the study must be capable of bridging the gap between the statistically trivial number or relatively uninformed substance of responses in a single "before" demonstration sampling, to an eventual marketplace application. This gap can be bridged by careful identification of key actors and, over a number of demonstration cases, key issues. The many potential issues must be put in a brief organizational framework of more generalized categories of factors which influence the solar decision. With the generalized factors aiding in orientation and understanding, and the cleanly defined and exhaustive lists of actors and issues identified in the demonstration situations, "what if" questions will be possible with

reasonable certainty of answers. As the framework is filled in, it will facilitate understanding the dynamics of the factors at work to allow projecting forward.

Thus, the approach developed is designed to meet the requirements of utility for the development of solar energy, credibility, completeness, and projections under a broad set of conditions. For these reasons, the societal impact evaluation will concentrate on attitudes of relevant actors toward solar energy exhibited before and after the ERDA demonstration projects are implemented in the selected communities.

C. Impact Assessment Methodology

1. Issues and Actors

From the foregoing, the major elements of the study organization can be identified. They are: (1) the generalized factors that influence a solar decision; (2) the actors and the roles that they play in a solar decision, that is, those individuals or categories of people which are involved directly or indirectly in the solar marketplace, either now or potentially; and (3) the issues that those actors raise as affecting the solar decision.

The first element can be broken down into two factors: "drivers" for, or "brakes" on utilization of solar energy for heating and cooling of buildings.

This element should be useful in understanding the workings of the solar marketplace and is intended for the particular use of marketplace analysts, legal and institutional policy makers, and for organization of the detail of data which will make up the other two elements. It will summarize -- in a market forecast sense -- the factors that can influence solar applications.

Associated with each entry in the first element will be a number of actors who make up second element entries; and, associated with each actor, there is likely to be a number of issues or attitudes that make up third element entries. A single actor can be entered in a number of different categories of drivers and brakes upon solar applications, and a single issue may be raised by a number of different actors or categories of actors. Therefore, a working paradigm would look like this:

As indicated in the paradigm, the Actors and Issues are columns that report more site-specific or demonstration-specific information. This may be done at different levels of localization or detail for different purposes: For purposes of the societal impact evaluation, the format is used to record the interviews or other data-gathering experience in a community, listing appropriate individual actors next to

the "drivers" or "brakes" that their attitudes (the "issues") justify. "Actors" in the community can be entered as groups according to the roles they are playing which are significant for solar, such as Planning Board, Contractor and Bank. Entries can also be made which report regional, or even national, conditions; this latter option permits use of the paradigm for concise summary statements, with supporting data available in the same format.

The Issues column will reflect the level of specificity of the actors being considered, because it is derived from the actors themselves. In the most immediate sense, this third column reports the attitude of a particular actor regarding a particular "driver" or "brake". In less immediate use -- representing a group or, say, economic sector of actors -- the attitudes become less specific and, because they are shared, are more correctly termed "issues". It can be anticipated that this less specific use will become more common.

Completed examples of the paradigm for separate demonstrations will contain a mix of actors expressing different attitudes opposite different drivers or brakes upon solar development. For instance, some specific examples of the three elements of the paradigm might look like this:

[GENERALIZED STATEMENTS]

[SITE-SPECIFIC DATA]

- Institutional inflexibility
 (Brake)
 - Product reliability
 (Brake)
 <li style="text-align: center;">(Driver) | <ul style="list-style-type: none"> (a) Architectural Review Board
 (b) Labor (Plumbers, Roofers, and Electricians)
 (c) Labor (general)
 (d) Labor (Plumbers) | <ul style="list-style-type: none"> - No rooftop collectors visible from street
 - Jurisdictional dispute re installation responsibility
 - Prefab collectors not acceptable; want to do the assembly at site
 - Installation offers new opportunity for work in, previously heavily electric heating region |
|--|--|--|

Looking at the entries (a) - (d), we first see that (a) an Architectural Review Board is acting as a brake on solar development by its ruling that a rooftop collector visible from the street will not be permitted. In (b), Labor is acting as a brake in seeing grounds for a union jurisdictional dispute over the installation work. These two cases can be viewed as instances of institutional inflexibility. In (c), Labor again is acting as a brake, this time refusing to accept prefabricated collectors (recommended by the manufacturer and designer for their reliability) because Labor wants to do the assembly at the construction site.

In (d), Labor acts as a driver, with a trade that previously had gained little local work related to heating, now seeing an opportunity to do some stages of installation and eager to prove its capability.

Since the first element, "Drivers for or Brakes upon Solar Development", can be viewed as containing summary categories for the findings reported in the other two elements, it will serve the double role of (1) framework for the questions that will be asked directly or indirectly of the actors and (2) reporting findings as they are made from the actors and the attitudes or the issues that they express. Therefore, the arrow from the first category is double-headed. The arrow goes from the actors, indicating that the issues are derived from them and -- because of the action or market-place orientation of the study -- are of interest only when related to the people who have raised them.

Application of the paradigm in the field starts with the selection of Actors to be involved. Solar will be asked to function in a marketplace not dissimilar from that of all other products. This marketplace has its actors involved in sectors that can be designated as follows: product design, finance, production, marketing, buyers, and regulatory structures. The solar marketplace will have the same types of participants -- as advocates for solar development, as competitors, as users, as regulators (pro and con) -- that other markets have. These participants and their inter-relationships are diagrammed on Figure VIII-1.

Figure VIII-1. NON-RESIDENTIAL SOLAR MARKETPLACE AND ITS ACTORS

In a field situation, specific actors in the locale can be identified by searching out those representing the categories of the diagram. With additional information available concerning economic, political, fuel supply and demand, and other local conditions, preliminary judgments also can be made regarding the relative significance of the various actors in the local solar decision.

A listing of some key issues that the actors can be expected to raise has also been made; this listing can be broken out in categories of specific drivers and brakes. Since the purpose of evaluating the demonstrations is to establish complete lists and to identify those actors who hold the various issues or would introduce new issues, the following list is hypothetical and no attempt is made to associate specific categories with actors.

DRIVERS OR BRAKES ON SOLAR
DEVELOPMENT

1. Product (non-)
reliability

ISSUES REGARDING SOLAR USE

- "Off-the-shelf" package readily available, reliable, stable, not quickly obsolescent
- Credibility of promised product performance
- Adequate level of energy delivery
- Credibility of supplier and installer
- Product warranties and insurance
- Leaks and resulting damage from the system
- Vandalism
- Need to prevent freezing of water in system
- Use of ethylene glycol (antifreeze) in the system, and its toxicity
- Compatibility of metals

2. Product characteristics and site impacts
 - Aesthetics
 - Obstruction of views
 - Effect of glare at certain view angles and times
 - Size of unit
 - Safety implications
 - Compatibility with existing systems in a retrofit installation
3. Institutional and infrastructure (in-) flexibility
 - Changes in work hours
 - New skills required in construction and installation
 - Anticipated higher costs for products and services of the commercial solar user; need of the user to expand his activities to meet additional solar costs
 - Existing building inspector capability
 - Solar information availability
4. Fiscal conditions, policies, legislation
 - Initial high capital costs
 - Maintenance costs
 - Replacement costs
 - Life cycle costing
 - Accelerated depreciation
 - Who bears increase in costs
5. Land use policies and legislation
 - Existing building codes restrictions
 - Sun rights protection requirement
 - Zoning, including three-dimensional and solar zones
6. Environmental policies and legislation
 - Space required, alternative uses of land
 - Dust, haze, glare, and/or heat generated
7. Baseline local and regional conditions
 - Cost of competing fuels and systems
 - Availability of competing fuels
 - Political climate for solar
 - Overall energy requirement for heating and cooling
8. Anticipated circumstances with established solar use
 - Changes in ecology of the area, climate changes
 - Increase in land value with a southern exposure
 - Socioeconomic stratification of preferred climatic regions as a function of orientation with respect to a southern exposure

- Changes in lifestyle, standards of living
- Marketplace penetration -- relationship between penetration and societal impact -- effects upon all aspects of the energy market and its participants
- Heavy peak load demands on utility in periods of low insolation

This listing of hypothetical issues was derived from experience and the work of previous studies. In order for this information to be meaningful, it requires identification with specific actors and a specific demonstration project or projects. Some of the issues seem to come from a particular sector of the marketplace; others are peculiar enough to suggest a unique individual actor; some of the issues might reflect problems of a particular demonstration; others are more philosophical and betray assumptions regarding a distant future solar marketplace. The listed issues are not complete nor do they suggest solutions to the problems they raise or answers to the questions they raise. The purpose of the listing here is to show the range of possible entries in the two columns -- Drivers or Brakes and Issues. The purpose of the organizational format is to place the data to be gathered in a structure suitable for analysis and assistance in the area of government, industry or other institutional program responses.

2. Impact Assessment Technique

The "Drivers or Brakes" are designed to be useful categories for data classification and analysis required to arrive at an societal impact assessment and determine appropriate program responses. Specifically, some of the drivers and brakes categories serve the major function of useful division of materials for analysis purposes, as in the division of product

performance reliability (1) and product characteristics (2) which are more on the order of packaging considerations and relate to appearance and installation questions at the site. Categories (1) and (2) function as reporting categories for local response to the technology and its characteristics. Category (3) -- Institutional and Infrastructure Flexibility -- is something of a working category, partly reporting local response to solar, and partly calling attention to problem sectors in the institutions and infrastructure. Therefore entries in this category can be useful in identifying local legislative and institutional changes which might be required (e.g., building codes changes or a need for a public information program on solar); with recurrence of entries in this category over a number of demonstration experiences, changes on a regional or national basis might be called for.

All of the categories are intended to be useful in terms of indicating differences among the technical applications at the different demonstration sites and in terms of planning both generalized and specific potential program responses to issues raised. Fiscal (4), land use (5), and environmental (6) categories permit the inclusion of policies and legislation issues along with reporting of existing conditions. Baseline conditions (7) (those that will vary by community but are not per se subject to program responses at a regional or national level) are separated from other entries to permit awareness of unique situations while recognizing the jurisdictional and market level at which those situations can be handled. These latter entries will define parameters for regional comparisons of demonstrations; included will be descriptors of the demonstration communities such as potential major uses of solar, local level of need for this type of energy source, and local economic and employment situations as relevant to solar development.

The final category of anticipated circumstances as a result of established solar use (8), undoubtedly will find actors

and issues in even the most parochial communities; however, separation of this material from the rest is useful for the following structural reasons: Much of the opinion material can be expected to be based upon questionable assumptions regarding an anticipated solar market. For program responses, long-term impacts can be considered in the context of immediate demonstrations impacts by permitting the inclusion of both in a single format. Opportunities also are created within the paradigm to consider changes over a longer time frame and across regions that are not in the before-and-after situations of the demonstrations.

Arranging completed data for a demonstration in the paradigm -- that is, all sectors of actors have registered wide-ranging responses to a solar inquiry -- the task of assessing the impact of the solar application will be greatly facilitated. Actors will have established their significance in the solar market through the relevance of their attitudes and roles. Issues that have been raised at the demonstration will be established as anticipated impacts, and in the "after" testing as more or less felt impacts; any problems that the demonstration itself will encounter will be known. Assessment of the market potential for similar solar products can be determined with assurance.

With comparison of findings from a number of demonstration projects conclusions can be broadened, the significance of purely local conditions can be assessed, patterns of actors and circumstances and issues will begin to arise and forecasts of regional and national market potentials will be possible with greater accuracy. The keys to assessing the magnitude of impacts and the likely directions of impact will emerge in this step.

3. Program Responses

A variety of possible Government responses in the fiscal, land use, and environmental areas will be suggested as the impacts at the demonstrations are assessed. These responses might be immediate -- as in a decision that an information program is necessary in a specific area -- or they may come as the result of assessment of impacts found in numerous cases and take the form of federal policy or legislation. Such responses can be facilitative in any of the three categories just mentioned: fiscal, e.g., an IRS policy change regarding accelerated depreciation; land use, e.g., alteration of federal highway development planning to encourage land use patterns compatible with solar communities and solar use in mixed energy communities; and environmental, e.g., incorporation of "clean air standards" in current EPA standards to specifically protect all-solar communities.

With the completion of the testing after the demonstrations have been in operation, recorded changes in public attitudes and actual changes in conditions at the demonstration sites will add substantially to earlier findings. The degree of interest in solar, increase or decrease, as a result of the demonstration will help to better indicate potential market. Comparisons of fears and hopes, and the reality of the solar performance, will strengthen forecasting and program response capability.

A particularly useful exercise would be the "proving out" of any planned program responses by reconsideration of demonstration impacts as if the planned changes had been in effect. Such a testing exercise would be valuable if a wide range of cases is available for consideration and attention is given to possible cumulative and synergistic

impacts under that and any other planned changes. This exercise would serve as an opportunity to preview program response impacts and to a degree, to project those impacts over time and to different sectors of the economy.

4. Data Collection

Given the foregoing paradigm, a wide range of techniques and methodologies were considered in arriving at a recommended data collection procedure.

The following four methods could each be used as a discrete approach to data collection. Each has its limitations on usefulness and quality of output and each must be placed in the context of reasonable economies of time and dollars to arrive at the most appropriate method for this societal impact study. Estimated costs have been given based on arriving at a minimum representative sample for the societal impact assessment. The need for additional studies may be determined as special problems arise.

NON-FIELD RESEARCH--While the preponderance of solar work has concentrated on technology, some studies have addressed "societal impacts", although without any consensus concerning what is included in "societal impacts" and without reference to well-selected, well-controlled demonstration situations as will be available from the National Demonstration Program. The analyst who would attempt a non-field study of societal impacts of solar will have to rely heavily on his own background and other study sources which address solar technology, basic understanding of the energy marketplace and government, consumer, industry and other sectors which play a part in it. Among the existing studies which do address societal impacts of solar are a few paragraphs in some of the demonstration projects such as the Grover Cleveland School (5), and the three Phase 0 studies (1,3) which considered societal impacts either through forecasting techniques or through surveys which were substantially more restricted in content and

sample than what we now have available. Marketplace study can add understanding of the competing technologies and fuels or energy sources, established infrastructures and business practices, and varying net energy assessments associated with the use of particular technologies and fuels. Additional background may be gained through study of the existing infant solar energy industry.

Therefore, a useful study could be done exclusively from what could be called "non-field" sources. There is adequate material to generate hypotheses regarding who and what are the possible solar market determinants. Analysis of existing characteristics of demonstration communities would permit some conclusions regarding community acceptance of solar. Non-field research would yield a group of generalizations regarding successful application of solar which could be applied to a basic data profile of the demonstration communities (available from secondary sources). The researchers could then comment on the demonstrations from their research point of view.

The staff necessary to perform this type of study must include the following skills: an economist specializing in the energy marketplace, an engineer understanding the capabilities and production of solar energy technologies, a sociologist understanding behavior characteristics and other local characteristics which will affect solar market decisions. Estimated performance cost: \$15,000 to consider eight solar demonstration communities.

PANELS--Panels can be used in research such as this both as sources that may be considered "non-field" sources and as sources that are more-or-less actors in solar situations. Several types of panels could be employed. Panel membership

could be developed which brings together academic and business experts whose opinions and learning will be useful in the direct pursuit of the research; this alternative will not be considered here, because under the previous alternative, staff are assigned to perform essentially the same task. Panel membership also could be developed for a number of reasons at the demonstration site: Panels may be selected to be made up of those representing the full scope of actors who are expected to be involved in the solar marketplace and their discussion of the local solar application used as background data for local societal impacts analysis. Such panels may also be useful in Decision Mapping discussed later. Another type of local panel may represent categories of actors who are disputing aspects of solar application; such a panel can be used by those responsible for the acceptance of the solar demonstration as a technique for information dissemination and for conflict resolution; however, such conflict resolution efforts are not the task of this study.

A panel--and a potentially very useful one--already exists in each region as the ERDA/ITC Solar Committee for that region. Some of these panel members are solar experts in their own rights, and others are experts on their region and their region's energy situations. While detailed knowledge of a specific demonstration community might not be represented in such a panel, there is a concentration of awareness and interest in this group which will be rarely duplicated from the separate demonstration communities.

A carefully structured panel session, lasting four to six hours, would require a staff of two persons skilled in such discussion and interview work, with discussion design and analysis back-up representing energy, economics and solar

technology. Estimated performance cost: \$12,000 for ten panel discussions and analysis of findings. Travel and direct expenses additional.

DECISION MAPPING--Decision mapping is a technique of qualitative interviewing which has been developed for and is used extensively in determining issues, actors, and their relevance to programs. Decision mapping refers to the study technique involving in-depth, respondent-centered interviewing conducted as follows. Pre-interview analysis is carried out to attempt identification of key issues and actors; the in-depth interviews serve a progressive purpose in sharpening the issues and actors identification; the emphasis of the process is on limiting the number of necessary interviews through quality interviews of persons capable of particularly useful and perceptive response. This technique is particularly useful for this program, because of the relative lack of knowledge of solar among the general public and the relatively low level of information among many of those who do profess knowledge.

As previously mentioned, there exists in the regional panels a source of potentially useful interviewees, as well as a source of identification of further interviewees in the demonstration communities. Other respondents can be selected from considerations of representation of all significant sectors of the marketplace (as diagrammed earlier-Fig.VIII-1), from suggestions of those who are interviewed early in the process, and from those who are involved in the demonstration or who have expressed interest in the demonstration. Subjects for interview are selected in part on the basis of their awareness of local actors and local concerns. Since decision mapping relies on its expert interviewers to work within an

open format which encourages the interviewee to expand on both his perception of the issues and those who are involved or interested in the subject, the interview is not constrained by preconceptions of the data to be gained. In this study the interview format could be effectively drawn from the eight major categories of the anticipated Drivers or Brakes on solar development, this list is itself an open-ended topic list for such interviewing.

Staff for this approach would involve primarily one interviewer, backed up by technical, economic and survey and analysis staff not in the field. Estimated performance cost for eight demonstration communities with a maximum of 20 persons interviewed in each community: \$24,000 plus travel and other direct expenses.

QUESTIONNAIRE SURVEYS--Surveys represent an interview technique which is, in its most general form the opposite end of the interview technique spectrum from decision mapping. A survey questionnaire is said to be a relatively "closed" technique, because either the questions asked or the range of answers offered for responses is quite specific. The designer of the questionnaire has been forced to make his trade-offs between risking excessive limitation in the range of responses possible in the questionnaire or getting relatively useless responses to safe general questions. In contrast, the "open" technique of decision mapping permits leading general questions which may be pursued into the specific interests and convictions of the interviewee without distortion by a restrictive set of answers among which the respondent must chose.

Although its degree of detail may vary, a survey is usually defined as a standardized interview, requiring very brief answers to questions, which may be multiple choice questions. A survey can be administered to larger numbers of persons than can be economically interviewed in-depth, and frequently the

survey sampling is predefined in only very broad characteristics, such as geographical location of residence, age, and type of employment. Expert interviewers are usually not required because the need for the interviewer to exercise his judgement is generally deliberately limited in the survey design.

For a very broad sampling of opinion, a survey has obvious advantages. In this case, however, it was necessary to consider usefulness of the potential responses on the part of a generalized sampling of interviewees to questions on a still unfamiliar topic, and whether or not the cost of such an effort could be justified in terms of useful information gathered. As in the case of non-field research, again the consideration of adequate detail and subtlety in the design of the questionnaire will be crucial.

The design of a questionnaire which is detailed enough and flexible enough to reflect the full range of situations which will be encountered -- without becoming an extraordinary long and cumbersome questionnaire to administer, is very difficult. The survey design would best emerge from extensive field experiences. For this discussion of surveys as a technique which would solely perform the societal impacts assessment, the cost would be \$10,000 which would include the design, drawing of the sample and pretesting of a survey questionnaire.

Administration of the questionnaire to 75 people in each of 50 communities, involving selection of the sample according to categories indentified by those who designed the questionnaire and administration of the questionnaire by professional market research firms or a firm, using telephone interviewing, would cost an estimated \$40,000. Any analysis of the data generated by the survey or overview reporting of the data would be additional.

Each of these four techniques could be utilized to perform the societal impacts assessment. Non-field research does not, however, advance our understanding of the societal impacts of solar, except through the collection and correlation of already existing materials and some application of gathered information to secondary demonstration community data; verification of the non-field findings would also be limited. Panel groups do serve some useful functions; however, they do not approach the scope of respondent coverage which can be obtained by surveys (and to a lesser degree, by decision mapping interviews), nor do they achieve the depth of response which can be achieved by decision mapping. Decision mapping, on the other hand is too expensive to be applied widely. Surveys, which can be economically applied widely, suffer from the risks of gathering inadequate or poorly defined data due to the closed questionnaire design.

All of the techniques present problems in addressing the analysis and response development steps. It is essential that rich and well defined data base be available for analysis to yield useful materials. Non-field research particularly limits the incorporation of demonstration data; the three field techniques all present problems in scope of the data gathered because of problems in either the scope of the sample (Panels are too limited in numbers, decision mapping is too expensive to apply in a large number of demonstrations.) or adequacy of the questioning in the case of surveys. Review of previous discussion which outlined data demands which would permit development of useful societal impact information indicates only decision mapping can approach these demands; surveys could not without becoming so long and cumbersome as to defeat their present advantages of economy of application and analysis.

Thus, each of these four techniques offers some advantages and each could also be employed in combination with some of the others. Within the context of considerations of richness of response and costliness of administration, a research design was developed which takes advantage of the best characteristics of each to achieve the stated goals. The following combination of the four techniques is recommended. The first three techniques have already been applied in two field situations.

1. Library research and consultation of relevant in-house expertise is the natural first step to any scientific study. This step has already been accomplished and has contributed to the content and organization presented here. The development of a preliminary test instrument drew on this background. Non-field research also supplied important information for field work, such as identification of key persons and anticipation of events and participants and their roles in the demonstration communities. By and large the non-field researcher has a difficult task with the solar marketplace and the demonstration projects will be a welcome source of data.
2. Panels are also useful in this pursuit of data because of the regional panels' ability to bring a higher level of interest and information to the assessment and their ability to enlarge the response from the demonstration areas to reflect the whole region. These panels are considered basic sources of information. Because of their roles as regional spokesmen for solar, the panel members will be able to comment with more than ordinary citizen awareness; they will be better able to anticipate problems of solar development within their regions, attitudes toward it, and future regional impacts of

solar under various development scenarios. Prior to going into the demonstration community, the panels can serve as initial data sources, suggesting by their interests and concerns about solar, the preliminary parameters for individual interviews and/or questionnaires to be used for collecting data from the actors. Although the usefulness of the panels seems to be pervasive and may well prove to be one of the richest sources of data available in the societal impact assessment effort, their inputs are not expected to have the immediacy of the responses of those at the demonstration sites: Actors at the sites will be less likely to give intellectualized or rationalized responses. The panels are therefore recommended as a supplement to contacts with actors immediately concerned with the demonstrations.

3. Decision mapping as a technique for data collection has considerable advantages because even if a closed instrument (questionnaire) is eventually used for collecting data for a large number of demonstrations, initial open-ended interviews permit development and testing of the closed instrument and pursuit of replies beyond the closed format. Using this procedure the interviewer can learn what he would have missed by using the closed format and make the necessary improvements before being totally committed to the closed format for all data gathering.

In addition to individual interviews, the decision mapping approach is particularly fruitful when applied to the regional panels, and could also be applied to panels of key local actors in the demonstration communities. Panel discussions in the decision mapping mode would be an economical way of doing decision mapping, however the detail of individual interviews would be sacrificed.

It is suggested that the major topics of a decision mapping interview cover the eight categories of Drivers or Brakes on Solar Development previously described:

1. Product reliability
2. Product characteristics and site impacts
3. Institutional and infrastructure flexibility
4. Fiscal conditions, policies, legislation
5. Land use policies and legislation
6. Environmental policies and legislation
7. Baseline local and regional conditions
8. Anticipated circumstances with established solar use.

In an actual interview, the interviewer might start with category 7, establishing the background of the interviewee and the community. Then the interviewer might move into the person's awareness of solar and his attitudes toward SHACOB in this community and elsewhere, letting the interviewee discourse freely while not only taking direct notes on the interviewee's comments but also noting the extent to which he is covering all eight categories. The interviewer will not confine his expectations of coverage of the categories to merely touching on each of the categories, but will seek responses to the range of issues which experience has taught him to expect in each category as well as seeking expression of new issues by the interviewee. For example, in pursuing responses to Category 2 experience indicates the interviewer should seek comment on each of the following issues as a minimum:

- Aesthetics
- Obstruction of views
- Effect of glare at certain view angles and times
- Size of unit
- Safety implications
- Compatibility with existing systems in a retrofit installation.

The style of questioning in the interview will initially work to encourage topic initiatives on the part of the interviewee and he will introduce new topics or subtopics only after he feels that those initiatives have been exhausted. This approach is designed to allow for the widest possible range of expression of interests and concerns regarding solar. It is intended that the interviewer not confine the materials covered to any preconceived topics or perceptions of topics, but that by the end of the interview he be certain that he has covered the entire range of topics.

For instance, in discussing what he knows about solar technology an interviewee develops his ideas regarding the appearance of rooftop solar panels and it becomes clear that he is not considering the need for the panels to be oriented toward the sun. Being questioned on this, he may indicate that architectural imagination and adequate space to allow for planting of trees without shading the panels would be necessary; also that an adjacent tall building may preclude use of solar altogether. Moreover, he may express that panels should not be retrofitted in situations where they would be aesthetically displeasing. This interviewee, without ever mentioning the words "sun rights", has stated his standards for the application of such rights--in terms that express visual, zoning and private property considerations. By the open technique of decision mapping, the interviewee was able to set his priority as being aesthetic; this spontaneous information is more valuable in market forecasting than a specific response to the broader question. Of course, it is next necessary to confirm that what was implied holds true: that the interviewee believes that aesthetic considerations prevail over saving conventional energy through use of solar, that aesthetic considerations prevail over a

would-be solar user's right to sunlight for his panels, and that zoning law should take these considerations as primary. Through such open interviewing as the above example, it will be possible to become aware of the real universe of potential answers, including visual, private property and zoning orientations. Then a closed survey question addressing this issue can be designed with confidence of its value and applicability.

Either during the course of the interview or at the close of the interview, suggestions will be solicited from the interviewee regarding others in the community who are concerned about solar or who they perceive as being important actors in the solar marketplace. Because the decision mapping interviewees are selected as leaders in the community, they can often significantly supplement the list of actors contacted and thereby enhance both the overall value of the response and the authenticity of the response as reflecting a unique community and demonstration projects.

As is evident, high levels of skill are required for the conduct of decision mapping interviews. However, careful selection of actors permits placing of limits on the number of interviewees necessary; therefore, costs can be held to a relatively low level for the amount and detail of information gained in decision mapping. After a survey of eight demonstration communities (possibly much fewer) with a maximum of 20 individual interviews in each locale, understanding of the impacts of solar should have reached the stage where this understanding can be applied to the development of a closed instrument for use in any additional demonstration communities.

4. Questionnaire Surveys employing a structured format for baseline assessment would be helpful in obtaining wide coverage of the demonstration communities. Collecting data in a structured format is an approach which offers the best potential for cross-case comparisons and collection and manipulation of data by persons without specially related skills.

However, based on the experience of collecting data in two pre-demonstration cases, development of a standardized multiple choice questionnaire is not appropriate at this time. It appears that the level of understanding of solar exists as either expert (and usually specialized and not susceptible to generalized questioning) or uninformed (and not capable of making a valid response to multiple choice questions). Experience to date indicates that even the most carefully phrased question was not susceptible to either a "yes-no" answer or a representative selection of multiple choice answers. Because of the benefits of a closed questionnaire, it is probably useful to attempt to develop and test a closed form questionnaire concurrent with the decision mapping process. The decision mapping process should supply the necessary experience in a range of different types of communities, potential and actual energy market places, and geographical locations. The important actors and issues will also be identified. As more and more communities are assessed by the decision mapping process, it will be possible to come closer and closer to a closed survey format. However, it is doubtful whether it will ever be possible to develop a meaningful multiple choice type of survey.

As questions which are of a more general and pervasive nature are amenable to a questionnaire format, it may be possible to employ a combination of techniques.

The effectiveness of employing a questionnaire for post-demonstration assessment is also difficult to predict at this time. The level of responses is dependent on the educational impact of the demonstration and any other solar activities in the area. A reasonably high educational impact would make possible meaningful responses to a survey questionnaire. It is believed an appropriate methodology for post demonstration cases will naturally develop as the pre-demonstration process is refined.

D. Baseline Study of Two Pre-demonstration Sites: Philadelphia and Scottsdale

The recommended information gathering and analysis methodology described previously was taken into the field for application in two communities slated for demonstration projects: Philadelphia, Pennsylvania and Scottsdale, Arizona. This field experience was designed not only to determine a societal baseline for the first two cases, but also to supply feedback information for refining the methodology with the goal of formulating a standardized approach to structured information gathering. Such a structured format will permit easy, cross-case analysis and cumulative program response recommendations.

1. Actors and Issues

Through contacts by telephone and in person, key "actors" were selected and interviewed using the "decision mapping" technique. The actors chosen for interview consist of those who are closely related to the demonstration and actors who are judged to potentially impact future solar projects in the community. Individuals fitting the various categories of actors diagrammed previously, along with their interrelationships, were sought out. The regional

solar committees as well as the demonstration sponsors were used as sources. The specific actors interviewed in each community are listed in Appendix A. Because some of those interviewed spoke more freely with a degree of anonymity, the responses have been presented separately in Appendix B and grouped to preserve this assurance.

2. Impact Assessment

After a certain amount of trial and error organizing of the material collected into various formats reflecting the "Drivers and Brakes", a presentational format evolved. This format efficiently reports the issues from the two communities, highlights major interview points, and facilitates analysis and identification of program response recommendations. Two major categories are used to set off the data: Local issues and pervasive issues. These categories feed directly into the consideration of program responses since local issues are susceptible to specific actions during the demonstration program, and pervasive issues can be accumulated over a number of demonstrations for development of broader program responses. To further aid in program response consideration subcategories of issues were selected as listed below.

<u>LOCAL ISSUES</u>	<u>PERVASIVE ISSUES</u>
Significance of geographical location	Economics of solar use
Interest in solar	Technical performance
Alternatives to solar and their advantages	Issues related to major operational sectors or actors

Field data presented in the analysis format follow. Several data entries appear in more than one category or subcategory because some local issues also have more pervasive significance and, for example, some comments concerning economics are related to a specific sector -- banking.

LOCAL ISSUES

PHILADELPHIA

SIGNIFICANCE OF GEOGRAPHICAL LOCATION

-100% back-up required in both heating and air conditioning

-relatively low potential effectiveness of solar (estimates between 30-60% of heating requirements)

-Proximity to refineries seems to lower local sense of vulnerability to fuel shortage

INTEREST IN SOLAR

-Initial Bell interest came from a new engineering section, possibly looking for ideas to justify its existence; the type of interest remains strongly engineering, i.e. monitoring the installation, figuring cost/benefits

SCOTTSDALE

-Some systems are claiming that less than total back-up is necessary (e.g. Hay system houses soon to be constructed in Tucson will have only a few space heaters available for emergency use; air conditioning--the major local requirement--depends on building design for back-up requirements)

-Some of the best isolation in the U.S.--makes for high interest and lots of experimentation, both professional and amateur

-80-95% of energy imported; natural gas (a major residential fuel) under moratorium, severe gasoline shortage during "crisis"; if planned nuclear power plant is refused, there will be a serious electric power shortage.

-No oil available, most new housing is all electric

-Initial Scottsdale interest came from city government, and is highly project publicity-oriented.

-There is some questioning of the capability of small manufacturers of solar units.

-The interest in solar systems of the volume constrained fuel oil supplier.

-Environmentalists consider solar to be the "number one energy type" because it will decrease fossil fuel use, cut pollution, and makes a good alternative to strip mining.

Energy costs are high.

-A utility: maybe 20 years from now. Another utility: we're going to offer a solar/heat pump package but don't expect much interest.

-An insurance appraiser: solar is "foreign" to this area.

-Testing firm indicates many collectors are not reliable and materials inadequate.

-On other hand, numerous small producers and marketers of solar are on the scene, and there is sentiment that they deserve a piece of the market and a chance to grow. Some think they may be offering a more realistic product in that it probably costs less and performs better.

-Same arguments are made in Scottsdale, but wildlife group will challenge any taking of valuable habitat for collectors.

-There is a tax incentive in Arizona for solar; solar investment is ignored for assessment purposes.

-Energy costs are going up 8-10% per year; electricity was up 33-35% last year.

-A utility: we're doing some experimenting and watching the field.

-There are lots of local solar "putterers" as well as University interest and interest on the part of some major industries located in the area--at least one did so for its solar research.

-An engineer with a construction firm: solar will be established in five years, fifty percent of the houses will be solar heated and cooled--although good cooling systems could be some time off.

-Two others in development: All the solar activity is like the fallout shelter syndrome. Solar is mythical.

- Solar need not be ugly.
- There will be residential neighbors to the Bell building.
- There are no problems with construction permits.

- Glare from the collectors could possibly reflect into the Cubs Park stands.
- The Design Review Board requires that rooftop mechanical equipment be hidden under current rulings.

ALTERNATIVES TO SOLAR AND THEIR ADVANTAGES

- An architect: heat pumps with electric are best locally; they are close to oil in economy and handle air conditioning easily.

- Reliability and costs are the primary questions with solar. Can it match electricity?

- Real estate investor: my buildings are 100% electric because of the uncertain supply of gas and oil. Solar would have to make economic sense.

- West Chester people are too conservative and would find solar too expensive for their own use (commercial or residential).

- Buildings certified historical could not have solar collectors, probably not even if hidden from street view.

- Even in the developments, the Georgian look is the style most commonly sought; however, it is possible that with the right door and window treatment, such people would accept collectors on the roof. These style considerations also apply to shopping centers, motels, offices, etc.

- Buildings must have a "western" look under current rulings of the Design Review Board.

PERVASIVE ISSUES

ECONOMICS OF SOLAR USE

-Even with a five year pay-back, what's its value when the U.S. moves every three years?

-Researcher: it should be possible to get the cost of solar down to \$2 a square foot.

-Investor: six years is a good payback period, ten at the outside.

-Engineer: solar requires up to 20 years to pay back.

-A ten percent tax credit on special equipment could be a fine incentive.

-Sunshine so far, is not taxed.

-Two classes of people are interested in solar; those who want to make a buck or those who want to save a buck.

-Researcher: we should look at the costs of materials and other energy expenditures that are going into solar or related to its use.

-Small rooftop HVAC systems suffer rising maintenance costs after five-eight years compared to central system.

-High capital costs are not always a disadvantage; an institution building financed through a construction fund drive might be better off with high initial cost than high operating cost.

[This is essentially a "residential" comment; however, Scottsdale has a large retirement population and also a few large employers, so maybe some of those people are moving to Scottsdale. Also, there is heavy commitment to commercial in form of large shopping complexes and motels.]

-Hay and buildings designed for high conservation of energy are two forms which can involve solar which should have reasonable pay-back periods.

-Arizona has a solar property tax incentive.

-Both are present in quantity in Arizona.

-Real estate investor:
all my tenants are on
"net lease" so they
absorb all increases in
operating costs.

TECHNICAL PERFORMANCE

-Solar seems a manageable
technology to most people.
-Traditional systems people
are interested.

-Hybrid systems should mean
trouble. A total energy
system is the ideal. Heat
concentrators might be able
to alleviate space and
storage problems. Reserve
storage of fuel against
shortages might be thought
of as similar to the storage
requirements of solar.

-We need standards for the
product and its performance.
-Service, parts and guaran-
tees.
-Some of the small solar
producers are not making an
acceptable product and are
going to give the technology
a bad name.

-Utility: our demonstration
home will be converted to
all copper collectors with
a drain-down system before
we sell it. This should
result in a trouble-free
system.

-In a particularly favorable
climate there is evidence of
this of this confidence being
widespread.

[Similar informed and interested
parties exist in the Scottsdale
area, and a range of such
provocative comments could
be culled from that experience
to match these.]

-Yes, but we also need to
preserve opportunities for
the small businessman
and inventor to get into the
market.

-Small solar producers are
getting customers, even for
custom designs.

-We will eventually have ten
solar demonstration homes,
testing different kinds of
technologies. We're not even
recommending the present one
for purchase.

-Insuror: putting the piping
outside as much as possible should
minimize leakage risks.

-The Revere copper house with
its copper roof and exposed copper
tubes for water attached, may
not be able to stand the
temperature extremes.

Researcher: conservation should be incorporated into solar operations to bring the heating and cooling requirements down to reasonable levels. Also, in the long run alternatives involving recycling and such should be major policy considerations.

Potential for vandalism seems high.

-Sunrights have to be protected.

-There has been little interest in conservation here because energy was clean and plentiful; wall insulation is a new idea here.

-A number of approaches to model solar law were discussed by a state Bar committee member.

ISSUES RELATED TO MAJOR OPERATIONAL SECTORS OR ACTORS

Investors, developers and their staffs

-Solar use of any magnitude is 5-10 years away.

-Several offers were made to install power demand computerized controls free and take payments only as a percent of the resulting power savings--this might be tried in the solar field.

-An institution might prefer higher up front building costs to be paid out of a building fund drive, to higher operating costs.

-Solar will be reliable and cost efficient only after many systems have been in operation many (possibly five) years.

-Need "certification" of systems.

-Bulk power resale now in operation has set up an infrastructure which could be applied in a solar utility.

-It has been considered for commercial uses, but hasn't proved out economically.

Insurors

- Vandalism
- Wide range of problems and rating expectations expressed--some of the anticipated rates very high compared to traditional.
- Ultimately, insurance cost determined by claims experience.
- Can handle glass damage as a deductible.
- Rates on existing and anticipated systems expected to be the same as traditional systems.
- Insurance of the proposed solar power plant not expected to be at unrealistic rates compared to traditional plants.
- In the case of small users, it would be necessary to watch the use of compressors for hazards..
- Exterior piping could solve some of leakage risks anticipated.

Solar researchers, producers and marketers

- Question the capability of small scale producers.
- Individuals have taken over the field and properly so.
- Want to see the market remain open to the small scale producer.
- Government funding has been inefficient, unresponsive to proposals, and directed to only bigger (and possibly Eastern) firms.

Utilities

- Need a growing level of sales.
- Have demonstrated heat pump/solar system in a model home. Do not expect much interest in the new demonstration homes they are going to offer.
- Are interested in heat pump applications, concentrating collectors, and total energy systems, in that order in time.
- If the nuclear plant is denied two of Arizona's largest utilities will be denied the source of one-third of their planned load.
- Conservation is an option which is being largely ignored, particularly in the use of adequate construction materials.
- One utility: solar? Maybe 20 years from now.
- Another: We are not planning for future urban power supply and this could get us in deep trouble.

-An observer: some Pennsylvania utilities have high summer loads and some high winter loads; perhaps there is some leverage between them.

Unions

-Conflicting precedents are cited, notably between the steamfitters and sheet metal workers.

-Work is down in all the trades and this could lead to disputes over jurisdiction.

-A longstanding dispute is cited between the sheet metal workers and the United Association (plumbers and pipefitters).

-Sheetmetal workers union employment is down about 50% from three years ago.

The following summarizes the major issues and contrasts between Philadelphia and Scottsdale.

LOCAL ISSUES

-The geographical location is significant in that for one it yields a low expectation from solar, but also a low sense of vulnerability to energy shortage; for the other it yields a high expectation from solar and a high sense of vulnerability to energy shortage.

-Interest in solar is unusually high in Scottsdale; the sponsors will be interested in publicity for the demonstration. In Philadelphia Bell has a more technical and performance-related interest in this demonstration and the publicity department is not yet aware of the project. Both demonstrations have characteristics which will bear local watching.

-Alternatives to solar are still routinely selected in both communities because of distrust of the performance capability, reliability and costs of solar. Both communities also have some difficulty adjusting to the appearance of solar, although acceptance seems more likely to occur on this ground quickly in Arizona.

PERVASIVE ISSUES

-Economics: Individuals in both communities expressed expectations that solar would soon become cost-effective through new technologies; however, an attempt to generalize would probably have most Philadelphians not expecting cost-effective solar for 20 years and Arizonans, in five years.

Traditional systems also have their problems over their years of use, and perhaps some fairer comparisons could be drawn between the systems; net energy considerations should also be figured in, and the full potential of design for energy conservation included. High capital costs can be an advantage over high operating costs if the construction is being financed by a building fund drive.

-Technology: Solar is a conceptually simple technology (except for some of the associated cooling systems) and people are comfortable enough with it to even dabble in invention and "home brew" systems, given the Arizona sunshine. Hybrid systems are looked on with suspicion and the total energy system is the ideal. Storage and collector space problems are substantial, although storage needs can be compared with storage required for traditional fuel supplies, particularly if increasing threats of shortages make additional fuel storage a necessity against emergencies. Heat concentrators are looked to to alleviate storage and collector space requirements. Standards for materials, equipment and performance are called for; however, in Arizona it is considered important to preserve the small producers' position. Design for energy conservation can contribute to reasonable performance requirements for solar.

-Operational Actors: Investors, developers and their staffs have considered solar in both communities, but not found it cost-effective. In Philadelphia there was at least as much concern over technical capability as cost; cost was emphasized in Arizona, where there is more confidence in technology. Insurers are much more ready to talk "nuts and bolts" in Arizona, and unlike Philadelphia where rates were guessed by one insurer to perhaps double for solar, Arizona insurers seem unanimous in expectations that rates will remain the same as for traditional systems. With exception of a single researcher, Philadelphians were not confident that individuals are capable of producing reliable solar units; Arizonans wanted a role preserved for the small scale producer and innovator. Utilities in both areas were moving slowly and cautiously into solar. Jurisdictional problems are a possibility with unions in both areas.

Long range impacts involving widespread use of solar energy were addressed by only two interviewees, one in solar research and one the supervisor of a solar demonstration. Generally, interviewees had done very little thinking about

solar impacts and then there was only concern with the most immediate prospects for applications. Another category of missing issues can be considered to be the slow approach of the utilities to future markets in alternative energy sources. They seem well aware of the problems which are developing for them.

The preceeding results indicate that the most significant local issues can be easily determined and the contrasts between two communities quickly drawn. However, the task of identifying significant pervasive issues is more difficult; the temptation (as seen in the above listing) is to include most everything at this time that can possibly prove significant for program responses until more evidence is in from other demonstration communities.

3. Program Responses

The final step of the assessment methodology involves the development of possible program responses based on what has been learned in the pre-demonstration studies. While two cases do not form an adequate base to recommend Government (ERDA) policy, there are significant indicators of what might materialize in the way of recommendations after more field experience is gained. A number of possible programmatic responses for enhancing the demonstration projects' value in building a local solar market have also been gained from the field experiences--through knowledge about existing attitudes toward solar, information needs, local requirements from a consumer point of view, and specific sources of anticipated project support and resistance. These indicators are given for consideration. Specific local responses are presented first.

- a. In spite of some individual assurances to the contrary, both cases suggest union jurisdictional problems--if not with the demonstration projects themselves, with others as time goes on. There are conflicting precedents

for union assignment of particular jobs, and unemployment pressures in the construction trades, e.g., construction is down 80 percent in Scottsdale from three years ago. Even peaceful inter-union settlements can lead to higher costs of solar systems, e.g., a composite settlement where members of each craft must always be present during installation.

- b. In the Bell project, the attitudes of the residential neighbors abutting the site should be watched closely because they evidently have an unobstructed view from higher ground of the site and, because of their location across a township line, may have few or no opportunities to voice any opposition which might develop over specific issues or generally.
- c. In the Scottsdale courthouse case, it would seem that the collectors may be situated so that they could reflect glare into the Cubs spring training park viewing stands and should be given consideration in the design of the solar system.
- d. Materials used in the Scottsdale project should also be capable of surviving the temperature highs and contrasts of the area; this was an anticipated source of trouble, according to a number of those who considered themselves knowledgeable regarding collector design.
- e. Any development of solar interest in the Philadelphia area will have to address the frequently conservative approach to local applications; in the commercial sector this means that applications on buildings in neighborhoods with much "general public" traffic or which will be used by the general public such as motels,

offices and shops, will have to be aesthetically acceptable. Solar applications in this area will have less public relations value and be less likely to attract experimenters who want to be at the front line of a new field. On the other hand, any demonstrations which are particularly pleasing aesthetically will be able to make telling arguments for solar.

- f. In Scottsdale the collectors will be on a flat roof, hidden (at least from ground level) by the parapet. Publicity associated with the demonstration could increase the flexibility of solar design if any effort were made to call attention to uses of collection systems which are incorporated into building design in a manner which is visible but would not clash with the Scottsdale style now advocated by their Design Review Board.
- g. Scottsdale is eager to publicize the solar building and there would be an opportunity to disseminate many types of information about different solar technologies and how well they can function in filling local needs. Publicity value should be high for any commercial enterprise which would decide to install solar, and the demonstration could capitalize on this.
- h. Philadelphia's interest in system cost-effectiveness is, of course, shared by Scottsdale. Information programs related to both demonstrations could well cover a wider scope by not only reporting such findings in the local demonstration, but comparing the demonstration technology cost-effectiveness with other types of solar technology which have interest in the local climate. Parallel publicity efforts could call attention to

successful incorporation of solar into architectural designs and address other sensitive local issues.

In addition to the above local program responses, regional and national issues have been suggested by the societal impacts information gathered in the two communities. Summarized below are a relatively large number of "pervasive" issues which could prove to be of interest if comparable or contrasting issues arise in other demonstration communities. (There are also potential regional and national program implications should any local issues be commonly replicated in other communities.) At this point, we will list only a few of the potential regional and national program responses:

- i. Regional programs may well address climate characteristics, e.g. the Arizona interest in higher performance from solar cooling systems, or the Philadelphia interest in higher solar performance in both heating and cooling under conditions of relatively low isolation.
- j. Nationally, the most important and basic issue is, and probably will be for some time, cost-effectiveness. It may be that national programs will eventually address what are seen to be basically national issues of cost, whereas regional programs will address what are seen as basically regionally appropriate technologies, with national standards for materials, warranties, third party testing of units.
- k. Some national programs might be designed to encourage energy conservation in solar buildings design and building materials choices. This could be only a part of a more sweeping program, considering the energy pay-off available through conservation.

1. There seems to be widespread preoccupation with many technical problems associated with solar systems which are basically short term in nature and certain to be solved. This undue preoccupation can be counter-balanced by a strong public relations program aimed both at professionals in the solar field and at the general public. In a parallel fashion, the justifiable concerns over the long-term life of some components of the equipment must be put to rest by convincing arguments and/or demonstrations.
- m. Because of the dangers of "fast buck" equipment manufacturers and installers, solar manufacturers' associations should be encouraged to establish certification procedures for solar products and the licensing of solar equipment suppliers and installers, or some comparable guarantees to solar system purchasers.
- n. The Actors and Issues approach utilized in this assessment demonstrates the importance of an orderly examination of all the "links" in the solar decision chain associated with each potential solar project--from developer, to lender, to ultimate user. Some specific overall observations generated during the course of developing and implementing this approach, but not mentioned elsewhere are listed below.
 - (1) It would seem highly desirable to encourage the R&D departments of private corporations to have greater participation in solar use within their own companies, perhaps in conjunction with the current emphasis on corporate-wide energy conservation programs.

- (2) Because of the multiplicity of actors in the solar process, information and ideas on solar use must be disseminated in a wide variety of journals in a wide variety of formats. For example, one vice president of the real estate loan department of a bank read primarily The Real Estate Law Journal.
- (3) It would appear desirable to encourage and facilitate greater education and involvement in solar of "front line" personnel, such as HVAC contractors who don't have the time or money to attend long seminars.
- (4) Finally, as more solar projects come into existence, much can be learned about solar incentives and barriers by talking to the individuals in these user firms who participated in the solar decision process.

Other issue sectors that may well be addressed by national policy include the small business and individual innovator role in the solar marketplace, union jurisdictional disputes (by the union national offices), utilities planning for future energy and the utilities' role in that marketplace. These last observations remain, however, speculative pending evidence from more demonstrations.

Other observations generated during the course of this study which do not explicitly concern us in the Actors and Issues format but are nonetheless worthy of note are:

- (1) The tendency to follow the leads of the largest and most successful companies.
- (2) Progressiveness and open-mindedness associated with younger companies and younger people.

- (3) Professional pride leading to the desire to try something new vs. conservativeness with regard to risk of failure (especially in engineering consulting companies).
- (4) The barriers associated with anything new or different which requires changes in the way of doing things, e.g., the loan approval routine of a lending institution.
- (5) The human factors, e.g., as evidenced by the possible tendency to feel cold in a solar-heated building on a cloudy day.
- (6) The in-house "solar expert" found in every organization, from developer, to engineering firm, to user firm--and the wide variation in his capabilities.
- (7) The extensive Japanese experience in sunrights legislation, e.g., their scale model for measuring shadow interference.
- (8) The variation of institutional attitudes toward the barriers of high initial costs vs. high operating costs, e.g., the relative ease with which an institution can raise capital via a building fund drive vs. the difficulty it has in meeting its year-to-year operating costs.
- (9) The tendency of architectural firms toward "energy integrated design".
- (10) The "power of the printed word"--that a surprisingly large majority of people have a reasonably true picture of current solar economics and risks.

E. Recommendations

Based on the baseline pre-demonstration information gathered in the two demonstration communities--Philadelphia and Scottsdale--the suitability of the three step paradigm has been confirmed. The findings in these cases has suggested a format for gathering and reporting case data which easily and efficiently allows data analysis to feed into program response development. However, these two cases have not been acceptable for finalizing this format.

It is therefore recommended that the tentative format be applied to a third community. It is important that this community be carefully selected to supplement the first two cases by filling in the remaining experience needs.

Such a community should be one characterized as "typical" --with little or no sense of vulnerability to energy shortages, widespread sense of escalating energy costs, and a mix of acceptable architectural styles (possibly in different areas of the community). The demonstration should ideally involve a different application of solar technology than the first two cases and a greater degree of incorporation of the solar system into the design of the structure; also, the developer should be from the private sector. A perceivable risk in more radical technical experimentation might be particularly interesting in terms of post-demonstration impact analysis; if the solar system in such a case failed to reach anticipated performance, the resultant impacts on solar acceptance would be useful to know, particularly the influence the radical system would have on decisions to purchase more conservative solar designs. Since these radical technologies tend to be visibly different to even the most casual observer, it is not thought that such gambles hurt the more conservative solar market; particularly if the project publicity is well handled.

This third case could be handled differently from the first two in that phone interviews with those reflecting the technological, construction, financial, insurance and related sectors (the "pervasive issues" sectors) would be done in a manner permitting development of basic information which could possibly be supplied by the demonstration proposer without requiring the expense of a field visit. If this format should prove to be too constraining after the data are in from these phone interviews and a questionnaire based on the interviews has been tried on the demonstration proposer, a questionnaire should be designed to adequately cover all data which have been gathered in these sectors in the three cases, and key actors should be identified to whom it can be addressed in future pre-demonstration cases. The remaining actors and issues (those representing the "local issues" sectors) should be contacted on the scene by a single interviewer--again with the more highly structured intent of resolving future interview demands through a standardized questionnaire consisting of open-ended questions.

In addition to the field work, the following tasks should be performed: (1) Interview data from the three cases should be developed in the paradigm format, writing up the actors and issues of the three cases in terms of the final interview format. (2) Analysis and programmatic responses should also be written to conform with this format for the three cases. (3) Standardized formats for interviews and other information gathering efforts should be presented, as evolved from the three case experiences; these formats can include a new emphasis on identifying potential project public relations opportunities in detail, if desired. (4) A standardized analysis and programmatic responses format should permit cross-case analysis for recommending larger policy based on accumulated case experience.

In sum, it is recommended that a single, well-chosen third case be investigated before a generalized format for societal impacts assessment is finalized. The resulting format should then be capable of use in any number of pre-demonstration situations at this stage of solar. Administration of the interviews and all processing of the data resulting from the interviews should be possible by anyone with a rudimentary understanding of solar and of the range of actors who will be included in the interviews. The data obtained from such interviews and any recommended associated information gathering, such as the proposed questionnaire for demonstration proposers, should be useful and worthwhile in three respects: (1) Baseline information will be obtained from pre-demonstration communities, with the option for post-demonstration comparisons. (2) Opportunities for enhancing the effectiveness of the demonstration for developing a local solar marketplace will be identified. (3) Regional and national programmatic response opportunities will also be identified through accumulation of data from a number of demonstration experiences.

After the demonstration projects are installed and operating, a follow-up survey can measure the felt impacts of the project, including any change in solar awareness and interest in the project communities. This survey questionnaire should be simple to design: it will be based on the questionnaire developed for pre-demonstration use, but will include recognition of the changes which have occurred with the installation of the solar demonstration. It should be designed so it can be administered by phone by a professional market research organization. Because of its basis in the original survey, analysis will quickly and easily identify changes from findings in the pre-demonstration situation, both in substance and degree.

Follow-up studies should commence as soon as demonstration installations are completed and placed in operation. As not all projects will be completed simultaneously, the follow-up assessments will impart a dynamic characteristic to the analysis by providing a continuous basis for making adjustments to the demonstration program. Input to demonstration site selection will be continuously provided by this approach.

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Section III Continued

Environmental

A. Introduction

Utilization of solar energy, in all its forms, has emerged as a unique form of energy in that its collection and use is generally non-controversial from an environmental viewpoint. Indeed, it has been suggested that the non-polluting characteristic of SHACOB is its most important characteristic.¹ Although a major impetus behind solar energy utilization at this time is to reduce dependence upon foreign energy sources, it is believed that improved energy market conditions would cause the forcing function to be environment improvement.

As with any new technology certain unknowns exist as to its widespread application. The environmental impact methodology described here is designed to reduce the uncertainty as to what will happen if certain courses of action are taken. Although the National Demonstration Program (NDP) is wide ranging in scope and unprecedented in its potential impact for development of a SHACOB industry, the overall energy and environmental impact in the near term will be small on a national basis. What the program will do is supply a broad base of real data which will allow anticipation of future impacts and planning to reduce unwanted and undesirable effects as well as encourage development of beneficial aspects.

Rather than attempt to develop an assessment/evaluation methodology around a framework of critical assumptions and subjective value scales, a more quantitative approach was taken centered around the NDP. Emphasis has been placed on areas which are amenable to quantification: materials usage, energy supplied, and pollution avoided. Such an approach is essential if the relative benefits and costs of SHACOB are to be established with certainty.

A framework is presented which will facilitate collection of data to allow comparison of a variety of solar energy systems with conventional energy systems as well as with themselves.

The following test and evaluation plan will employ real design, real cost and real performance data to arrive at the energy efficacy of various systems, and combined with pollution avoidance data, for assessment of the overall environmental impact of specific solar energy systems. The data which will be obtained from this impact evaluation plan are designed to feed information directly into the preparation of environmental impact statements which may be required in the future, and should prove invaluable for effectively planning the commercialization of SHACOB in an environmentally sound manner.

B. Objectives and Orientation

When assessing the environmental impact of widespread application of an alternative technology, such as SHACOB, it is first necessary to enumerate and then evaluate all the meaningful impacts -- both direct and indirect, favorable and unfavorable -- of that technology.

The goal of the test and evaluation plan presented here is to provide data which will not only facilitate environmental impact assessment by others, but will significantly improve the credibility of the results.

The first step in developing a methodology to accomplish this goal was to examine the range of possible impacts which can be expected from widespread application of SHACOB and then to determine which impacts were amenable to direct evaluation under the NDP. An inspection of the listing on the following page, which is not meant to be all inclusive but which includes the most meaningful environmental impact areas, reveals that the majority of these areas are directly related to reduced usage of conventional energy for heating and cooling of buildings and increased usage of materials and energy required for solar system production. It is in these areas that the NDP can

TABLE VIII-POTENTIAL ENVIRONMENTAL IMPACT AREAS OF SHACOB

1. Reduced demand for primary fossil fuels and natural gas.
2. Reduced demand for electricity.
3. Reduced needs for imported petroleum.
4. Reduced environmental effects of coal extraction.
5. Reduced air pollution associated with fossil fuel power plants.
6. Reduced air pollution associated with primary use of fossil fuels on site.
7. Reduced thermal pollution.
8. Reduced incentive to develop nuclear waste technology.
9. Reduced incentive for development of off-shore petroleum resources.
10. Reduced incentive for development of geothermal resources.
11. Reduced incentive for development of fusion technology.
12. Reduced incentive for development of oil shale resources.
13. Reduced incentive for development of synthetic fuel industry.
14. Reduced incentive for development of breeder reactor.
15. Fewer than expected new fossil fuel and nuclear power plants.
16. Increased emphasis on land use planning.
17. Increased demand for water resources.
18. Increased demand for materials used in solar systems.
19. Increased environmental effects associated with extraction of raw materials used in solar systems.
20. Increased demand for petroleum based heat transfer fluids.
21. Increased pollution caused by disposal of toxic heat transfer fluids.
22. Increased demand for recycled materials used in solar systems.
23. Increased desire for weather modification (reduce cloudy days).
24. Increased peakload demands on electric power plants.

supply valuable contributions to the quantification of the environmental impacts of SHACOB technology. The NDP is composed of all significant solar technologies applicable to SHACOB, thereby providing a wide variety of systems, in diverse locations, for analysis.

The objective, then, of the environmental portion of the test and evaluation plan is to provide a framework to collect real design, cost and performance data, to evaluate them and to present them in a format usable for rational planning of widespread application of SHACOB technology and the preparation of environmental and societal impact assessments.

C. Environmental Impact Evaluation Methodology

The impact evaluation methodology is designed around the development of unit factors describing the "environmental performance" of the myriad of solar systems that will be represented in the NDP. The environmental performance will be based on four factors:

1. Reduction in conventional energy usage associated with use of solar energy systems,
2. Reduction in pollution associated with use of solar energy systems,
3. Conventional energy usage associated with manufacture of solar energy systems,
4. Pollution associated with manufacture of solar energy systems.

A less thorough treatment of this subject might include only the first two factors; however, since environmental impacts are interrelated -- an improvement in one area can cause an adverse impact in another -- it is important to know how much energy and pollution are associated with the alternative.

Once factors are developed based on unit relationships, it will be a fairly straightforward procedure to utilize such factors for comparison of solar energy systems to conventional or other alternative energy systems as well as to each other. These unit factors can be inserted in various "environmental performance" equations to arrive at such quantities as net energy savings as well as potential pollution reduction due to SHACOB. Since the factors will be based on the actual demonstration projects themselves, the results will reflect a high degree of accuracy and provide a comfortable basis for making planning and policy decisions.

1. Development of Environmental Performance Factors

The following sections describe the methodology which can be employed to develop unit factors for each of the above categories of energy/environmental impacts for entire systems or individual components of those systems. Then, by combining factors with each other and with estimated component lifetimes, it will be possible to develop ratios and indices for making comparisons.

a. Reduction in conventional energy usage associated with use of solar energy systems.

This factor will of course be based on the amount of solar energy supplied compared to the total heating and/or cooling requirement of the building.

The exact type of factorial presentation will have to await the results of some trial data manipulation to see what works best. However, an expression relating usable solar energy to the number of degree days and unit area of the solar collector will probably be appropriate. Therefore, factors for each discrete solar system comprising the NDP matrix

will be easily determined. Other unit relationships might involve relating useable solar energy to the number of pounds of copper in a system, or the amount of glass, the amount of concrete, the amount of aluminum, the amount of steel and so forth. It may also be desirable to equate the amount of solar energy supplied to its equivalent in conventional energy.

Table IX-1 presents values for net useable thermal energy for various energy types and applications. The table was developed by using gross thermal energy content values for the fuel and applying average efficiency or coefficient of performance values for each application. The table includes considerations of the effects of part load operation on conversion efficiency.

- b. Reduction in pollution associated with use of solar energy systems.

A complete evaluation of this factor requires consideration of both direct and indirect effects associated with use of conventional energy which is being replaced by solar energy for heating and cooling of buildings. Whether the conventional energy source is electricity produced by coal, gas, oil, uranium, or one of these same fuels converted directly into thermal energy at the site, pollution resulting from the entire process leading to its use should be evaluated. Extraction, preparation, manufacture, distribution and ultimately the by-products of the thermal conversion process should be evaluated to obtain a total picture of the pollution associated with conventional fuels.

To quantify this factor, established emission and effluent factors should be employed where available or developed as needed. Primary emphasis for development of this factor should be placed on the air, water and land use areas. A data presentation employing unit

TABLE IX-1. NET USEABLE THERMAL ENERGY FOR VARIOUS ENERGY TYPES AND APPLICATIONS*

APPLICATION	INPUT ENERGY TYPE					
	OIL BTU/GAL	NAT. GAS BTU/FT ³	COAL BTU/LB	ELECTRICITY BTU/KW-HR	STEAM BTU/LB	NUCLEAR BTU/LB (U ²³⁵)
Hot Water Heating	112,000	722	-	3,413	-	-
Hot Water Boiler Space	112,000	774	7425	3,225	-	-
Steam Boiler Space Heat	105,000	774	7425	-	-	-
Hot Air Furnace Space Heat	105,000	774	-	3,225	-	-
Centrifugal Chiller Space Cool	-	-	-	8,874	-	-
Reciprocating Chiller Space Cool	-	-	-	12,969	-	-
Absorption Chiller Space Cool	56,000	413	-	-	582	-
Evaporative Cooling Space Cool	-	-	-	47,782	-	-
Dessicant Dehumidification	-	-	-	1,365	621	-
Electric Generation	44,100	330	3980	-	-	6.42 x 10 ⁹

* References 2-9

quantities of pollution compared to units of energy supplied should be utilized.

For example, Tables IX-2 through IX-7 present air pollution emission factors resulting from the combustion of various conventional fuels. (In order to retain the qualifications under which these factors were presented in the original publication¹⁰, the tables have been extracted and reproduced in their entirety. If the user desires further information concerning the references cited in the Tables, the Environmental Protection Agency publication AP-42, "Compilation of Air Pollutant Emission Factors", should be consulted.) The factors are presented as the weight of atmospheric emissions per unit of fuel consumed. To convert these factors to a common base, e.g., pounds of pollutants per million Btu of fuel consumed, the gross thermal energy values for various primary energy sources presented in Table IX-8 can be utilized. Additional factors reflecting water and air pollution generation associated with extraction, processing and distribution of conventional fuels should also be considered in the final analysis. As an example, air pollutant emission and water effluent factors associated with petroleum refining are presented in Tables IX-14 and IX-15 of this Section can be consulted.

- c. Conventional energy usage associated with manufacture of solar energy systems.

Factors developed in this category will possibly be the most interesting and revealing of all indicators developed. As people's sensitivity to environmental matters has increased, it has become more and more important to look at the entire range of environmental impacts associated with the widespread application of

TABLE IX-2. EMISSION FACTORS FOR BITUMINOUS COAL COMBUSTION WITHOUT CONTROL EQUIPMENT

Furnace size, 10 ⁶ Btu/hr heat input ^a	Particulates ^b		Sulfur oxides ^c		Carbon monoxide		Hydro- carbons ^d		Nitrogen oxides		Aldehydes	
	lb/ton coal burned	kg/MT coal burned	lb/ton coal burned	kg/MT coal burned	lb/ton coal burned	kg/MT coal burned	lb/ton coal burned	kg/MT coal burned	lb/ton coal burned	kg/MT coal burned	lb/ton coal burned	kg/MT coal burned
Greater than 100 ^e (Utility and large industrial boilers)												
Pulverized												
General	16A	8A	38S	19S	1	0.5	0.3	0.15	18	9	0.005	0.0025
Wet bottom	13A ^f	6.5A	38S	19S	1	0.5	0.3	0.15	30	15	0.005	0.0025
Dry bottom	17A	8.5A	38S	19S	1	0.5	0.3	0.15	18	9	0.005	0.0025
Cyclone	2A	1A	38S	19S	1	0.5	0.3	0.15	55	27.5	0.005	0.0025
10 to 100 ^g (large commercial and general industrial boilers)												
Spreader stoker ^h	13A ⁱ	6.5A	38S	19S	2	1	1	0.5	15	7.5	0.005	0.0025
Less than 10 ^j (commercial and domestic furnaces)												
Spreader stoker	2A	1A	38S	19S	10	5	3	1.5	6	3	0.005	0.0025
Hand-fired units	20	10	38S	19S	90	45	20	10	3	1.5	0.005	0.0025

^a1 Btu/hr = 0.252 kcal/hr.

^bThe letter A on all units other than hand-fired equipment indicates that the weight percentage of ash in the coal should be multiplied by the value given.
Example: If the factor is 16 and the ash content is 10 percent, the particulate emissions before the control equipment would be 10 times 16, or 160 pounds of particulate per ton of coal (10 times 8, or 80 kg of particulates per MT of coal).

^cS equals the sulfur content (see footnote b above).

^dExpressed as methane.

^eReferences 1 and 3 through 7.

^fWithout fly-ash reinjection.

^gReferences 1, 4, and 7 through 9.

^hFor all other stokers use 5A for particulate emission factor.

ⁱWithout fly-ash reinjection. With fly-ash reinjection use 20 A. This value is not an emission factor but represents loading reaching the control equipment.¹

^jReferences 7, 9, and 10.

TABLE IX-3. EMISSIONS FROM ANTHRACITE COAL COMBUSTION WITHOUT CONTROL EQUIPMENT

Type of furnace	Particulate ^{a,b}		Sulfur dioxide ^c		Sulfur trioxide ^{c,d}		Hydrocarbons ^{e,f}		Carbon monoxide ^g		Nitrogen oxides ^{d,h}	
	lb/ton	kg/MT	lb/ton	kg/MT	lb/ton	kg/MT	lb/ton	kg/MT	lb/ton	kg/MT	lb/ton	kg/MT
Pulverized (dry bottom), no fly-ash reinjection	17A	8.5A	38S	19S	0.5S	0.25S	0.03	0.015	1	0.5	18	9
Overfeed stokers, no fly-ash reinjection ⁱ	2A	1A	38S	19S	0.5S	0.25S	0.2	0.1	(2 to 10) ^j	(1 to 5)	(6 to 15) ^k	(3 to 7.5)
Hand-fired units	10	5	36S	18S	0.8S	0.4S	2.5	1.25	90	45	3	1.5

^aReferences 2 through 7.^bA is the ash content expressed as weight percent.^cS is the sulfur content expressed as weight percent.^dReferences 5, 7, and 8.^eBased on Reference 2 and bituminous coal combustion.^fExpressed as methane.^gBased on bituminous coal combustion.^hEmitted as NO, but calculated as NO₂.ⁱBased on data obtained from traveling-grate stokers in the 12 to 180 Btu/hr (3 to 45 kcal/hr) heat input range. Anthracite is not burned in spreader stokers.^jUse high side of range for smaller-sized units [less than 10×10^6 Btu/hr (2.5×10^6 kcal/hr) heat input].^kUse low side of range for smaller-sized units [less than 10×10^6 Btu/hr (2.5×10^6 kcal/hr) heat input].

NOTE: Approximate efficiencies of control devices used for anthracite are: cyclone, 75 to 85 percent, and electrostatic precipitator, 85 percent.

TABLE IX-4. EMISSION FACTORS FOR FUEL OIL COMBUSTION

Pollutant	Type of unit							
	Industrial and commercial							
	Power plant		Residual		Distillate		Domestic	
	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters
Particulate ^a	8	1	23	2.75	15	1.8	10	1.2
Sulfur dioxide ^{b,c}	157S	19S	157S	19S	142S	17S	142S	17S
Sulfur trioxide ^{b,c}	2S	0.25S	2S	0.25S	2S	0.25S	2S	0.25S
Carbon monoxide ^d	3	0.4	4	0.5	4	0.5	5	0.6
Hydrocarbons ^e	2	0.25	3	0.35	3	0.35	3	0.35
Nitrogen oxides (NO ₂) ^f	105 ^g	12.6 ^g	(40 to 80) ^h	(4.8 to 9.6) ^h	(40 to 80) ^h	(4.8 to 9.6) ^h	12	1.5
Aldehydes (HCHO) ⁱ	1	0.12	1	0.12	2	0.25	2	0.25

^aReferences 2 through 6.^bReference 2.^cS equals percent by weight of sulfur in the oil.^dReferences 2, 7 through 10, 12, and 15.^eReferences 2, 6, and 9 through 12.^fReferences 2 through 6, 9, 10, 12, 13, 15, and 16.^gUse 50(6) for tangentially fired units.^hUse 40 (4.8) for tangentially fired units and 80 (9.6) for horizontally fired units.ⁱReferences 2, 9, 11, and 14.

TABLE IX-5. EMISSION FACTORS FOR WOOD AND BARK WASTE COMBUSTION IN BOILERS

Pollutant	Emissions	
	lb/ton	kg/MT
Particulates ^a		
Bark ^{b,c}		
With fly-ash reinjection ^d	75 (15)	37.5 (7.5)
Without fly-ash reinjection	50	25
Wood/bark mixture ^{b,e}		
With fly-ash reinjection ^d	45 (9)	22.5 (4.5)
Without fly-ash reinjection	30	15
Wood ^{f,g}	5-15	2.5-7.5
Sulfur oxides (SO ₂) ^{h,i}	1.5	0.75
Carbon monoxide ^j	2-60	1-30
Hydrocarbons ^k	2-70	1-35
Nitrogen oxides (NO ₂) ^l	10	5

^aThese emission factors were determined for boilers burning gas or oil as an auxiliary fuel, and it was assumed all particulates resulted from the waste fuel alone. When coal is burned as an auxiliary fuel, the appropriate emission factor from Table 1.1-2 should be used in addition to the above factor.

^bThese factors based on an as-fired moisture content of 50 percent.

^cReferences 2, 4, 9.

^dThis factor represents a typical dust loading reaching the control equipment for boilers employing fly-ash reinjection. The value in parenthesis represents emissions after the control equipment assuming an average efficiency of 80 percent.

^eReferences 7, 10.

^fThis waste includes clean, dry (5 to 50 percent moisture) sawdust, shavings, ends, etc., and no bark. For well designed and operated boilers use lower value and higher values for others. This factor is expressed on an as-fired moisture content basis assuming no fly-ash reinjection.

^gReferences 11-13.

^hThis factor is calculated by material balance assuming a maximum sulfur content of 0.1 percent in the waste. When auxiliary fuels are burned, the appropriate factors from Tables 1.1-2, 1.3-1, or 1.4-1 should be used in addition to determine sulfur oxide emissions.

ⁱReferences 1, 5, 7.

^jThis factor is based on engineering judgment and limited data from references 11 through 13. Use lower values for well designed and operated boilers.

^kThis factor is based on limited data from references 13 through 15. Use lower values for well designed and operated boilers.

^lReference 16.

TABLE IX-6. EMISSION FACTORS FOR LPG COMBUSTION^a

Pollutant	Industrial process furnaces				Domestic and commercial furnaces			
	Butane		Propane		Butane		Propane	
	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters	lb/10 ³ gal	kg/10 ³ liters
Particulates	1.8	0.22	1.7	0.20	1.9	0.23	1.8	0.22
Sulfur oxides ^b	0.09S	0.01S	0.09S	0.01S	0.09S	0.01S	0.09S	0.01S
Carbon monoxide	1.6	0.19	1.5	0.18	2.0	0.24	1.9	0.23
Hydrocarbons	0.3	0.036	0.3	0.036	0.8	0.096	0.7	0.084
Nitrogen oxides ^c	12.1	1.45	11.2	1.35	(8 to 12) ^d	(1.0 to 1.5) ^d	(7 to 11) ^d	(0.8 to 1.3) ^d

^aLPG emission factors calculated assuming emissions (excluding sulfur oxides) are the same, on a heat input basis, as for natural gas combustion.

^bS equals sulfur content expressed in grains per 100 ft³ gas vapor; e.g., if the sulfur content is 0.16 grain per 100 ft³ (0.366 g/100 m³) vapor, the SO₂ emission factor would be 0.09 × 0.16 or 0.014 lb SO₂ per 1000 gallons (0.01 × 0.366 or 0.0018 kg SO₂/10³ liters) butane burned.

^cExpressed as NO₂.

^dUse lower value for domestic units and higher value for commercial units.

TABLE IX-7. EMISSION FACTORS FOR NATURAL-GAS COMBUSTION

Pollutant	Type of unit					
	Power plant		Industrial process boiler		Domestic and commercial heating	
	lb/10 ⁶ ft ³	kg/10 ⁶ m ³	lb/10 ⁶ ft ³	kg/10 ⁶ m ³	lb/10 ⁶ ft ³	kg/10 ⁶ m ³
Particulates ^a	5-15	80-240	5-15	80-240	5-15	80-240
Sulfur oxides (SO ₂) ^b	0.6	9.6	0.6	9.6	0.6	9.6
Carbon monoxide ^c	17	272	17	272	20	320
Hydrocarbons (as CH ₄) ^d	1	16	3	48	8	128
Nitrogen oxides (NO ₂) ^e	700 ^{f-h}	11,200 ^{f-h}	(120-230) ⁱ	(1920-3680) ⁱ	(80-120) ⁱ	(1280-1920) ⁱ

^aReferences 4,7,8,12.

^bReference 4 (based on an average sulfur content of natural gas of 2000 gr/10⁶ stdft³ (4600 g/10⁶ Nm³).

^cReferences 5, 8-12.

^dReferences 8, 9, 12.

^eReferences 3-9, 12-16.

^fUse 300 lb/10⁶ stdft³ (4800 kg/10⁶ Nm³) for tangentially fired units.

^gAt reduced loads, multiply this factor by the load reduction coefficient given in Figure 1.4-1.

^hSee text for potential NO_x reductions due to combustion modifications. Note that the NO_x reduction from these modifications will also occur at reduced load conditions.

ⁱThis represents a typical range for many industrial boilers. For large industrial units (> 100 MMBtu/hr) use the NO_x factors presented for power plants.

^jUse 80 (1280) for domestic heating units and 120 (1920) for commercial units.

TABLE IX-8. GROSS THERMAL ENERGY VALUES

ENERGY TYPE	ENGLISH UNIT	BTU		S.I. UNIT	K-CAL	
		RANGE	AVERAGE		RANGE	AVERAGE
Oil (Distillate)	Gal		140,000	Liters		9309
Oil (Residual)	Gal		150,000	Liters		9974
Natural Gas	FT ³		1,032	M ³		9190
Coal	LB	6,700-14,500	11,880	KG	3719-8076	6594
Propane	FT ³	-	2,500	M ³	-	22,000
Electricity	KW-HR	-	3,413	KW-HR	-	860
Steam	LB		970	KG		538.4
Wood	LB	7100-7400	7200	KG	3940-4107	4000
Nuclear	LB [*]	-	3.5×10^{10}	KG [*]	-	1.94×10^{10}

* U235

a technology. Solar energy may be free, but utilization of solar energy for SHACOB is not. Manufacture of materials and components for solar energy systems is an energy intensive process in many respects and one must be careful that reduction in conventional energy usage at a solar heated and/or cooled building is not being offset by increases occurring during the manufacture of the solar systems themselves.

A cursory look at energy requirements for manufacturing flat plate collectors was made during the Phase 0 studies.¹¹ Examples of the "energy costs" associated with the principal energy intensive materials used for manufacture of a typical flat plate collector are presented in Table IX-9. Certain assumptions were made to develop this data which do not apply to all flat plate collectors. Further, only the collector assembly was evaluated with no consideration given to piping, heat exchangers, insulation or storage subsystems -- all of which can employ a significant amount of energy intensive materials. As a result, a more intensive investigation was conducted in order to develop similar factors for other subsystems. The results of this investigation are contained in Table IX-10, Solar Subsystem Material Extraction and Manufacturing Energy Requirements. The table analyzes a solar energy system by subsystem, and subsystems by component. Energy values for the extraction and manufacture of candidate materials for each component are then presented.

TABLE IX-9. COLLECTOR COMPONENT* ENERGY COSTS

MATERIAL	Total Thickness (in)	Weight (lbs/ft ²)	Energy Cost (Btu/lb)	Energy Cost Per Unit Collector Area (Btu/ft ²)
<u>Covers & Pan</u>				
Float Glass	0.25	3.3	5×10^3	16.5×10^3
Steel	0.0312	1.25	20×10^3	25.0×10^3
<u>Collector Plates</u>				
Steel	0.0624	2.50	20×10^3	50.0×10^3
Copper	0.0365	1.68	51×10^3	85.6×10^3
Aluminum	0.060	0.85	100×10^3	85.0×10^3

*All collectors were assumed to have a total glazing thickness of $\frac{1}{4}$ -inch and a 22-gauge steel sheet metal pan to contain the "collector components." The steel collector was assumed to be comprised of two 22-gauge steel sheets; the aluminum collector of two 0.030-inch sheets comprising a "Roll-Bond" (Olin Industry Trade Name) panel; and the copper collector was of tube and sheet construction with an equivalent aggregate average thickness of 0.0365-inch.¹¹

TABLE IX-10. EXTRACTION AND MANUFACTURING ENERGY REQUIREMENTS FOR FINISHED MATERIALS USED IN SOLAR SUBSYSTEMS*

SUBSYSTEM	COMPONENT	MATERIAL	EXTRACTION ENERGY REQUIRED (a)	MANUFACTURING ENERGY REQUIRED
			BTU x 10 ⁶ /TON	BTU x 10 ⁶ /TON
Collectors	Absorber Plate	Copper	21.6	90.7
		Aluminum	4.8	239.1
		Steel	(d)	24.
		Plastic	(d)	96.2
	Fluid Passage- ways	Copper	21.6	90.7
		Aluminum	4.8	239.1
		Steel	(d)	24.
		Plastic	(d)	96.2
	Cover Plate	Glass	3.75	21.0
		Plastic	(d)	96.2
		Plexiglas	(e)	(e)
		Lexan	(e)	(e)
		FRP	(e)	(e)
		Tedlar	(e)	(e)
		Polyethylene	(d)	90.
	Insulation	Fiberglass	(e)	(e)
		Mineral Wool	(e)	(e)
		Polyurethane	(e)	(e)
	Frame	Steel	(d)	24.
		Aluminum	4.8	239.1
		Copper	21.6	90.7
		Wood	(e)	(e)
	Fluids	Water	--	--
		Glycol	(d)	.6
		Air	--	--
Storage	Tank	Steel	(d)	24.
		Concrete	.5 (b)	7.7
Distribution	Pipes and Fittings	Steel	--	24.3
		Copper	21.6	90.7
		Aluminum	4.8	239.1
	Pumps	Steel	(d)	24.
	Ducts	Steel	(d)	24.
	Heat Exchanger	Copper	21.6	90.7
		Aluminum	4.8	239.1

TABLE IX-10. EXTRACTION AND MANUFACTURING ENERGY REQUIREMENTS FOR FINISHED MATERIALS USED IN SOLAR SUBSYSTEMS* (continued)

SUBSYSTEM	COMPONENT	MATERIAL	EXTRACTION ENERGY REQUIRED ^(a)	MANUFACTURING ENERGY REQUIRED
			BTU x 10 ⁶ /TON	BTU x 10 ⁶ /TON
Controls	Valves	Steel	(d)	24.
		Brass (35% Zn)	18. (c)	75.6
		Aluminum	4.8	239.1
	Dampers	Steel	(d)	24.
		Aluminum	4.8	239.1
	Thermostats	Steel	(d)	24.
		Brass (35% Zn)	18. (c)	75.6
		Aluminum	4.8	239.1
		Copper	21.6	90.7
		Zinc	12.6	52.9

(a) Includes mining and transportation.

(b) Includes sand and gravel mining and cleaning data in reference document to allow for concrete mixture.

(c) Does not include alloying energy.

(d) Extraction data not available, manufacturing data includes extraction energy.

(e) Data not available.

*References 12-17

Performance variations between collectors made with identical absorber plate materials, variations in insolation throughout the country, and other considerations require that a total system be evaluated based on its own configuration and specific geographical location to obtain meaningful data.

However, using the data appearing in Table IX-9 as an example, the next step of the evaluation is illustrated in Table IX-11. The total energy cost per unit of collector area is calculated and divided by an assumed amount of useable solar energy captured by that area. The result is an energy payback period. Using the NDP as a data source, the energy payback period of real solar systems, as well as individual components, can be determined with accuracy. Instead of making assumptions about system and component configurations, detail design drawings and specifications will be available for take-off of actual information.

If it is deemed desirable, assumptions can also be made as to component or system life and used to arrive at an "energy efficacy" value. For example, using the previous data, if it is assumed that the life of a steel collector is 20 years, copper is 30 years and aluminum is 10 years, the resultant energy efficacy values are 40, 43, and 14 respectively, as listed for Example 1 in Table IX-12 (the higher the number, the better). However, if the lifetimes of all collectors were the same, as assumed in Example 2, the relative energy efficacies change significantly. Comparison of these two examples demonstrates the importance of accurate determination of component lifetimes if realistic efficacy values are to be obtained.

Comparative factors for other alternative energy systems as well as conventional systems have been developed by the Stanford Research Institute and are given in Table IX-13.

TABLE IX-11. TOTAL COLLECTOR ENERGY COSTS

Material	Energy Cost Per Unit Collector Area (Btu/ft ²)	Payback Period* (Years)
Steel	91.5 x 10 ³	0.5
Copper	127 x 10 ³	0.7
Aluminum	127 x 10 ³	0.7

*Assumes an average of 500 Btu/day of solar energy collected and utilized in the reduction of conventional energy consumption.

TABLE IX-12. COLLECTOR ENERGY EFFICACY VALUES

Material	Example 1			Example 2	
	Payback Period (Years)	Lifetime (Years)	Energy* Efficacy	Lifetime (Years)	Energy Efficacy
Steel	0.5	20	40	30	60
Copper	0.7	30	43	30	43
Aluminum	0.7	10	14	30	43

*The higher the Energy Efficacy number, the better.

TABLE IX-13. ENERGY EFFICACY VALUES FOR ALTERNATIVE AND CONVENTIONAL ENERGY SYSTEMS (Source: Stanford Research Institute)

<u>SYSTEM</u>	<u>EFFICACY*</u>	<u>COMMENT**</u>
Coal mining	42	Excludes energy required for delivery to final demand.
Petroleum refining	4.8	Excludes energy required for delivery to final demand.
Gas utilities	5.9	
Nuclear fission reactors (LWR)	32	Based entirely upon energy consumed by gaseous diffusion isotopic enrichment of fuel.
Energy plantations	3	Electric output. American Southwest. Assumes three crops per year, field drying, and combustion to generate electricity.
Ocean thermal gradients	15	Electric output. Considers only energy input into material (aluminum for boiler, condenser, and cool water intake conduit.)
Photovoltaic system (large satellite)	6	Electric output. Published projections revised to account for indirect energy inputs into materials.
Photovoltaic system (large terrestrial)	27	Electric output. Considers only total energy input to aluminum support structure for solar cell array.
Thermal system (large plant)	55	Electric output. Considers only total energy input to aluminum support structure (which may form part of collector) and double glazed glass cover.
Thermal system (small plant, on buildings)	56	Heat output. Considers only total energy input to copper rooftop collector and double glazed glass cover.

* Thirty-year installation lifetimes are assumed.

** Consideration of additional energy inputs necessarily reduces the energy efficacy coefficient.

Factors of the type described above can be developed for all actual systems in the NDP matrix and will assist in balancing the environmental assessment equation. Such factors are essential for a creditable evaluation and will most surely affect solar system design, and ultimately, the commercial feasibility of SHACOB.

- d. Pollution associated with manufacture of solar energy systems.

This category is the companion to the preceeding one and completes the total energy/environmental impact equation. Again, unit factors can be prepared based on units of pollution generated per unit quantity of product manufactured, including pollution generated starting with the extraction of raw materials. This basic factor can then be manipulated in a variety of ways to arrive at such relationships as units of pollution per square foot of solar collector or units of pollution per unit of solar energy used. Also, factors can be generated which apply to individual components as well as entire solar systems.

Table IX-14 presents air pollutant emission factors to compute pounds of pollutants generated per ton of product produced (Kg/KKg of product produced). In general, these factors are based on specific manufacturing processes and do not include auxiliary fuel consumption related pollutants. In addition, air pollutants resulting from raw material extraction and transportation could be developed to complete the total picture of the pollution associated with the production of the various materials.

TABLE IX-14. AIR POLLUTANT EMISSION FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS¹⁰

		IRON and STEEL		ALUMINUM (Primary)		ALUMINUM (Secondary)	
		LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
PARTICULATES	Uncontrolled	229	114.5	530	265	4.3	2.15
	Controlled	21	10.5	20.3 ^a	10.15	1.3	0.65
SULFUR OXIDES	Uncontrolled	4.02	2.01				
	Controlled						
CARBON MONOXIDE	Uncontrolled	1795	897.5				
	Controlled						
HYDROCARBONS	Uncontrolled	2.2	1.1				
	Controlled						
NITROGEN OXIDES	Uncontrolled	0.04	0.02				
	Controlled						
FLOURIDES (GASEOUS)	Uncontrolled	0.1	0.05	25.6	12.8		
	Controlled			2	1		
MISCELLANEOUS GASES	Uncontrolled						
	Controlled						

^a Assumes ESP controls. Includes bauxite and alumina production.

TABLE IX-14. AIR POLLUTANT EMISSION FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS¹⁰
(continued)

		COPPER (Primary)		ZINC (Smelting)		BRASS and BRONZE	
		LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
PARTICULATES	Uncontrolled	540	270	128	64	65	32.5
	Controlled	5.4 ^a	2.7 ^a	1.28 ^b	0.64 ^b	0.65 ^b	0.325 ^b
SULFUR OXIDES	Uncontrolled	5000	2500	1100	550		
	Controlled						
CARBON MONOXIDE	Uncontrolled						
	Controlled						
HYDROCARBONS	Uncontrolled						
	Controlled						
NITROGEN OXIDES	Uncontrolled						
	Controlled						
FLOURIDES (GASEOUS)	Uncontrolled						
	Controlled						
MISCELLANEOUS GASES	Uncontrolled						
	Controlled						

^a Assumes 99% ESP control

^b Assumes 99% fabric filter control efficiency

TABLE IX-14. AIR POLLUTANT EMISSION FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS¹⁰
(continued)

		LEAD (Primary)		LEAD (Secondary)		GLASS (Melting)	
		LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
PARTICULATES	Uncontrolled	605	303	170	85	2	1
	Controlled	6.05 ^a	3.03 ^a	3.4 ^c	1.7 ^c	0.02 ^a	0.01 ^a
SULFUR OXIDES	Uncontrolled	595	298	66.5	33.25		
	Controlled	30 ^b	15 ^b				
CARBON MONOXIDE	Uncontrolled						
	Controlled						
HYDROCARBONS	Uncontrolled						
	Controlled						
NITROGEN OXIDES	Uncontrolled						
	Controlled						
FLOURIDES (GASEOUS)	Uncontrolled						
	Controlled						
MISCELLANEOUS GASES	Uncontrolled						
	Controlled						

^a Assumes 99% fabric filter control efficiency.

^c Assumes 98% control efficiency.

^b Assumes 95% recovery in the form of H₂SO₄ or S.

TABLE IX-14. AIR POLLUTANT EMISSION FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEM^{c 10}
(continued)

		CONCRETE		RUBBER (Synthetic)		PLASTICS	
		LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
PARTICULATES	Uncontrolled	58.2	29.1			7.5	3.75
	Controlled	0.26 ^a	0.13 ^a			0.075 ^c	0.038 ^c
SULFUR OXIDES	Uncontrolled	2.0	1.0				
	Controlled	1.00 ^b	0.5 ^b				
CARBON MONOXIDE	Uncontrolled						
	Controlled						
HYDROCARBONS	Uncontrolled						
	Controlled						
NITROGEN OXIDES	Uncontrolled						
	Controlled						
FLOURIDES (GASEOUS)	Uncontrolled						
	Controlled						
MISCELLANEOUS GASES	Uncontrolled			83	41.5		
	Controlled						

^a Assumes 99.9% control efficiency of cement manufacturing process.

^b Assumes baghouse control of cement process - 50% capture by filter cake.

^c Assumes 99% control efficiency.

TABLE IX-14. AIR POLLUTANT EMISSION FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS¹⁰
(continued)

		MINERAL WOOL PROCESSING		PETROLEUM PRODUCTS	
		LB/TON	KG/KKG	b	c
PARTICULATES	Uncontrolled	45	22.5	242	0.695
	Controlled	0.5 ^a	0.25	44.7 ^d	0.128 ^d
SULFUR OXIDES	Uncontrolled	0.02	0.01	493	1.413
	Controlled				
CARBON MONOXIDE	Uncontrolled			13,700	39.2
	Controlled			Neg. ^d	Neg. ^d
HYDROCARBONS	Uncontrolled			596	1.707
	Controlled				
NITROGEN OXIDES	Uncontrolled			71	0.204
	Controlled				
FLOURIDES (GASEOUS)	Uncontrolled				
	Controlled				
MISCELLANEOUS GASES	Uncontrolled			73	0.209
	Controlled				

^a Assumes 99% control efficiency.

^b Units - lb/10³ bbl. fresh feed.

^c Units - kg/10³ liters fresh feed.

^d Assumes ESP and CO boiler controls.

Similarly, Table IX-15 presents wastewater effluent factors associated with specific materials manufacturing processes. In general, these factors are based on actual measurements and reflect various (albiet undocumented) degrees of water treatment. Additional factors should be considered to account for water pollution associated with raw material extraction.

2. Environmental Impact Evaluation

Utilizing factors developed for the preceeding four categories, the actual impact evaluation becomes very straightforward. Determination of the "environmental performance" of a specific system or an individual component is simply an additive process whereby the various factors are combined to arrive at a relative ranking or index. As the factors result from quantitative data, it will also be possible to model and project expected environmental impacts due to widespread deployment of solar heating and cooling systems based on assumptions about the number and mix of system types. Further, with the addition of cost data to the environmental performance factors, the costs and benefits of SHACOB can be determined with a certain degree of accuracy. The quantitative data will also be readily useable for trade-off studies conducted for policy decisions concerning program planning for research, development and demonstration.

Another important attribute of this method of environmental impact evaluation is in the area of consumer education. The energy and environmental performance of the whole range of solar system types will be reduced to a comparable data base making really informed decisions possible for the first time.

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	ALUMINUM (18) (Primary)		ALUMINUM (18) (Secondary)		GLASS (19)	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids	9.4	4.7			.0041	.0020
Suspended Solids	4.3	2.15			.028	.014
Dissolved Solids	4.8	2.4			.0041	.0020
COD	0.9	0.45	0.344	0.172	.0005	.0003
BOD						
Alkalinity	0.02	0.01				
Ammonia			0.025	0.0125		
Arsenic						
Cadmium						
Calcium						
Chloride	0.2	0.1	0.098	0.046		
Chromium						
Cobalt						
Copper	0.002	0.001				
Cyanide						
Flouride	10.0	5.0				
Lead						
Magnesium	0.6	0.3				
Manganese						
Mercury						
Molybdenum						
Nitrate			0.0002	0.0001		
Nitrogen						
Oil and Grease	0.55	0.275			.0014	.0007
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium	0.9	0.45				
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc	0.03	0.015				

(continued)

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	CEMENT (18)		STEEL (18)		PETROLEUM PRODUCTS (18)	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/10 ³ BBLS	KG/10 ³ m ³
Total Solids	0.63	0.314				
Suspended Solids			58.382	29.192	7.6	29
Dissolved Solids	0.54	0.272				
COD					154.7	590
BOD			0.45	0.225	62.4	238
Alkalinity	0.17	0.087				
Ammonia			0.896	0.448	9.2	35.4
Arsenic						
Cadmium						
Calcium	0.19	0.095				
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide			0.064	0.032		
Flouride			0.066	0.033		
Lead						
Magnesium	0.31	0.156				
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease			0.864	0.432	34.9	133
Phenolics			0.1605	0.0803	1.7	6.5
Phosphorus						
Potassium	0.15	0.077				
Selenium						
Silver						
Sodium	0.48	0.238				
Sulfate						
Sulfide			0.511	0.255	0.45	1.7
Tellurium						
Tin						
Zinc						

(continued)

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	COPPER (20) (Primary)		COPPER (21) (Secondary)		LEAD (22) (Primary)	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids	7.4	3.7	9.434	4.717		
Suspended Solids	0.94	0.47	2.778	1.389	0.16	0.08
Dissolved Solids	3.8	1.9	3.208	1.604	0.82	0.41
COD	0.74	0.37				
BOD						
Alkalinity	0.28	0.14	13.92	6.96		
Ammonia			4.272	2.136		
Arsenic	0.06	0.03	0.0586	0.0293		
Cadmium	0.0002	0.0001	0.0036	0.0018		
Calcium	0.26	0.13	0.2522	0.1261		
Chloride	1.34	0.67	14.08	7.04		
Chromium	0.0002	0.0001	3.22×10^{-4}	1.61×10^{-4}		
Cobalt			0.004	0.002		
Copper	0.14	0.07	0.266	0.133		
Cyanide						
Flouride			0.0238	0.0119		
Lead	0.02	0.01	0.150	0.075	0.001	0.0005
Magnesium	0.20	0.10	0.030	0.015		
Manganese			0.002	0.001		
Mercury			4.7×10^{-4}	2.35×10^{-4}		
Molybdenum	9.44	4.72				
Nitrate			0.082	0.041		
Nitrogen			5.816	2.908		
Oil and Grease	0.06	0.03	4.444	2.222		
Phenolics			0.4192	0.2096		
Phosphorus			0.1258	0.0629		
Potassium	0.70	0.35				
Selenium	0.04	0.02	0.122	0.061		
Silver			7.0×10^{-5}	3.5×10^{-5}		
Sodium	4.62	2.31	0.8226	0.4113		
Sulfate	15.1	7.55	0.720	0.360	0.28	0.14
Sulfide						
Tellurium	0.10	0.05				
Tin			3.0×10^{-4}	1.5×10^{-4}		
Zinc	0.04	0.02	0.0706	0.0353	0.002	0.001

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	ZINC (18) Smelting and Refining		RUBBER (18) Synthetic		RUBBER (23) Hose Manufacture	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	5.491	2.746	2.438	1.219	0.40	0.20
Dissolved Solids			2.55	1.275	18.9	37.8
COD			1.744	0.872	4.308	2.154
BOD			1.638	0.819	1.402	0.710
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese	0.0282	0.0141				
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease			0.536	0.268	0.318	0.159
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc	1.202	0.601				

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	RUBBER (23) Seals, etc. Manufacture		ETHYLENE GLYCOL (24)			
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	0.14	0.07				
Dissolved Solids	91.6	45.8				
COD	2.8	1.4	64.12	32.06		
BOD	3.3	1.65	10.36	5.18		
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease	3.6	1.8				
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

(continued)

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	PLASTICS (18) Polyvinyl Chloride		PLASTICS (18) Polystyrene		PLASTICS (18) LDPE	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	60.0	30.0	8.4	4.2	0.8	0.4
Dissolved Solids						
COD	50	25	6	3	24	12
BOD	11.4	5.7	2.0	1.0	8.8	4.4
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease						
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	PLASTICS (18) HDPE		PLASTICS (18) Epoxy		PLASTICS (18) Acrylics	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	3.4	1.7	28	14	3.4	1.7
Dissolved Solids						
COD	4.8	2.4	158	79	90	45
BOD	2.0	1.0	140	70	52	26
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease						
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	PLASTICS (18) PV Acetate		PLASTICS (18) Phenolic Resin		PLASTICS (18) ABS/SAN	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	2	1	6	3	16	8
Dissolved Solids						
COD	3.0	1.5	154	77	67	33.5
BOD	2.8	1.4	66	33	41.4	20.7
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease						
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

(continued)

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	PLASTICS (18) Rayon		PLASTICS (18) Polyester		PLASTICS (18) Cellulose Acetate	
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids			1.4	0.7	22	11
Dissolved Solids						
COD	110	55	52	26	110	55
BOD	44	22	40	20	110	55
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease						
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

TABLE IX-15. WASTEWATER EFFLUENT FACTORS FOR MATERIALS USED IN SOLAR SUBSYSTEMS

	PLASTICS (18) Nylon 6 and 66 Fibers		PLASTICS (18) Nylon 6 and 66 Resins			
	LB/TON	KG/KKG	LB/TON	KG/KKG	LB/TON	KG/KKG
Total Solids						
Suspended Solids	0.4	0.2	8	4		
Dissolved Solids						
COD	16	8	28	14		
BOD	10	5	20	10		
Alkalinity						
Ammonia						
Arsenic						
Cadmium						
Calcium						
Chloride						
Chromium						
Cobalt						
Copper						
Cyanide						
Flouride						
Lead						
Magnesium						
Manganese						
Mercury						
Molybdenum						
Nitrate						
Nitrogen						
Oil and Grease						
Phenolics						
Phosphorus						
Potassium						
Selenium						
Silver						
Sodium						
Sulfate						
Sulfide						
Tellurium						
Tin						
Zinc						

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Section IX Central Site Requirements

A. General

The national requirements set down in Section IV and the discussions concerning the remote sites together imply a set of requirements at the level of the central site. We will attempt to summarize these requirements here and perhaps outline the general characteristics of the solution. But it is not proper to attempt the same level of recommendation as before because of two related factors. The central facility is now viewed by ERDA as interacting with both the commercial and the residential demonstrations and must be appropriately configured. ERDA has assigned responsibility for this central site to NASA and its contractors.

Consequently, this section will treat only those requirements which relate to the commercial part of the demonstration.

B. Data Flows

To estimate the data flowing from the remote sites to the Central Data Collection facility, the mix of sites described in Section IV will be used together with the estimates of the data coefficients generated at each site each day. (For the Micro site the estimate is the average of two nominal sites and one maximum site.) The results are tabulated in Table IX-1 which also show the amount of time that would be required to transmit this data asynchronously at an assumed nominal rate of 1200 baud; a telecommunications scheme which yields the lowest cost. Since there are transmission errors requiring some retransmission, the data transmission efficiency is less than unity. Assuming that the polling is done at night, efficiencies of 0.7 are achievable, giving an effective transmission rate of 840 baud. Table IX indicates that the commercial sites can be polled daily in about seven hours. One WATS line would be enough to permit the polling during the off-peak hours. This confirms the acceptability of the low cost solution assumed above. Although reliability suggests the desirability of a second line, the facilities provided for the residential part of the demonstration should be the source of this support.

Table IX Data Transmission Estimates

	Macro	Extended Macro	Micro
Total Number of Sites	60	30	110
Annual Number of Sites	20	10	40
Number of Data Coeff./day	150	250	8,000 ⁽¹⁾
Header Coefficients	10	10	200
Diagnostics	2	2	100
Total Coefficients/site	162	262	8,300
Bits/Coefficient	60	60	60
Transmission time ⁽²⁾ (min.)	0.2	0.3	9.9
Connect time (min.)	0.5	0.5	0.5
Total time/site (min.)	0.7	0.8	10.4
Total transmission time:	13.9	8.1	415.2

Total Commercial time = 7.29 hrs.

(1) Based on an average of 2 nominal and one maximum configuration

(2) 1200 baud at 0.7 efficiency; numerically equivalent to dividing total coefficient rate by 840 for simple schemes where 1 baud is one bit/sec.

From Table IX-1, it can be shown that the commercial demonstration will generate

$$(60 \times 162 + 30 \times 262 + 110 \times 8300) \times 365 = 339.6 \times 10^6 \text{ coefficients.}$$

If each coefficient is represented by two 16 bit words, then these 340 million coefficients will occupy about 140 spools of magnetic tapes. (If the residential demonstrations are instrumented at the Macro level, then some 60 million coefficients would be generated and would fit on about 25 spools of tape).

C. Processing Requirements

The processing tasks to be carried out at the central site have already been discussed in Sections IV and VI. This section will summarize these in the sequence they will be used.

1. Initial Data Processing

- a) Communications
 - Automatic dialing of sites
 - Establish and maintain data transfer
 - Implement error control techniques as needed
- b) Site check
 - Verification of received data
 - Evaluation if site diagnostics
- c) Disposition
 - Storage of data in temporary file
 - Printout of diagnostic analysis

2. Subsequent Processing

- a) File update
 - Examination of received data
 - Storage in permanent file
 - Interpolation as needed
- b) Site Upgrade
 - Remote program load as needed

- c) Record Capture
 - Maintenance data
 - Failure Analysis
 - Expenses by cost element
- 3. Site Evaluation
 - a) Subsystem
 - Calculate actual performance
 - Compare with design values
 - Identify abnormalities
 - b) System
 - Calculate actual performance
 - Compare with design values
 - Identify abnormalities
 - Determine actual effective costs
- 4. Demonstration Evaluation
 - a) Effectiveness
 - Select (energy) model best fitting partial data
 - Compute coefficients
 - Forecast performance with complete data
 - b) Design Rules
 - Correlate sites and design rules
 - Evaluate rules based on site effectiveness
 - c) Institutional Barriers
 - Record barriers encountered
 - Compile attempted solutions
 - Compare and evaluate cost effectiveness of solutions
- 5. Prediction of Viability
 - a) Technical factors
 - Possible changes in economics and/or technical performance of components

b) Non-technical factors

- Define and quantify economic scenarios
- Establish necessary statistical data bases (weather and insolation trends, building populations, thermal properties and loads of buildings)

c) Forecasts

- Forecast improvement in cost and performance of each site
- Forecast ultimate effectiveness of entire demonstration

Section X Management Plan

A. Organization

1. General

It is the purpose of this section to estimate the resources necessary to carry out the Test and Evaluation Plan. (The material in this section is provided primarily for completeness. The responsibility for conducting the T&E part of the National Program has been assigned by ERDA to NASA who has included this effort in a recent RFP). This first part deals with the organization required to carry out the T&E Plan and for this purpose the tasks discussed earlier may be regrouped:

- a) Collect necessary test and evaluation data.
- b) Process and reduce data and analyze and forecast performance.
- c) Collate and publish results of demonstration sites.
- d) Acquire, install, (maintain), remove and dispose of T&E equipment.

The personnel necessary to discharge these tasks are discussed below. Fig. X-1 displays one possible organizational structure.

Fig. X-1 TEST & EVALUATION PLAN: MANAGEMENT STRUCTURE

2. Data Collection Group (Technical)

- a) The role of this group is to assure that the necessary data is collected. It will
 - 1) monitor (daily) the collection of site data and take necessary actions to bring the T&E site systems back to the desired level of operation.
 - 2) Visit sites periodically to collect reports on operational costs, maintenance logs, etc.
 - 3) Collect the needed statistical data on weather, insolation, conventional fuel systems and operating costing, building populations and use patterns. Amass bases for cost trend forecasts.
- b) Personnel required: monitoring (1/1) Site Visits (1/2) Statistical group (1/0). Total 3P + 3 NP = 6.

3. Data Processing Group

- a) It is the responsibility of this group to convert the data collected into statements of present performance and forecasts of future performance under appropriate circumstances.
 - 1) On a per site basis, verify consistency of data and smooth, interpolate to fill in missing data as needed. Normalize as required. Compress and reduce raw data as necessary.
 - 2) Upon completion of year's operation, perform life cycle cost analysis for each site.
 - 3) Create statistical data base (from 2/3 above) and help create necessary scenarios for forecasts of performance.
 - 4) Estimate monthly present and forecasted performance, using available actual site data and remaining projected site data.
- b) Personnel Required: Data smoothing (1/1), LCCA (1/0) Data Base (1/0), Performance statements (2/1) total 5P, + 2 NP = 7

. Analysis and Reporting Group

- a) This group will collect all useful T&E results for purposes of action and publication and will report problems on an exception basis to the T&E program manager.
- 1) By examining performance of demonstration sites and comparing with predicted performance identify sites needing attention. Contribute to diagnosis of difficulty and proposed remedy. Recommend to T&E Program Manager and implement as directed.
 - 2) Study performance of subsystems and identify needed improvements. Publish recommendations and advise T&E manager on present and future installations.
 - 3) Prepare reports on site performance. Assist ERDA in collating and comparing results from various demonstration and various conventional fuel alternatives.
- b) Personnel requirement: Site Analysis (2/0), Subsystem (1/0) Reporting (1/1) Total 4P + 1 NP= 5

. Equipment Group

- a) This group has the responsibility of providing the necessary hardware for the technical part of the T&E program.
- 1) Provide the necessary hardware for the data collection subsystems at the sites (as defined in the T&E plan).
 - a) Acquire basic equipment modules and dispose of as required.
 - b) Refurbish and modify equipment for re-use.
 - c) Provide necessary communications equipment.

- 2) Supervise the equipment installation and removal
 - a) Configure equipment needed and ship.
 - b) Install and debug systems and supervise attachment of transducers.
 - c) Disconnect and remove equipment at end of demonstration.
- 3) Provide assistance to Data Collection Group in case of hardware difficulties.
- b) Personnel Requirement: Hardware provision (1/2), Installation (1/2 per team for 2 teams)
Total 3P + 6 NP = 9

7. Personnel Summary

	<u>Prof.</u>		<u>Non-Prof.</u>		<u>Total</u>
Management	2	+	1	=	3
Data Collection	3	+	3	=	6
Data Processing	5	+	2	=	7
A&R	4	+	1	=	5
Equipment	3	+	6	=	9
Total	<u>17</u>	+	<u>13</u>	=	<u>30</u>

B. Equipment

1. In addition to the equipment installed at the remote sites, there will be equipment necessary to carry out the data processing tasks at the central facility as well as that gear needed to service and maintain the site equipment.
 - a) The data processing workload described above appears to be within the capability of a moderate sized computer facility working two shifts. For purposes of cost estimates, we have selected a configuration outlined in Table X-1 based on a DEC PDP 11/35. To provide the appropriate communication interfaces, a system control unit as well as serial and parallel interfaces have been included. One Bell 801 automatic calling unit (ACU) has also been provided. The leased communication facilities include one WATS line

(Grade 5 at \$1675/mo.) and one Dataphone (Modem at \$54/mo.) for the full three years.

- b) Equipment will be needed to calibrate and configure the site equipment. to service and refurbish equipment returned from the field. The laboratory test and repair equipment might total \$150M. A spare parts inventory of \$50M (5% of the remote site equipemnt) was provided.

C. Cost Summary

The estimated costs for the total three demonstrations are summarized in Table X-2. Labor costs assume 100 man years at an average rate of \$15M. An overhead rate (100%) accounts for employee benefits, taxes, rent and occupancy charges, etc.) Travel costs are premised mostly on \$250 expense per monthly site visit. Shipment of equipment between the remote site and the equipment depot was estimated at \$1M per trip.

The remote site cost estimates assume 200 sets of transducers (140 at the nominal level and 60 at the maximum) where the results of Table VII_1 were doubled for the maximum site. The estimates provies for 70 systems, half of which have second transducer interfaces (\$1300 ea.) mounted in remote field cabinets (\$2500 ea.).

The total T&E Cost is about evenly divided between the central and remote locations, with the total just below \$9MM. The per site costs are higher than the \$18M given in Section VII partly because of the central site allocation and partly because of the inclusion of some maximum configuration sites.

Table X-1 A Possible Configuration
for the Central Site Computer
Facility

	<u>Price</u> *
DEC PDP 11/35	\$52.7M
96K memory	
2 Disk Paks	
2 Tape Drives	
1 DEC Writer	
Software	
Communication Peripherals	
Interface equipment	\$ 2.4M
ACU	
Leased Items (3 year rental)	
WATS line (Grade 5)	\$62.2M
Dataphone (202S)	
Total	<u><u>\$117.3M</u></u>

*Discounted as appropriate

Table X-2 Estimate of Total
Test & Evaluation Demonstration
Cost

Central Site

Labor	\$1,500M
Overhead	1,500
Travel	700
Shipping	400
	<hr/> \$4,100M

Computer Facility	117
Equipment Repair	200
Office Materials	100

Total Central Costs: \$4,517

Remote Site

Transducers	\$1,638
Installation	1,092
Data Acquisition subsystems	1,372
Dataphone rental	<hr/> 136

Total Remote Costs: \$4,238

Total T&E Cost:	\$8,755M
Cost per Site	<hr/> \$43.8M

Section XI - Pilot Program

A. General

In this presentation of the Test and Evaluation Plan, there have been a number of issues which have not been resolved. These include the choice of scan frequency, assignment of compression algorithm and the size of program and computational load at the Site Data Acquisition Subsystem. It is the purpose of the pilot program to resolve these issues and to provide verification of performance and projected cost-effectiveness of the SDAS design.

B. Configuration

The pilot program consists in the operation of a small solar collector system and a skeletal SDAS for several months to collect some basic data and test the proposed SDAS design.

The solar energy system is shown schematically in Fig. XI-1. It is a water based system and uses two flat plate collector panels with a 35 gallon hot water heater as a storage tank. A radiator is used to provide the load. The SDAS is a DEC PDP 11/03 with 16K RAM, a dual floppy disk, and the Adac 600 LSI-11. All the equipment is mounted in a van located at a Singer facility in Fairfield, N.J.

The sensors shown in this figure were chosen with two things in mind. The first was to obtain a representative sample of the data associated with each of the major variables of interest. This is needed to provide a reasonable data base from which to select sampling frequencies and compression algorithms. The second factor relates to verifying the SDAS performance and is introduced through the vehicle of embedding these measurements in the context of a component evaluation, namely that of the collectors.

C. Sensors

The specific sensors being used, together with their characteristics and descriptions are listed in Table XI-1.

Fig. XI-1 Configuration of Pilot System

T_1 Tank Temperature

T_2 Temperature of the inlet to collectors

T_3) Surface Temperature

T_5 Outlet Temperature

T_6 Outlet Temperature:

T_7 Inlet Temperature to Radiator

T_8 Outlet Temperature from Radiator

F_1 Flow Rate in Collector Loop

WS Wind Velocity

WD Wind Direction

R Insolation Meter

TA Ambient Temperature

TABLE XI-I: SENSORS IN PILOT STUDY

Sensor	Type	Manufacturer/Model	Range	Accuracy	Cost	Remarks
Temperature	Thermistor	YSI Sostman 44018	0-100°C	0.2°C	\$12	For Ambient Air
	Thermistor	YSI Sostman Probe 710	0-100°C	0.1°C	\$50	Steel Fitting for Water Use
	Thermocouple (Iron-Constantin)	Omega TJ 36ICIN316	0-275°C	1°C	\$250	Includes 10' of Shielded Cable
Fluid Flow	Digital Meter	Flo-scan Model 100c	0-50 GPH	5%	\$60	Intended for Auto Fuel Measurement
Solar Insolation	Pyranometer	Star Pyranometer R413	0-350 Btu/ Hr/Ft ²	±2%	\$560	Slow Response
Wind Speed & Direction	Anemometer & Vane	Weather Measurement Corp. W-121 SD	0-100 MPH 0-360°	±2 MPH ±2%	\$125	Price includes \$25 Estimate for Interface Electronics

Two kinds of temperature sensors are involved. The first is a thermistor which is a linear, low cost device with a reasonably large output signal (10mV/deg C) but operates over a somewhat limited temperature range. A change in the fixturing adapts this element to measure either air or water temperature, but at different though acceptable accuracies. The second sensor is a thermocouple which operates over a larger temperature range but is less accurate and more costly because its low level output signal requires shielding and temperature compensated amplifiers. However, the thermocouple is a possible candidate to measure collector plate temperatures which can exceed 200°C in the summer if no fluid flows through the collector.

For fluid flow measurements, the pilot program has used an atypical sensor. Since this variable should be quite stable (at real sites), the sensor is present in the pilot primarily for the performance verification and consequently a low cost flow meter designed to monitor automobile fuel flow has been used. This sensor has neither the capacity or the reliability needed in an actual site, but is adequate for the pilot program.

The solar insolation is measured by a pyranometer of standard design. It has a somewhat lengthy time constant (50 sec. to full scale deflection) thereby filtering out some higher frequencies. However, the rise time (to 80%) is rapid enough so that some compensation may be possible if it is required. (An examination of some data will suggest how much of a problem this really is.) It might also be noted in passing that the calibration of this instrument has proven somewhat awkward. There appear to be few reference instruments available in the New York area and the state of their calibration is somewhat uncertain.

The measurements of wind velocity and direction are straightforward, once a digital electronics interface was fabricated. A standard interface would be helpful.

D. Sampling Frequency

The SDAS design is simplest if there is one sampling frequency (scan rate) for all channels. To find this

frequency, it is necessary to begin with good records of the basic data, records which are continuous or based on very closely spaced samples. Information theory tells us that no information is lost if we sample a signal at the Nyquist rate (twice the highest frequency present in the signal). By looking at records of the basic data and identifying the highest frequency signal of interest for each measured variable, it is possible to determine a Nyquist rate for each variable. The highest of these should be the first estimate of the SDAS sampling frequency.

This estimate will probably be too high in light of the data processing load. Furthermore, this rate is probably well past the point of diminishing returns in reducing the effects of noise (through repetitive reading) because of the additional smoothing of the compression algorithms. Some reduction from this first estimate is appropriate but how much is a question that should be answered as part of an iterative design procedure that selects the SDAS sampling frequency and the various compression algorithms together in a cost effective way that satisfies the accuracy requirements.

A second sampling question can be treated somewhat independently. This relates to the basic sample. The transducer interface has a reasonably wide band width (20KHZ) and makes it possible to combine many high frequency readings into one basic sample in a way that will minimize the effect of 60 HZ noise and its harmonically related overtones. For example, if one channel were sampled 20 times during one cycle of a 60 HZ tone*, it would be possible to reject much high frequency noise by averaging these 20 readings. By a proper weighting in the average, it is also possible to build in special rejection of 60 HZ tones and their higher harmonics. This is an attractive possibility because non-linear effects of other equipment in the building will manifest themselves as 60 HZ noise and noise at higher harmonics. Consequently, during the pilot program, the averaging of the high frequency samples into the basic sample will be studied to assure as high a noise immunity as seems feasible.

E. Compression Algorithms

Using the SDAS sampling frequency as determined above, the pilot program can identify that compression algorithm which appears best suited for each variable. Using the data base it is possible to measure the improvement in fit as the compression algorithm increases in complexity. The minimum complexity which yields adequate performance is the algorithm to be chosen for each variable. Adequate performance is determined by the needs of the computer simulation and the

* at a 50% duty cycle, about 8 such channels could be interleaved during one 60 HZ cycle

deviations due to noise and the approximation in the algorithm. As noted above, iterative design seems likely.

F. Computational Load

It is difficult to estimate the computational load that a particular program represents for a specific processor. This difficulty is of course compounded in the present case by the uncertainties discussed above. Consequently, it is appropriate to verify that the basic software package can be executed by the proposed SDAS in a fashion that permits modular expansion up to the maximum configuration.

While it is not clear at this time how complete a version must be included for a realistic test, the following software elements will be included as part of the pilot verification.

- 1) SCAN Control A program to control the actual scanning of the channels and storage of the basic samples.
- 2) Compression A program which processes the sampled data in accord with the proper compression algorithm and stores the appropriate coefficients in the coefficient file.
- 3) Checks A program which checks data in each channel at compression for high/low limits, redundancy, loop checks, etc. This program also carries out system checks on SDAS components. Results of the check are stored in data file.
- 4) Communications This program prepares the data for transmission to the Central facility, including the header and diagnostic summary as well as the data stored in the coefficient file.
- 5) Configuration A program which takes an English language input describing the channel assignments, calibrations, compression algorithms and sets up appropriate computer assignments in the SDAS.
- 6) Reports A program to provide a local output record of the channel data in the format of the configuration program.

G . Experimental Goals

The specific goals set for the pilot program are as follows:

- 1) Choice of basic set of compression algorithms (polynomials, exponentials, etc.)
- 2) Selection of high frequency and basic sample scan rates together with appropriate compression algorithm for key data channels.
- 3) Evaluation of noise control and S/N enhancement techniques.
- 4) Evaluation of various checks and diagnostic techniques to include high/low limits, cycle limits, and loop checks.

At the conclusion of the pilot experiment, the transducers employed will be evaluated and, to the extent possible, an evaluation will be made of the solar collectors as subsystem elements.

Appendix A: Parametric Model

A. General

The heart of the demonstration program is the documented performance of a set of sites where solar energy made a significant contribution to the heating and cooling of these sites. However, this set of sites is somewhat limited and what is needed is a statistically reliable way of extrapolating their performance to other sites and structures. This is the basic purpose of the parametric model.

It is intended to extract statistically significant data on the contribution of solar energy to the heating of different structures in different regions with different solar energy systems.

B. Model Details

The usable energy generated by a SHAC system, ES, depends on many factors as suggested in Fig. A-1.

$$ES = \text{Function (Insolation, SHAC System,)} \\ \text{(Building-Climate Interaction)}$$

A basic objective of the parametric study, discussed in Section IIC, is to find the proper form for this equation and determine the appropriate coefficients. For example, one equation model to be examined treats the first order effects of insolation ($a_j I_j$), sized SHAC system ($b_{ij} Z$), and building/climate interaction ($r_j B_j$).

$$ES_j = \bar{E}_j + a_j I_j + \sum_{i=1}^N s_j b_{ij} Z + r_j B_j$$

FIG. A-1 GENERATION OF USABLE SOLAR ENERGY

$$\text{ENERGY REQUIRED} = \left\{ \begin{array}{l} \text{USABLE SOLAR ENERGY (ES)} \\ + \\ \text{SUPPLEMENTAL CONVENTIONAL ENERGY} \end{array} \right.$$

Append.A -2

where

ES_j = useful Solar energy provided during the j^{th} season (MBTU)

j = 1 heating season

j = 2 cooling system

$\bar{E}_j$ = average of ES_j overall demonstrations (MBTU)

a_j = Coefficient to be determined (MBTU/Langley/ j^{th} season)

I_j = Total insolation in j^{th} season

s_i = SHAC System type (i - 1,2,3, ---N)

(e.g., s_i = 1 for flat plate water system
= 0 otherwise)

b_{ij} = Coefficient to be determined (MBTU for reference size system. Z_o of the i^{th} type.)

Z = Size of SHAC system relative to reference system

r_j = Coefficient to be determined
(MBTU/MBTU for j^{th} season)

B_j = Building HVAC requirement for j^{th} season
(MBTU/season)

Here the key elements on which ES_j depend, namely insolation, SHAC system and building requirement, are present as first order effects and by measuring (ES_j , I_j , Z , B_j) for each demonstration, it is possible to determine ($\bar{E}_j$, a_j , b_{ij} , r_j)

by standard statistical techniques and evaluate whether this first order model is adequate for the current needs or whether a more elaborate equation is better suited. It should be noted that the selection and trial of different models such as this is a task to be carried out during and after the demonstration.

When the proper form has been determined and the appropriate coefficients obtained from the demonstration, it will then be possible to use this equation in conjunction with the economic model to forecast the resultant economic savings as outlined in Figure A-2.

FIG. A-2 DETERMINATION OF ECONOMIC SAVINGS
FROM SOLAR ENERGY

Appendix B: Comparison of Data Collection Methods

A Introduction

There are a number of ways in which the engineering data recorded at a demonstration site could be brought to a central facility for processing and storage.

1. T and E personnel could visit each site every few weeks and manually retrieve the media on which the data was recorded.
2. The storage equipment could be connected to the public switched telephone network and contacted perhaps daily to automatically retrieve the data stored there.
3. The data collection equipment could be connected to a private leased telephone line so that the data is immediately forwarded to the central facility.

The earlier discussion concerning data requirements (Section V3) concluded that an average channel might be described by 3 coefficient per hour, so that the capability of a leased line far exceeds what is needed and represents an unnecessary cost. Consequently, this Appendix focusses on a comparison of the first two methods. The relative effectiveness of these methods is dependent on the characteristics and capabilities of the data collection and recording system and thus three options will be considered.

1. a conventional data logger (non-intelligent) with manual retrieval of data.
2. a conventional data logger with retrieval via the public telephone network.
3. A computer based data collection system (intelligent) with retrieval via the public telephone network.

All three options have been configured for 80 analogue channels with the results shown in Table A-1.

B. Data Logger and Manual Retrieval

An example of a reliable but reasonably priced data logger is the Datel LPS-16 (~ \$1695), which accomodates 16 analogue channels, requiring 5 of them for an 80 channel installation. The transducer interfaces (instrumentation front ends) offered by Datel will handle 32 channels, so that three of these are, needed (~ \$695 ea.).

The printed record will have to be picked up every few weeks by T&E personnel who can service 10 sites each, assuming that on the average one site can be done each day. The cost estimates assume labor and overhead total about \$20M per year with travel, materials, etc. averaging about \$250 per visit. Thus data retrieval from one site for a year totals \$8000.

At the central site, the printed records could be automatically scanned by optical character reading machines. Two machines (at about \$100K each) should be adequate, so that about \$1,000 of the central site allocation is for data capture. The remaining allocation covers the processing requirement, which is probably three times that of computer based option but can be accomplished in a more cost effective manner because of reduced computer overheads.

As outlined in the attached Table B-1 this option has no advantages relative to the other options. Exclusive of transducers, it has a total cost per installation year of \$21,560.

C. Data Logger and Automatic Retrieval

To provide automatic retrieval of the data, the data must be stored in electronically recoverable form (e.g., on a magnetic tape cassette) and read out from that tape into a modem for transmission over the switched network

Table B-1

COMPARISON OF OPTIONS

	Data Logger Manual Retrieval	Data Logger Automatic Retrieval	Computer Based Automatic Retrieval
Relative Advantages	None	1. Rapid detection of system malfunction 2. Freedom from errors introduced by manual intervention	1. Rapid detection of system malfunction 2. Freedom from errors introduced by manual intervention 3. Reduction of transmitted data volume by factor of three 4. Local intelligence to assist calibration and maintenance, and to provide local site reports
<u>Cost Summary</u>			
Data Collection & Recording	\$8,475	\$8,475	\$6,060
Transducer Interface	2,085	2,085	2,620
Manual Retrieval	8,000	-	-
Data Storage	-	2,835	3,000
Modem	-	648	648
WATS line allocation	-	1,800	600
Central Site allocation	3,000	2,000	1,000
Site Totals	<u>\$21,560</u>	<u>\$17,843</u>	<u>\$13,928</u>

to the central facility where another modem is required. The cost estimates assume modem rentals of \$54/mo. and usage of WATS rates (\$1675/mo.) to determine the connect time charges. (It is assumed that 6 such lines are required to handle the 67 sites which are simultaneously active.)

As outlined in the Table, this option provides the possibility of at least daily detection of system malfunction, and reduces the likelihood of error or loss of data. Even allowing for the uncertainties in the central site allocations, this option appears to be less expensive than the manual retrieval. Considering maintenance and reliability factors, the costs would probably become equivalent, but the present option is more attractive because of its advantages.

D. Computer Based System and Automatic Retrieval

This option is essentially the one detailed in the body of the report and the undiscounted figures have been used for costs. The central site allocation is based primarily on the data entry and storage requirements and does not include the System Level Plan functions.

It is clear from the Table that this option offers the most advantages and yet is probably the least expensive of the three, due primarily to advances in electronics and computers. Consequently, it is the one embodied in the present plan.

Appendix C Data Requirements for
SHAC Elements

The following pages identify those sensors which we feel are needed to provide the appropriate description of the performance of each of the major SHAC elements. The catalog is not complete nor does it provide for the following considerations.

- a) Elements are described without reference to a system configuration. Thus the descriptions may provide some unnecessary duplication without leading to desired levels of redundancy.
- b) Cost estimates do not include any discounting which may reduce the transducer cost. On the other hand, no provision was made for electric power meters, whose number is greatly dependent on the system configuration.

In computing the installed channel cost, it was assumed that \$120 is needed for the calibration and test of an analogue line and \$80 for a digital one.

SHAC ELEMENT : WEATHER STATION

MEASUREMENT	Accuracy	Unit Cost	Cost
AMBIENT TEMPERATURE (1)	$\pm 2\%$	20	20
WIND SPEED (1)	5%	} 100	} 100
WIND DIRECTION (1)	5%		
INSOLATION DIRECT (2)	$\pm 2\%$	570	1140
DIFFUSE		570	570
RELATIVE HUMIDITY	$\pm 3\%$	170	170
BAROMETRIC PRESSURE		86	86

TRANSDUCER Cost = \$ 2100
 Channel Cost = 960
 TOTAL \$ 3060

Channel Count : 8 Anal
 0 Digit.

SHAC ELEMENT : COLLECTOR SYSTEM

MEASUREMENT	Accuracy		Cost
AIR TEMPERATURE (REAR)* (1)	±2%	20	20
SURFACE TEMPERATURE) (2)	±5%	250	500
FLUID TEMPERATURE			
INLET (1)	±1%	50	50
OUTLET (1)	±1%	50	50
FLUID FLOW	2%	600	600
PUMP STATE	-	15	15

* FRONT AMBIENT TEMPERATURE
OBTAINED FROM WEATHER STATION.

TRANSDUCER Cost = \$ 1235
Channel Cost = 800
TOTAL \$ 2035

Channel Count : 6 Anal
1 Digit.

SHAC ELEMENT : STORAGE TANK

MEASUREMENT		Accuracy	Unit Cost	Unit Cost
LIQUID TEMPERATURE				
INLET	(2)	1%	50	100
OUTLET	(2)	1%	50	100
TANK	(3)	2%	50	150
FLUID FLOWS		2%	600	1200
PUMP STATES		-	15	30

TRANSDUCER Cost = \$ 1580
 Channel Cost = 1240
 TOTAL \$ 2820

Channel Count : 9 Anal
 2 Digit.

SHAC ELEMENT : HEAT EXCHANGER

MEASUREMENT	Accuracy		Cost
FLUID TEMPERATURES			
INLET (2)	1%	50	100
OUTLET (2)	1%	50	100
PUMP * (0)	-	-	

* FLOWS & PUMP STATES
will be monitored
at adjacent elements.

TRANSDUCER Cost = \$ 200
Channel Cost = 480
TOTAL \$ 680

Channel Count : 4 Anal.
0 Digit.

SHAC ELEMENT : AUXILIARY HEATER, CHILLER

MEASUREMENT	Accuracy		Cost
FLUID TEMPERATURE			
INLET (1)	$\pm 1\%$	50	50
OUTLET (1)	$\pm 1\%$	50	50
FLUID FLOW			
WATER	2%	600	600
FUEL	2%	600	600
PUMP STATE (2)	—	15	30

TRANSDUCER Cost = \$ 1330
 Channel Cost = 640
 TOTAL \$ 1970

Channel Count : 4 Anal
 2 Digit.

SHAC ELEMENT : COOLING TOWER

MEASUREMENT	ACCURACY	UNIT COST	COST
FLUID TEMPERATURE			
INLET (1)	± 1	50	50
OUTLET (1)	± 1	50	50
MAKE-UP (1)	± 1	50	50
FLUID FLOW			
OUTLET (1)	2%	600	600
MAKE-UP (1)	2%	600	600
PUMP STATES (2)	—	15	30

TRANSDUCER COST = \$ 1380
 Channel Cost = 760
 TOTAL \$ 2140

Channel Count : 5 Anal
 2 Digit.

Appendix D Configuration Program

The configuration program is a software device which tailors the intelligent controller at a remote site to fit the data acquisition needs of that specific site. It permits identification of channels, specification of gain and calibration and choice of compression algorithm along with a set of appropriate checks.

Specifically, this program takes an English language description of the configuration of the instrumentation on a channel by channel basis and converts it to a set of tables which the remote site controller will use in carrying out its daily and hourly tasks. These tables are also on file at the central site for validation and verification purposes* as well as to reinitialize the remote site system, should that become necessary.

The content of the program is most readily described by means of the input format, shown in Fig. . Field entries on the form, reading from left to right, are as follows:

- 1) Channel number
- 2) A 30 character descriptive field which identifies the measurement being performed by that channel. For example, "Collector bank #3 inlet temp."
- 3) A one character field identifying this channel as a digital (D) or analogue (A) channel. It is desirable to list digital channels before those analogue channels whose compression algorithm they affect. For digital channels, this is the right most entry.
- 4) A 12 character descriptive field for entering the proper engineering units for that channel. For example, "BTU/Sq. Ft."

* The table stored at the site (or some derived quantity) will be included as part of the preamble in each daily transmission.

- 5) Gain setting for the programmable transducer interface. The entry is one of a small set of discrete values (e.g., 1,2,5,10).
- 5,6) Calibration offset and Slope are entries used to convert the transducer digitized reading into the proper engineering units.
- 7,8) High and low limits are entries used in checking the system to detect malfunction, as discussed in Section
- 9) Data reduction code specifies which of the compression algorithms are to be used for this channel. The algorithms being considered are discussed in
- 10) Data Interval specifies the type of interval over which the data is to be compressed (hourly or cyclically) and for cyclic smoothing what digital channel is the reference channel.

Given a completed form of the type shown in Figure B-1, the fields can be entered into the configuration program in a one to one format, readying the system to perform the site monitoring task. Note that the computer programming is completely transparent to the user.

Normally, the configuration program will be executed only once when the site is put into operation. However, if it is desirable to reconfigure the system at some later time (add or delete measurements or change channel assignments) the program can be activated to accomplish the task. The same is true for recalibration.

Not shown in Fig. B-1 is another option considered for the configuration program: derived channels. Since all variables are expressed in engineering units, it is relatively easy to combine certain variables to obtain quantities of interest. For example the energy removed from the local storage unit might be expressed as a mass flow times the difference between two temperature readings. A subtraction and a multiplication of values stored in temporary memory could easily accomplish this. Implementation of this option will be decided upon after the basic site software has been completed.

Fig. D-1 Configuration for Site _____

[illegible]

Appendix E - An SDAS for MACRO Site

The Site Data Acquisition Subsystem (SDAS) proposed for the MICRO level of instrumentation was described in Section VII. This Appendix will outline one SDAS which is appropriate for the lesser requirements of a MACRO site.

For purposes of this estimate, we will assume eight or less inputs for analogue sensors and three digital ones. The schematic in Figure 1E shows four of these analogue lines which can determine both the solar and the auxiliary heater contributions to the building by measuring temperature differences and flow rates. A digital signal from the pump can be used to activate the SDAS.

A microprocessor such as the Fairchild F-8 is used to control the scan, to store the digitized values of the variables measured and to combine these (when the pump is active) into expressions for energy flows which are cumulatively stored on a daily basis and forwarded upon request over the telephone network to the centralized data facility. In an extended MACRO configuration, weather data would also be recorded.

Many of the program operations in scanning, compressing and communicating would be similar to comparable functions as described for the MICRO configuration. However, for a restricted set of sites such as this, it is probably easier to standardize the sensors, have calibration and conversion to engineering units done other than at the site. In this regard, the MACRO SDAS differs from the MICRO configurations.

The configuration shown in Fig. E-1 can be expanded to a total of 16 analogue lines and 8 digital ones with no further overhead hardware penalty.

A preliminary cost estimate for 100 of these units is given in Table E-1, and totals about \$200 exclusive of sensors. This is a fully absorbed factory cost and does not include S & A, development expense, margin, etc. which will probably raise the unit price to the \$800 - \$1000 range.

FIG E-1. A POSSIBLE SITE DATA ACQUISITION
SUBSYSTEM FOR MACRO SITES.

Table E-1

Cost Estimate for MACRO SDAS (100 quantity)

F-8 System (Fairchild)	\$85
38501 CPU - 40	
7861 (ROM (I/O Interface)-15	
3853 Memory Interface -15	
1702 P-ROM -15	
A/D Converter	
National Semiconductor 5357	7
Analogue Multiplexer	
RCA - CA 4051	1
Communications Interface	5
Power Supply	
Power One - HTAA-16W	\$40
Miscellaneous electronics, PC board	10
Connectors, etc.	
Cabinet	20
Wiring and Assembly	38
Test	5
Total Cost (Factory Level) =	<hr/> \$211

APPENDIX F

List of persons interviewed for pre-
demonstration assessment of the
societal impacts baseline and highlights
of interviews.

PHILADELPHIA AREA PRE-DEMONSTRATION INTERVIEWS

Washington-New York Solar Committee meeting

Jean Andrews, Research Director, Housing Guidance Council
T. M. Coffey, Price Waterhouse & Co.
Jack Cooper, A. P. Woodson Co.
Clarence Dodge, Jr., Chairman of the Board, Weaver Bros. Inc.
John W. Gill, President, H. A. Gill & Son, Realtors
David Lubell, Environmental Technology Seminar Inc.
Jack A. Mankes, Mayor's Science and Technology Advisory Council,
Philadelphia

Amterre Management Inc., Leonard Feldman, Construction Coordinator

W. M. Anderson Co., Mechanical Contractors, Robert B. Miller, Vice President

Bell Telephone Co. [Bell warehouse/office building is anticipated demonstration.]
Al Haron, Walter Platt, Headquarters Engineers
Larry Momorella, Local Office Engineer
Bud Starr, Local Real Estate

Bennett, Levin and Associates, Engineers, Robert L. Muska, Vice President

Environmental Design Associates, Jack Curtis, Richard Farley [project
designer for a solar post office in a residential community in
Philadelphia]

Franklin Institute, Edmund Thelen, Director, Physical and Life Sciences
Department [Institute sponsors solar seminars, does solar research,
is patenting a solar collector system.]

Golz and Wick, Consulting Engineers, David A. Wick, Jr.

Historical Commission of Philadelphia [Certifies historic buildings and sets
standards for maintenance of period visual integrity.]

INA, John Moore, General Liability Department [manufacturers' coverage]
John "Jay" Kelley, Philadelphia Service Office [user coverage]

Insurance Information Institute

W. F. Lotz, Inc., Designers, Engineers, Constructors, William F. Lotz, Jr.,
President

Marsh-McClennon, William Debracini

Pennsylvania Environmental Council

Pennsylvania Power and Light, Robert Romanchek [supervisor of solar demonstrations for Pennsylvania Power and Light]

Philadelphia BULLETIN, Walter Froelich, Environmental Editor

Philadelphia, City of, Department of Licenses and Inspection, Raymond Tate, Deputy Commissioner

Philadelphia, City of, Mayor's Science and Technology Advisory Council, Jack A. Mankes

Philadelphia Electric, Charles Martin

Provident Mutual Life, Craig Snyder, Assistant Manager, Mortgage, Loan, and Real Estate

Provident National Bank, Allan C. Kirkman, Senior Vice President [real estate loans]

Prudential Insurance Company of America, Mid-Atlantic Real Estate Investment Office, O. C. Lawrence, Regional Appraiser, and Carolyn F. Hatcher, Senior Appriaser

Sheet Metal Workers' Union, Local No. 19, Gene Mayer, Assistant Business Manager

Sierra Club

United Association of Journeymen and Apprentices of the Plumbing and Pipe-fitting Industry of the United States and Canada, Local No. 690, Thomas J. McNulty, Assistant Business Manager

Wright/Klett, Burt Klett and Otto Fisher [architects for the Bell demonstration]

SCOTTSDALE AREA PRE-DEMONSTRATION INTERVIEWS

Scottsdale Officials

Marty Almon, Grant Planner

Vince Canzano, Building Division Senior Plan Examiner;
chairman; National Solar Committee of the
International Association of Plumbing and
Mechanical Officials

Jim Davis, Maintenance Superintendent

Bill Ensign, Parks Maintenance

Walt Nemetz, Head, Department of Public Safety;
former Acting City Manager; chairman
of the city solar committee

Woody Parker, Project Coordinator for solar demonstration

Lou Witzeman, Fire Chief (owns Fire Department)

Donald I. Aadland, Consulting Engineer

Arizona Air National Guard, Col. H. Porter, Procurement Officer

Arizona Public Service, Bill Meek

Arizona Solar Energy Research Commission, Jack Haenichen, Associate Director

Arizona Wildlife Federation, Dianna Goebel

Armour and Company (division of Greyhound Corp.), K. Ries, Manager,
Energy Programs

Cash, Sullivan and Cross Insurance Agency, Carl Menke

Environmental Law Section, Arizona State Bar, Peter A. Neisser

Jack Ford, M.D.

Franciscan West Development Company, J. Eveld

INA, Larry Velasco

Insurance Services Office, Arvie Korstad

Johannessen and Girand, Consulting Engineers, R. McNulty

Kaufman Mortgage Company, R. Lass, Vice President

Robinett and Avery, Consulting Engineers, W. Robinett, M. Freitas

Roofers' Local No. 135, Don Prosise, Business Representative

Sheet Metal Workers Local 359, William Miller, Business Manager

United Association of Journeymen and Apprentices of the Plumbing and
Pipefitting Industry, Local No. 469, Jack Kienstra, Business Manager

Valley National Bank, R. Heinrich, Chief Appraiser

Del E. Webb Development Co., George S. Flagler, Manager of Residential
Architecture

Westcor, Inc., Jerry Sandrig, Vice President of Planning and Construction
(Commercial Property Development)

John Yellot, University of Arizona School of Architecture

APPENDIX G

The Issues: Highlights of interviews obtained for pre-demonstration assessment of the societal impacts baseline.

THE ISSUES

Highlights of the separate interviews presenting the materials in a format similar to the actual discussion: While the full range of anticipated drivers for and brakes upon solar development was raised at each of the interviews, meaningful comments or discussion were not always elicited. If a topic is not presented in a report of an interview here, this indicates that the interviewee had not thought about the topic and did not respond to it. In the case of the Committee report and the Scottsdale officials, each sentence implies a different speaker.

PHILADELPHIA AREA

THE WASHINGTON-NEW YORK SOLAR COMMITTEE--There are a few examples of self-financed solar operations--Long Island Bell is an example with their warehouse; but today solar is a "loss leader". Return on investment is important; what good is a five year payback if the owner plans to move in three years? What incentive is there to change to something that is cheaper in the long run? Moreover, with the current inefficiency of absorption systems for cooling, one can't get a complete package of heating, cooling and hot water. [Person in real estate investment and financing:] Six to seven years is a good payback period, 10 years would be an outside figure.

People haven't been concerned about security of their fossil fuel supply. A hybrid system means continuing trouble; you would have a tough time selling anybody on short technology--and short lived suppliers. On the other hand solar seems a manageable technology to most people; nobody's figured out how to tax the sunshine; there's interest. The University of Maryland had a seminar and it was packed each day with people wanting to make a buck or to save a buck.

[One of the committee members describes a strip shopping center he has proposed for a solar demonstration grant; he indicates that although he knows little about the pros and cons, he would not have considered solar

had he not been a member of the Committee.] The 100% back-up requirement is a significant factor; thirty percent of the typical construction job can be assigned to HVAC costs. There are also the questions of "Will it work in a cold climate?" and "What about low insolation?" Sunrights are another problem. Maximum height regulations in zoning would be necessary. This could have fantastic impact. It could be a fantastic threat; there is also the tax assessment for the solar improvement; the demonstrations, however, could be very useful as educational tools. Investors in the open marketplace, on the other hand, are only interested in whether or not the improvement will pay. There is the possibility that the commercial sector would be interested in the savings which could be shown from demonstration experiences.

There would have to be guarantees against risks of a higher neighboring building cutting off the sunlight. Vandalism could be a threat although the use of plastic materials could prevent this, leakage caused by different metals could also be a problem; there are no requirements now for reserve storage of fuel to assure service in apartment buildings and such, solar could play a role in guaranteeing energy supplies for specific uses. [A staff member pointed out that with interruptible service the individual takes the risk, whereas utility backup is different, with brownouts being a possibility if low insolation periods should result in heavy demand.]

The use of solar requires energy and finite materials for equipment delivery, etc.; conservation potential should also be considered in long-term policy decisions. Impacts of progressive shortages of fossil will affect the market; what is required now is... Reliability, service, parts. [A staff member added: Installers, suppliers, plumbers, HVAC people...] They are

interested in learning. Some construction product firms and fossil suppliers are looking at solar; on the other hand, conservation is difficult for a utility to handle because they need a growing level of sales; there is probably a market now for solar water heaters, sales and maintenance.

There are presently problems to the insurer and investor, although there are also positive factors such as environmental concerns and shortage threats in fossil supplies. We need standards for the collectors and their performance. The higher the cost of natural gas goes, the better sunshine looks. Solar need not be ugly; there is at least one example of a beautiful solar building. There is a waste treatment plant in Maine that uses solar and is well sited, using backfilling to advantage. The problem of solar energy storage remains; it involves a significant mass of material; possibly heat concentrators will be able to help the space problems.

THE BELL TELEPHONE STAFF PARTICIPATING IN THE SOLAR DEMONSTRATION [Because Bell had not yet announced the solar project, only those few who are aware of it could be interviewed; persons at the West Chester site and those in other sectors of the Bell organization, such as public relations department, were not included among those who knew of the project. Those privy to the executive decision to apply for the solar demonstration grant were also not included.]--The Bell engineers are aware of two other solar examples in the Bell system, one in New York and one in New England (Chelmsford, Massachusetts); these are both retrofit situations. The "energy crisis" and need to establish independence from fossil fuel was given as an incentive to investigate solar, and the New England example was mentioned in this context. However, fuel shortage was later in the interview specified as not being a reason for the Bell application for a demonstration grant. The collectors and storage location both presented problems in the New England example, we were told, and it was particularly expensive; there is an attempt

to capitalize in public relations on the solar operation, with a slogan about it appearing on each billing sent out in the area. Both installations are for buildings serving the same purpose as the proposed West Chester office/warehouse which will function as an installer departure point.

The original interest in the Bell of Pennsylvania project evidently came from the engineering sector, specifically from a former aerospace engineer who, among other space projects, was responsible for the solar simulation at Martin Marietta. He believes that probably a single enthusiast (most likely from the engineering sector) was responsible for the New York solar project too. With these origins, the project is intended as an opportunity to learn about practical problems--leaks, breakage, payoff period, etc. "You don't know 'til you try. We're at the bottom of the learning curve..the way to learn is to have your own system."

A proliferation of solar is expected in the next five to ten years; however, it's not reasonable to attempt to guess the rate at which it will take hold..possibly at the two percent anticipated by ERDA by the end of the century. Within the Bell system, if the early applications prove to be a good investment (that is, can be amortized within ten to fifteen years), the use of solar in warehouse/office buildings could spread, but not to central office uses until cooling is more effective and efficient because the large amounts of heat generated by the equipment make cooling an important feature in these buildings. Solar might be useful in business offices, though. Bell will not be expected to develop its own designs, but rather to hire specialized consulting for this purpose. Should solar prove to be cost-effective, the procedure for dissemination of this information would be that Bell Labs via the AT&T system would report to the companies, and the companies may or may not act on the information (as they may act independently now). This solar

is seen as possibly "something of a 'development first' for an operating company". Back-up energy systems in Bell buildings are likely to be electric, although there was a difference of opinion about the acceptability of oil--evidently a history of explosion or fire with oil could strongly militate against its future use or at least require excessively expensive safety precautions. Bell is self-insured.

About the solar marketplace generally, engineers who would design solar units were regarded with caution, and small companies which might get into their production were suspected of overselling their products. "People could get turned off if expectations were raised unjustifiably."

Regarding sunrights: 'Architects don't like to have to deal with orientation to the sun, but there are ways of handling the requirement. It would be interesting to see a cost comparison of rooftop collectors vs. setting them into a wall. Particularly if air were the medium of heat collection.'

The site for the solar demonstration and its designation for a "work center" was determined before the decision was made that this project be solar. It is a five acre plot from a 36-acre industrially-zoned area that is in single ownership; of the 36 acres the Bell land is the only plot which has yet been bought and the Bell land is located at a corner of the area, with developed land on two sides. Across the street from the Bell land is the headquarters for a trash collection operation and the office for a label and tag company which does its manufacturing a short distance down the road. Backing up against the other side of the corner is a row of single-resident homes, 3-4 bedroom, "better than average for the area". Separating the Bell property from these homes is the township line, and, on the Bell property a few small trees (the only "landscaping"

on the otherwise stripped land). There is a telephone man among the owners of these homes, and he has talked with the others about the work center which will be built there (although not mentioned that it will be solar--a fact of which he is unaware); no problems are expected from these neighbors.

The Bell people expect that the building will be in all respects the same as their other work centers, with the exception of the requirement that it be oriented to the sun and that its heating system will be different. There is another work center which is expected to serve as a comparison operation--with the same type of location, insulation and building materials, heat pump and general design. This building is electrically heated and cooled. The building will be flat roofed, with a chain link fence surrounding three sides and the Bell vehicles which will take up a large portion of the lot (about 100 are expected). Outside the chain link fence and to the front and/or side of the building will be the private vehicles of the installers and supervisors (another 100 more or less).

It is expected that the solar collectors will look like skylights on the roof of the building. Vandalism problems are not anticipated--because the neighborhood does not seem to breed this kind of thing and because the collectors should not be within reach of stones.

The community is of about 10,000 people, more rural than suburban and too far from Philadelphia for commuting; it is a county seat, has no major manufacturer, but a few smaller ones, and more than the usual share of lawyers. It's a "young-old" town, and no interest in personal solar uses is thought likely to develop among the citizens from this demonstration--at least in part because cost would be prohibitive for most of the residents.

The Bell building will have to meet the requirements for commercial buildings of the state's Department of Labor and Industry, and will be subject

to both township and state inspections. There was a difference of opinion regarding the amount of interest the solar aspects of the design would generate among the locals, but no local problems are expected and local building and inspection requirements are assumed to be less restrictive than the state's. It was not clear how the presence of the township line would affect any objections which might be raised by the residential owners on the one side of the building.

Interest in solar in the Bell group was not limited to the former aerospace engineer; others have attended or heard about the seminars which have been given on solar by the Franklin Institute ("they frequently use manufacturers' representatives, but the Institute people keep them honest... Nobody claims that solar is cost competitive yet. But, it's interesting.")

ENVIRONMENTAL INTERESTS--There have been a number of solar uses of which people in the Philadelphia area are aware: a residence in Indian Mills, N.J. which is more than half solar with oil back-up, the GE solar operation at Valley Forge, a post office for a North Philadelphia residential community, a Burger Chef in a nearby township which has a solar unit, Pennsylvania Power and Light's demonstration residence and planned demonstration houses, and the University of Delaware's SolarOne house. There is also awareness of the research at the University of Delaware, including the CdS cells, as well as familiarity with the Franklin Institute programs in research and the public seminars.

Solar problems were listed by one student of the local solar scene as (1) cost of the systems, and (2) public acceptance of the technology, that

is, 'will the new technology work..and in this area?' Legislation in Congress to provide tax write offs for solar investment is seen as a possible assistance with the first problem.

Solar is generally viewed by environmentalists as the "number one energy type". There seems to be little thought or concern for social issues or long term social impacts, although it is recognized as something which is likely to be of residential use primarily by the upper, upper middle and suburban users. There is no awareness of any problems regarding mortgage financing, insurance, etc. Zoning and land use implications seem to be viewed as premature considerations. The major advantage and the basic desirability of solar seems to be that it should decrease use of finite fossil fuels and decrease both the pollution and undesirable practices associated with their use, particularly stripmining of coal. No tradeoff has been made between stripmining and probable greater spacing of buildings and greater number of smaller buildings which could result with extensive solar use.

One organization is sponsoring an environmental conference in Harrisburg in February. It will be attended by at least 350 persons from state and local government, environmental organizations, businesses and academia. The liveliest interest among the 12 seminars being offered is in "Alternative Sources of Energy"--which of course includes solar.

GOVERNMENTAL AGENCIES--It is not believed that any of the presently existing regulations in Philadelphia should apply to solar, except in the sense that construction, plumbing and other such practices would be utilized. A retrofit solar system set up on an "A-frame" structure and using water as the carrier for solar heat, got the necessary permit for construction and experienced no

problems with inspections. Aside from a minimum degree requirement for residential structures, there are no heating requirements in the city at all and buildings can be without heating equipment. There are plumbing code requirements, but no standards for heating systems, no insulation standards. Storage structures, including say a pit for storage of heat in rocks, would require a structure permit and inspection during installation.

A building which has been certified by the Historical Commission would be subject to the approval of that Commission for any solar retrofitting. Should the solar unit in any way alter the appearance of the facade of the building, it is unlikely that permission would be granted. Should any aspects of the solar unit be visible from the street, permission is only slightly less unlikely. Since look-alike substitute materials are frowned upon (and not acceptable if--for instance--the original brick is available or wood framing is available instead of the aluminum equivalent), an argument that a solar collector looks like a (remotely possible) period tin roof or an original skylight would not be acceptable.

The Commission has certified whole blocks of buildings even when some of the buildings were not of the period exemplified by the best of the block in order to assure a more desirable historic consistency to the block. Even without certification, buildings' owners may well attempt a period appearance for their structures because of the extra value imparted to the buildings and because of the general appreciation for older styles prevalent in Philadelphia. The owner's consent is required for certification.

There is some thinking going on about "solarizing" a city building, perhaps a health center, a multiple-residence, a school or a community-run shopping center. One possibility would be for vocational school students to do a project including construction and installation of solar collectors

for a building being rehabilitated. Such a project is thought of as not only a useful exercise of skills for the students, but something which could capture ordinarily jaded interests and develop understanding and skills for a coming solar industry.

ARCHITECTS--The Bell building itself is likely to be similar to their other work centers in its being one story high (in spite of the lack of energy economy involved in such a structure) and having the "T" shape of the others with the offices along the cross bar front of the building and the warehouse area extending from them. There is the possibility of some change in building materials to better blend with the collector appearance, but basically Bell can't be expected to go in for structural innovations although the architect will make an effort to present some reasonably innovative alternatives to them. Since the houses on adjoining lots will have a view of the collector as well as 100-plus vehicles, he expects a substantial challenge in this design and hopes to integrate the collector visually into the general structure. There is no state agency involved in this project, he asserts, and he expects the local inspectors and any others to be essentially passive towards the project.

Because of the costliness and unproven reliability of solar, one of the architects described his initial substantial interest a few years back as having been aborted. His typical client, he feels, is interested in construction for speculative purposes and can't justify the extra expense or risk the inefficiency or unreliability of a solar system. He had specific factual questions about maintenance, the expansion and contraction of glass and cleaning of solar collectors, but did not feel that reliable collectors could not be

obtained or that these questions indicated any insoluble problems. Building orientation and the use of glass have always been the concern of the "contemporary" architect; his firm was using maximum insulation six years ago. Architectural schools, moreover, are more and more energy conscious today and this interest is reflected in the trade literature. Planning for future fuel availability and future fuel costs should be an architect's concern also: fuels of the future are not, however, likely to be coal because of the storage and parallel systems requirements; dual systems such as oil and electric could be acceptable as a guarantee against fuel shortage, but only if they were common because the higher initial investment could not compete in the market unless all were bearing it. Heat pumps and electricity are the present ideal combination; they are close to oil in economy and they easily handle air conditioning, which is a must in the Philadelphia climate.

In the long run the utilities will survive in one form or another; but, that doesn't mean that a self-sufficient system will not be and isn't now the most desirable. "Nowindmills, please. Coal either--it will rise in price to equal the competition." Even now we must consider the net energy implications of adding on such units as low-yield solar collectors which can take substantial energy to produce and install; also, any crash programs in energy can be very energy wasteful, inefficient. Zoning and land use generally will be straitjacketed by the time new thinking relating to energy use is acceptable.

Generally, an engineering change is more acceptable to people than a design change. The Georgian look which is much sought after in the Philadelphia area is characterized by door and window treatments, however, and a solar roof should be scarcely noticeable.

A "one zip number customer service unit" with solar heating and cooling will be built in a north Philadelphia suburb. The post office will be in a settled community of large single family homes and small apartment buildings and it will be overlooked by an existing large hospital. The community's population is made up largely of commuters, with some retired persons; not much interest is expected to be generated in solar use by others in the community because the use would most likely be residential and retrofit, and beyond the rather limited incomes which are typical of the area and also beyond the rather conservative nature of the community. However, the job is being handled directly from Washington (it is assumed the project was also initiated from there and very detailed requirements were made of the architect), and there is enough intention to publicize and study the project to include a "penthouse enclosure" on the roof for visitors.

The building will be 6500 square feet, one story, and include a work-room, locker and bathrooms, mechanical room (including space for solar), lunch-room, records room, postmaster's office and two lobbies; there is a fifteen foot ceiling height to permit the mandatory gallery for monitoring mail handling. An off-the-shelf Honeywell HVAC system will be used, with Honeywell monitoring the performance for two years; beyond that time, service and warranties were not known. The architectural firm is supervising the HVAC and doing the building design: L.G. Spielvogel is serving as the mechanical consultant. There will be a 100 percent conventional back-up system. Rooftop heating and cooling units were considered for this size of building; however, the decision was made to go with an oil fired boiler linked to an air conditioning system. The solar medium will be ethylene glycol; there will be 2500 square feet of solar collectors on the roof, which will not be incorporated into the roof structure physically although a great deal of attention has been paid to the visual integration of the collectors. They will be set at an angle of approximately

35°. "U" factors for the walls and roof have been brought down to 1. The exterior walls will be porcelain metal panels, the tinted windows will have overhangs; there will be 3 5/8 inches of insulation and drywall used. The architects have tried to give a human scale to the 17 foot high walls by varying the surface plane; the facade is 80 feet wide. "We tried to make the collectors an aesthetic plus. It should be a Twentieth Century building with a machined look compatible with the Post Office vehicles."

A government building does not require either a building permit or inspection, it was asserted, although if it had been required there should have been no problems. In the case of the post office, sunrights are protected by present use patterns in the area; however it was seen that for expanded use of solar there would have to be formal provisions and protections for users' sunrights.

The architects were enthusiastic about the opportunities of designing solar buildings, even though at least one of them was feeling the design constraints placed by a conservative client. Both look forward to the completion of the buildings and to being able to show them to future clients who might become interested in adding solar to their building plans.

UTILITIES AND RESEARCH- -Philadelphia Electric spokesman didn't see solar development soon: "Gee, maybe 20 years from now we might be getting into that". The company considers nuclear its main source of power and has two hydro plants, two coal plants and typically obtains 20 percent of its power from its two nuclear plants; two additional nukes are expected to be on line in 1980 and 1982. Solar application in commercial is seen as more unlikely than in

residential, and most of the Philadelphia Electric kilowatt hours go to the commercial sector. They do serve the solar operations at GE, at the Burger Chef and at the new post office. They see the residential use level at a typical 500 kWhrs per month, and solar as having a potential of producing 250 kWhrs per month assuming energy storage on site. With the long delays anticipated before solar goes into use, the spokesman expressed the possibility of fuel cells being as good or a better alternative energy prospect.

Philadelphia Electric has an engineer assigned to the Electric Power Research Institute, and itself has a five foot model of a building with an experimental solar collector on its roof. This model is run under various conditions experimentally on the roof of the utility's building. The utility is also involved with Franklin Institute in the Pennsylvania Power and Light solar demonstration home outside Allentown. (PP&L has a larger service area but a load level similar to Philadelphia Electric.)

The solar demonstration home is now in its second winter of operation (although there were six to eight months in which it was not occupied). It is approximately one-third solar--for heat only, and a heat pump does the air conditioning and heats the water. They are now modifying the operation from an aluminum absorber panel to all copper in the collectors and from an ethylene glycol solution to a water drain-down system; these changes are expected to eliminate the possibility of corrosion and the problem with marriage of metals that results in leakage, as well as difficulties in use of the ethylene glycol. With these modifications they feel the system should be reliable and easy to use; the house will be put on the market and sold at a price reflecting its value without solar--it is not felt that the cost of the solar could be recovered.

The company has gotten into this R&D "looking for benefits to the consumer without problems to the utility." They are now constructing three units (in Lancaster, Harrisburg and Williamsport) to demonstrate a heat pump and solar collector concept to builders and contractors. These homes will be sold on the open market, and PP&L expects to sell plans for the concept to those interested. (The heat pump may be bought from any manufacturer and the design and fabrication of the collector system will be farmed out. It is expected that since it will be made of copper, maintenance will be minimum--but the purchase "will be caveat emptor".) "We don't expect a large market", the spokesman said, "but it gives a consumer an alternative." The system can integrate with natural gas, if off-peak rates develop it can utilize them. Electric back-up is considered undesirable, since reduction of peak power demand is a justification for this effort. Although there is a project on the implications of these solar applications to the utilities, the spokesman would not comment on it. The heat pump, of course, is electric.

Architects are today's solar experts; there's a lot of interest in solar, but when the costs are mentioned those interested "fade out or disbelieve" what they hear. The cost of solar will remain high because the raw materials will be comparatively high and because production is labor intensive. Add in markups at all stages. If we come to the situation that we may need solar in any case, Federal subsidies are likely to be part of the picture. An immediate source of power that should be realized is thermal discharge from power plants. The spokesman sees greatest potential for energy realization from conservation, coal and nuclear--in that order.

Future energy sources will be determined to an extent by the ability of the utilities to grow. Now they can't afford to build power plants; 25 percent of the total U.S. energy is electric and the need is growing. The

government doesn't want coal, people don't want nukes (the nuke's problem is that it started as a bomb--nuclear power plant safety records have been great). Wind isn't too good a resource in this region, and there are storage problems, costs of getting it, and some environmental problem regarding wind energy levels.

For personal use on-site, people are afraid of oil and can't get natural gas.

For the distant future it seems that nukes will be the source of power for the urban areas--unless there is some other technical breakthrough. A major energy crisis is expected by the year 2100--with the period of 1980-85 marking the beginning of "a very trying energy time", all due to the difficulties listed above. Solar is essentially a rural or suburban potential. 'All the money being poured into solar is not for urban dwellers..for the poor..blacks. There are massive socio-economic problems for power..because power supply is not being planned for everyone.' This spokesman considered riots and vandalism on a scale we have not yet seen to be a reasonable expectation from the lack of planning for urban power now.

Regarding the financing of on-site solar today, banks base their mortgage decisions on the owner's reputation. Insurance should be available just as any building's conventional HVAC systems can be insured.

An interview at a research institute yielded the expectation that the first market for solar is likely to be in retrofitting units for residential use; this, based on a potentially 40 percent larger available market. Such users will be looking to save fossil fuel, and will install solar to function at an efficient performance level, that is, at about 60 percent of the typical heating load. The market goal must be to get the cost of collectors down from the approximately \$10 per square foot to something in the \$2 range.

(The Institute is applying for patents now on a collector design which should be capable of being produced at about that cost, assuming a compatible existing central heating system. The Institute will then seek a manufacturer for the system and demonstration and performance monitoring opportunities.) In commercial uses of solar there is much more potential for unique systems which incorporate conservation to a substantial degree. Heat from lights and body heat can be used in offices. In factories requirements to control pollution can particularly create conservation problems, preventing large scale flow-through designs and inhibiting heat exchange opportunities. Factories can also lack adequate roof and/or wall for collector space; however, process heat can offer conservation potentials such as driers incorporating parabolic mirrors for energy concentration or tight cycles of energy use for specific purposes in which a multitude of thermostats, dampers, etc. are unnecessary.

In the long run the materials required for solar units could prove to be a constraint on their use and weighing the alternatives now could be useful. There are the fans and electric pumps and such to be considered, as well as the alternative materials in essential aspects of the solar designs. Acrylates and polycarbonates might be less desirable than glass; copper is best for use with water, but use of air as the medium allows greater flexibility in materials used in collector units. There are also secondary materials considerations: Structural and other building materials that will blend well visually with collectors (collectors reflect the sky, and should not be assumed to be black panels as was done in the SolarOne project when the roof shingles were painted black); there is a 15° flexibility in orientation to the sun which offers some design flexibility, although the thermal efficiency of row houses and high rises should not be ignored. Materials used in interior decoration can also be a consideration in the future when greater use of glass on the

sunny sides of buildings will permit gathering solar energy directly; the bleaching, drying and rotting effects of the sun on wood, cotton and wool fabrics and dyes will particularly be significant.

This interviewee did not see solar as having limited application in highrise areas of the cities, particularly because of recent zoning trends to encourage higher structures with more open space around them. Sunright laws will, however, be a basic requirement, although central solar collection locations might be a more efficient solution to collection location than having such units on separate structures. Requirements of thermally tight well-insulated structures with zonal heating could cut down on necessary collector sizes. It would be interesting to consider what legal opportunities would be created by declaring solar to be a public utility rather than an individual opportunity.

There is a good future potential for solar, although it will probably exist in conjunction with other alternatives which are becoming available-- particularly conservation and the use of various wastes, including wood remnants, garbage, sewage and feedlot wastes. Others mentioned, ocean temperature variants, the pumping up of nutrients from the ocean floor in tropical waters, tidal and wind. The interviewee was particularly interested in hybrid possibilities.

He did not see solar development as a government area, with the exception of sponsorship of demonstrations and the dissemination of information. Individuals have taken over the field, and should be encouraged to continue to do so--at both the design and production levels. Federal regulation through standard setting should be expected. Insurance should not be a problem.

In Philadelphia specifically, it should be noted that there is more confidence in oil supplies because of the many refineries. While Philadelphia

is similar in cloudiness to the rest of the country, the number one variable is heat loss. Of course, the relatively high payoff of the more northern location makes the additional requirements of a larger system more acceptable.

The Institute is running a series of seminars on solar, but the interviewee felt that while the seminars were very useful in popularizing solar, the message that 'solar doesn't pay now' may have been overemphasized.

INSURANCE--Although a number of insurance men were interviewed--representing different aspects of the industry, but all representing large firms or brokerage houses with clients in not only many states, but often many countries--none were able to find any examples of solar coverage within their firms' experience. Therefore, responses tended to take the form of speculation regarding likely scenarios for coverage and insurance formats. However, there was little agreement on these formats or scenarios. The interviews cover mortgage and loan activities of insurance companies, coverage of solar manufacturers, and commercial and residential users.

Mortgage decisions would require that the insurer "be satisfied that the solar equipment be effective--we would go to great lengths to satisfy ourselves of this." They would look at competitive costs of alternative energy systems, although this could be less of a factor in manufacturing than in residential and some commercial, because in manufacturing special uses can justify higher occupancy costs. Of probably overriding importance, however, would be the credit of the mortgage holder--"we would go along with a Sun Oil". A developer of a more humble reputation might be considered a more questionable risk, and greater justification of the project (probably

in terms of marketplace rental rates) would be required. The added cost of a dual system need not, however, be out of the question: In Minneapolis oil and gas systems are fairly common, where natural gas is available from Canada but on an interruptible basis. However, in this case the dual system is common in the community and reflected in community rental rates, etc. Solar seemed a long way off in the future for Philadelphia to this interviewee-- "The average Philadelphian considers it foreign, unlikely."

Coverage of a solar unit as a part of a building's coverage did not draw any consensus among those interviewed. One thought that the solar was not likely to be covered and could even be pointedly excluded from other policy coverage; retrofitting of solar of which the insurance agent was unaware could even void existing policies, it was suggested. Recommendations on rates for coverage of a solar operation could be sought from an insurance information organization which serves the industry; it was considered possible that the rates for coverage of a solar operation vs. a single traditional system "might be double the rates for traditional systems".

Another insuror took a much more positive point of view, asserting that if a unit were attached to a building it could probably be considered as a part of routine coverage of the building, and if retrofitted to a building it could probably be covered in an all purpose "floater" coverage. (This latter opinion was strongly contested by others.) If a unit were not attached to a building, it could present particular problems to the insuror and require a lot of judgement on the part of the agent. Factors to be considered would probably include location, construction quality, protection from vandals if needed, protection from the elements if needed, risk from vandals and the elements. Planning for these factors could make possible "a lot less expensive coverage".

A review of rates would become possible after more solar units had been covered and the increase in the size of the coverage sample could indicate more about the actual risks being covered. An individual insured operation might be able to gain a review of rates after some years without problems, i.e. an "experience credit". Size of the deduction which is taken will also affect rates, as would size of the total coverage. (A lower rate could be expected by a party with \$100,000 coverage than one with \$10,000 coverage, because the former will be paying a more expensive total premium.) The type of damage anticipated in a claim would also be a factor, e.g. a firm running a substantial risk of leakage from a solar system and insuring a stock of paper goods would expect a higher rate than one insuring a less fragile stock or not using a system with a water medium.

All-in-all, though, drawing a comparison with rates for coverage of accidental water discharge from a sprinkler system, this insurer did not feel that coverage such a leakage should be near as high as that of, say, fire coverage generally. Ordinary wear and tear, such as rusting, would not be coverable, and outside piping could bring rates up.

An insurer of a manufacturer for liability connected to the malfunction of his products would expect to make a separate judgement on each of the products, although all of the products would probably be covered. Again, if an agent were not informed of new product lines, there is the possibility of voiding all coverage. Such an insurer "anticipates that agents will be informed and reasonably assured of product quality and performance capability."

Engineers at the insurance information service anticipate that solar use in residences should present no greater risk and cause no additional premium--with a probable increase in the amount of insurance carried to cover the additional investment. Commercial applications are expected to be no

different in respect to hazard, although commercial policies involve examination of premises and the specific installations. (This source also did not think that residential solar retrofitting would risk voiding an existing policy.) To assess individual systems, the agent might look to an independent engineering review, probably from Underwriters' Laboratories.

ENGINEERING, DESIGN AND CONSTRUCTION FIRMS--The representative of the mechanical contracting firm felt that he was no stranger to solar heat because in 1939-40, he was in Honolulu where sheetmetal absorbers were in widespread use for hot water heating.

With regard to current manufacturers' sensitivity (or lack thereof) to energy conservation, he had recently sent out a letter to about fifty firms (each with more than 100 employees) advocating waste heat recovery and other possible conservation-related improvements and suggesting an energy audit by his firm. He received only two responses.

We discussed some tax-related and philosophical differences between buildings built for institutional owners (e.g., hospitals, colleges) vs. those for private companies. An institution might prefer higher up-front building costs (e.g., solar system) in order to reduce later operating costs because they can raise construction money (e.g., a building fund drive) easier than year to year operating money. For a private owner (with high taxes, annual operating expenses are directly deductible whereas capital expenditures are depreciated slowly.

He anticipated that a solar installation would be expensive (collectors on roof, backup system) and with not a good payoff currently.

He mentioned three relevant unions: Steamfitters, Plumbers, and the Building Trades Council which is an association of 48 building trade unions such as asbestos workers, roofers, painters, operating engineers, etc. He anticipated no real jurisdictional problems among the various unions with regard to solar systems although the jurisdiction may be settled differently from region to region depending, to a certain extent, on local precedent. He did cite a problem that had occurred in Delaware connected with installation of an air-conveying system for plastic pellets. In the same geographical area (two different job sites), due to apparent lack of communication and to differing contractor policies, steamfitters did the work at one site and the sheetmetal workers at the other site. The resulting jurisdictional claims for future air-conveying systems in this geographical area have not yet been settled and the case is currently before the NLRB.

Generally, he assumed prior convention would rule adequately for solar systems. Plumbers typically handle the domestic water systems (including sanitary facilities) and steamfitters handle space heating. For example, for hot water for drinking, plumbers typically start from the take-off for the hot water coil at the boiler. For factory-made solar collectors integrated into the roof, the pipefitters would do the work, with caulking done by roofers.

With regard to other peculiar regional precedents, in New York City the plumbers install all automatic temperature controls whereas elsewhere the steamfitters do this. In Philadelphia, specifically, the duct workers install the heating coils, the temperature sensors are installed by the steamfitters, and wiring is by the electricians.

We discussed briefly the rights of "assignment" of a new product which has no prior jurisdictional precedent (as in the air conveyor case discussed previously). Assignment would typically be by the contractor or manufacturer. After assignment, the unions can contest the assignment, e.g., in Washington, but they can not go on strike over it.

One engineering firm interviewed will do the engineering work for the solar demo installation for Bell of Pennsylvania. When discussing how far away he saw widespread use of solar, the interviewee guessed perhaps fifteen years. He recalled attending a solar presentation at Franklin Institute which certainly didn't give him the impression that solar was here already. Economics will be the major factor. The need for 100 percent backup was noted as a disadvantage. The most likely form would be a solar-assisted heat pump system. Plumbers would probably have jurisdiction.

He had been proposing solar at Bell of Pennsylvania for about two years without too much success because of the poor economics. About one year ago a building engineering function was created at staff level in Bell of Pennsylvania. These people then provided the current impetus for solar, perhaps partly out of the need to prove their own value to the company. The Pennsylvania Public Utilities Commission (PUC) was mentioned as not being too friendly to Bell--thus any significant investment in solar would have to be justified to the PUC on a solid economic basis.

He noted an interesting fact, Bell Telephone historically has been responsible for the construction of more buildings throughout the United States than any other company.

He saw his company, a well-established older engineering company, as having to be quite conservative toward the use of solar because "good judgment was their stock in trade". He was the prime person who followed solar in his organization. He felt the potential bugs with solar systems would start coming to light only after many more systems were installed and maybe only after the systems were five to ten years old.

With regard to more general use of solar by Bell of Pennsylvania, he emphasized that this first installation must be successful. One factor mitigating against significant future new construction by Bell (and therefore the use of solar therein) was that they had recently developed a new switching system which used only one-third the space of the old systems. Thus, as they replaced the old system they were creating a lot of spare space.

As positive factors for solar he mentioned public relations, the general public clamor for conservation, and the rising price of electricity.

With regard to the attitudes of other engineering firms in the Philadelphia area, he could rank them from conservative to very progressive toward solar, with the firms with younger people being generally the more progressive. He mentioned a slow change in the way architectural firms viewed energy conservation. In the past they just did "shell design" with no concern for building energy consumption. The engineering firms would then design the HVAC system as best they could. Now the trend was toward more energy-integrated design, especially for those architectural firms with in-house engineering capabilities.

The problem of possible lack of reliability or poor performance of solar was strongly stressed. He felt an equipment "certification"

system should be developed, preferably by an association of responsible solar manufacturers. He mentioned one past case where "certified" cooling towers were supplied which turned out to be undersized and were then replaced by the manufacturer at no charge.

With regard to his influence on others, building owners were constantly asking his opinion on whether they should look at solar.

Another consulting engineering firm was contacted; this is a smaller firm (about \$500,000 gross income per year), but appears to be fairly progressive. They have been quite active in the energy conservation area, utilizing heat exchange wheels, heat pumps, etc. They have a water-air heat pump system in their own building. About 90 percent of their business is with developers and the remainder with architectural firms.

In a typical job, the following sequence of events occurs:

1. The developer initiates a project (e.g., apartment house)
2. An architectural firm does the shell design
3. The consulting engineering firm does a rough design of the HVAC system for estimating purposes
4. If the project is financed, the consulting engineering firm then does a detailed design for bids by contractors
5. The consulting engineering firm checks the final contractor shop drawings.

His feelings on solar are that it currently is hurt by high first costs resulting in up to 20 year payouts. They would have some problem in doing a solar estimate for a developer because of lack of prior experience. They might go to the Franklin Institute for help. He noted that the Franklin Institute had recently worked with Korman Corporation in connection with a \$36,000 HUD solar grant for two homes (hot air systems with oil heat backup).

They are very active in power resale projects for large building owners, e.g., apartment buildings. In Pennsylvania power can be purchased from utilities at bulk rates and then resold at a profit to individual users at higher (though controlled) rates. A recent project was the installation of individual meters in a 400 unit apartment house. They have an in-house Wang computer for billing purposes for each tenant. A conservation side effect is that as soon as the tenants are individually metered and billed, their overall power consumption drops about 20 percent.

With regard to potential future problems arising from a solar system that they may design, he indicated that they had liability insurance for these types of problems.

He appeared to be quite knowledgeable about the reasons for possible differing attitudes of utility companies toward solar. He observed that some utility companies had peak power demand in the summer (for cooling) whereas others had peak power in the winter (for heating). This presumably is a function of the type of customers. The former class of utilities, with spare power in winter, might not have great incentives for solar, especially if they had no nearby utility to sell their spare power to.

A third firm, doing design, engineering, and construction was a relatively well-integrated firm in terms of its in-house capabilities (engineering, architect, etc.). They recently developed an industrial park for a major insurance company and are currently developing one of their own parks. They do 90 percent of the work in-house including feasibility studies, land searches, mechanical design, electrical design, etc. They hire outside consultants for such specialized purposes as material handling, sophisticated air conditioning for special uses and surveying.

Their annual gross sales are \$10,000,000-\$15,000,000.

They are very proud of their sound economic approach to problems and also of their progressiveness with regard to applying new technology. They claim to have been doing value engineering and life cycle costing for years--even before it became "fashionable". They were one of the first people to install heat pumps on buildings ten years ago.

They have a man in the firm who tries to keep abreast of solar technology. They had a recent project (a four-story office building) for which they were asked for a rough estimate by the owner as to whether solar should be considered. Their analysis (supplemented by some outside help) indicated that it was not economical. If it had been close, it probably would have been tried because of potential public relations advantage.

He was quite sensitive to the long-term maintenance aspects of new technology. He noted that you can't sell something and walk away from it. As a case in point, he mentioned the current use of distributed small roof top HVAC systems vs. one central system. For many of these small systems, after 5-8 years, the maintenance costs start to increase very rapidly. He was also sensitive to the human factor problems in controlled environments. He noted that maybe on a cloudy day people in solar heated buildings might feel cold, even though the temperature is being controlled by a backup system.

He also discussed the tax-related differences between operating costs and capital expenditures. Operating costs are written off directly. Long-term depreciation of capital costs (e.g., solar) is not too attractive. He noted that some special equipment in his buildings qualified for a 10 percent tax credit and this he felt would be a fine incentive if applied to part or all of the solar equipment.

REAL ESTATE INVESTMENT AND DEVELOPMENT--The insurance company appraisers indicated that their company is one of the largest private investors in real estate in the United States. During the last few years their emphasis has shifted from making long-term loans to developers to actually purchasing existing buildings or doing the development themselves. One reason for this is that they have had to charge such high rates for their money that it has tended to discourage developers. They have about 20 real estate investment field offices across the United States. The Philadelphia office covers Delaware, Pennsylvania, and New Jersey. They are interested particularly in industrial parks, office buildings, and shopping centers (regional malls).

They are not currently actively following solar developments, but they do have several engineers in their Newark office who are up-to-date in solar. They feel solar use of any magnitude is five to ten years away.

A typical schedule for a project is

1. A feasibility study in-house (If the project includes solar, they would probably have to go to outside consultants at this point. The cost for this service on a \$50,000,000 project might be \$25,000.)
2. Presentation of the project to the Finance Committee (Board of Trustees for the company).
3. Design by an architectural firm which typically handles the engineering design in-house also.
4. Plans sent out to contractors for bidding. All financing is handled internally.

A major stress in the interview comments was on conservativeness with regard to anything new or untested, including solar.

A major current task for one of the above appraisers was evaluating several (electrical) power demand computers for possible application in one of their large office buildings. These systems temporarily shut off

noncritical power users (e.g., fans) to reduce power demand charges. Interestingly, they received several offers from bidders to install them free of charge and take payments only as a percent of their resulting power savings--very attractive offers.

The official in charge of real estate loans interviewed at a commercial bank had made no loans for solar-heated buildings yet (apparently no application had been made). His bank makes primarily short-term construction loans, one to two years in duration. He commonly loans to developers of shopping centers and these loans often fall in the range of \$15,000,000-\$30,000,000 each.

Among his criteria are (1) availability of a long-term investor; (2) financial position of the developer, and (3) specific costing and other information related to the proposed project, e.g., marketing, environmental, traffic, subsoil, zoning, legal, etc. He has his own people who can do most of this analysis for him, but if a solar project came up he would have to go outside for help. He mentioned one firm in New York City that specialized in helping lenders with these types of problems. He would expect to pay perhaps \$15,000-\$25,000 for this service.

The major exposure to solar to him and his people to date is through technical articles in the journals they read, e.g., Professional Builder, Real Estate Review, and Construction Industry News. The journal of major interest to him is Real Estate Law Journal. He noted that all tenants were on "net least" basis and thus the tenants absorbed all increases in operating costs.

Located just outside Philadelphia, the developer interviewed is one of the country's largest publicly-owned shopping center and real estate

development companies. Their major business is shopping centers (51 to date), but they also build motor inns, office buildings, industrial parks, and some residential development. Total gross income in 1974 was about \$40,000,000. The construction coordinator who was interviewed was the principal employee in the firm concerned with potential solar applications.

Generally, the firm builds for itself. It then leases its stores to the various tenants on a "net lease" basis, i.e., the tenant pays operating expenses, taxes, etc. (Less common is the arrangement whereby the tenant pays the owners a fixed percent of sales plus a minimum fee.) Even under a let lease, there is great incentive for the owner-developer to minimize the building operating costs so as to attract and keep tenants.

Generally, a long-term loan on the shopping center is arranged by the owner-developer shortly after construction, typically with an insurance company. The tenants commonly are on short-term leases with the owner-developer. The construction money itself comes out of a pool of money loaned to the developer at the beginning of each year (e.g., by a bank) to be used on a variety of projects as the developer sees fit. Collateral for this construction loan is typically existing land and buildings owned by the developer.

With regard to a solar installation included in one of its developments (not done yet by this developer), one possible barrier would be failure to get the long-term loan from the insurance company--the solar system might "raise eyebrows". A very careful presentation with sound economic justification would be required.

He was very much aware of the classic "sunrights" court case in Miami between the Fountainebleau and Eden Roc Hotels--the offender built a

hotel which put the pool and part of the beach of the other hotel into shadow. The offender eventually had to build a new pool for the plaintiff which extended out from the shadowed area.

With regard to their fuels experience, they don't touch gas because they can't get long-term commitments for supply. They don't want oil because price and supply are too uncertain. They use 100 percent electric for heating, air-conditioning, etc., in all their developments.

They are becoming very much aware of the need for energy conservation measures. For example, they are experimenting with color-corrected mercury-based lighting. For solar, they see it purely in a cost/benefit sense, looking hard at such things as system life expectancy and maintenance factors. They were one of the first firms to use heat pumps. They also look up to certain leading developers to set the example, e.g., the Rouse Company in Maryland.

UNIONS--The available work in the Philadelphia area for plumbers is currently not enough to keep all the union members employed full time--so it is shared among members, who are thus working perhaps 50-75 percent of the time.

There seemed to be no concern about solar jurisdictional problems, at least partly because they had not done that much thinking about it. Though the plumbers and steamfitters (pipefitters) have separate locals, they have a common union in Washington. If a local jurisdictional problem arose, they would call an organizer from the National Office to settle it. They could recall no recent jurisdictional disputes about anything in the area.

With regard to the relationship locally between the plumbers and steamfitters, if an excess of work were available, plumbers and steamfitters would be allowed to cross each others craft lines as the need arose.

He recalled reading an article in the Philadelphia Bulletin a week or two ago by an official of the Home Builders Association and one thing that he remembered was that there was a visual problem in connection with residential solar installations. The next weekend he was planning a trip to Delaware with his family to view a solar home, out of personal interest.

With regard to the solar collectors sitting on top of a flat roof, he expected that the sheetmetal workers would set them up.

Sheetmetal workers handle sheetmetal work associated with heating, (air systems), air conditioning, metal roof decks, siding, and metal decor. Their major jurisdictional disputes occur with the pipefitters. In the Philadelphia area, at least, these disputes have recently centered on convector covers, backup plates, and attenuator boxes. Most of the disputes are settled locally, rather than going to the national unions in Washington or to the National Joint Jurisdiction Board. He referred me to a publication by the Bureau of National Affairs which helped define areas of jurisdiction: "Construction Labor Report--Construction Craft Jurisdictional Agreements". He could not recall any specific references to solar system installation.

With solar systems, there seemed to be much potential for disputes between the sheetmetal workers and the steamfitters if past experiences is any guide. For example, radiant heating panels on ceilings are installed by sheetmetal workers, but the steamfitters do the solder connections.

SCOTTSDALE AREA--The City has a Solar Energy Committee, which is an outgrowth of the Energy Planning Committee formed at the time of the "Energy Crisis"; in addition to being interested in developing uses of solar energy, it has been concerned with emergency allocations of fuel. Types of energy in use in the area are natural gas (which was curtailed, and is currently under a moratorium on new hook-ups, with whether or not the cut-off will include those who have been promised gas undecided), gasoline (during the "crisis" supplies fell dangerously low, even for fire vehicles), electricity, and propane and butane (used more and more frequently as an alternative or a supplement for natural gas). There is a utilities plan to store propane (it was also said to be butane) in natural caverns in the Yuma area (southwestern corner of the state) and use it during the heavy demand winter season, introducing it into the natural gas lines as needed. Private use of propane and/or butane was questioned by the plans examiner and the fire chief on grounds of the hazard in storage, and a fire at a distributorship had resulted in deaths of firemen.

Eighty-five to 95 percent of the state's energy is imported, it was said, with power coming from Hoover Dam, the Four Corners coal burning plants and the Northwest Tier power loop. Water resources have been dropping by two

inches per year and local water contains a quantity of salt, which seems to have been accumulated from natural sources. Coal gasification is not thought well of, because of attendant air and water pollution. Solar is the choice locally, because it is not polluting and because of the high insolation and clear skies. The safety (as designed into interfaces between solar and other systems) and the reliability of solar are what is being sought; "50 to 75 percent of the local mechanical engineers are attending a solar conference being held this week." Main area energy uses: space, hot water and pool heating, space cooling and vehicles. Space heating requirements are very low, pool heating is considered essential; the cooling and vehicular uses are high demand sectors, although air conditioning does not seem to be used in excess but cars used in the area tend to be the large, heavy models and air conditioning in them seems to be used habitually.

The City is proud of its innovations and economies which have resulted from them and enjoys a national reputation earned by its fresh approach to government and operations. [See the Scottsdale INNOVATIONS looseleaf for examples.] An "Imagineering Task Force" of experts volunteered from local research groups (Motorola Research Labs, which specializes in solar R & D, and Armour Research Labs, the Arizona State University and Arizona University and local scientists) seeks innovative solutions to City problems. An NSF grant is expected to permit more formal work along specific lines in the near future.

Nineteen years ago Scottsdale had a population of 2000; today it is 80,000; unlike the neighboring state capital of Phoenix with its decaying and honky-tonk areas, Scottsdale looks like a newer city, works at maintaining its "most western of the western towns" image and strictly limits signs and other advertising. A Design Review Board requires that mechanical equipment located

on roofs not be visible, and such equipment as air conditioners is usually masked by extending wall lines upward to form parapets. This was the solution used for a solar residence being widely advertised as a model for others which will be built in Sun City, a retirement community located on the other side of Phoenix. It is expected that the Design Review Board will "have to change its version of what looks good" as solar becomes a popular heating and cooling source. (There seems to have been some shift over the years from more rigid western style requirements, and more innovative architecture exists in present examples in the city so no difficulties are anticipated in this regard.) Planned unit development opportunities exist in larger zoned developments; however the majority of the lots available in city are in the one acre category. Commercial opportunities to use solar have been considered, recently by a realty development company and an insurance company. There has also been some industrial interest, with engineering expertise for such considerations coming from within the firms involved. The fire chief proposed solar for one of his stations being constructed in nearby Paradise Valley; however, commitment had been made to plans before the solar was considered and things were too far along to make changes without incurring substantial expense; there was also objection to the appearance of the proposed solar building. An insurance company looked at this proposal and anticipated no problems in coverage arising out of the solar alternative.

Arizona has had legislation offering tax incentives for solar-- a five year amortization period for solar equipment in residential use; this has been recently amended to add commercial, industrial and institutional coverage and to essentially ignore the solar investment for tax assessment

purposes. Tax assessment is done through the county rather than the city.

Reliability is the primary question about available solar equipment; standards for performance need to be set and criteria developed for performance under different circumstances. With this type of guarantee and information equipment could be purchased with reasonable assurance.

Environmentalists are not very active in this part of the country. A nuclear power plant has been proposed for location in nearby Buckeye and opposition has been coming in from California where there is now an initiative petition being circulated to close down all nuclear plants until safety can be guaranteed. The proposed plant will use sewer effluent for its cooling towers. Conservationists will oppose the nuke strongly. There is close monitoring of industries here. The city has extensive conservation lands.

Residential construction is off 80 percent from what it was three years ago. This drop off seems to have coincided with a shake-up in City government which required substantial belt-tightening and some lay-offs. The maintenance superintendent projects an 18 percent increase in his utilities budget per year--based on recent years.

[On our last day in the area, preliminary plans were received for the solar demonstration. It is to consist of 2850 square feet of collector located on the roof of the Maricopa County Courthouse (just under 7,000 square feet). This one-story building is owned by the City of Scottsdale and leased to the County; it is in the new Civic Center area of the city. It seems that the collectors will face obliquely toward the hospital which is located across the street and down about a block, and directly toward the stands of the Chicago Cubs spring training field, which is on the same side of the street--although any effect of glare could not be ascertained. The City has built the ball park for the

Cubs, and it seems that it is used only by them.]

STATE SOLAR ENERGY RESEARCH COMMISSION--This Commission was formed in June of 1975 and is currently seeking funding for its continuance from a legislature which is preoccupied with other things. There is a staff of five and two of their main projects have been to get the Solar Energy Research Institute and a 10 megawatt solar electric power plant in Arizona (an ERDA project having a good possibility of materializing in a few years, probably in the Yuma area which offers some of the best climatic conditions in the country). Other projects which have interested the Commission include conducting a heating and cooling feasibility study for state and public buildings, a study of exact insolation in Arizona compared to other parts of the country, a solar planning guide for school construction, solar powered irrigation, and general solar research conducted in Arizona. The Commission evidently functions as liaison for industry and academia in seeking government funds, and, through its larger interests such as SERI, makes special efforts to be aware of and publicize the range and depth of solar-related activities in all sectors of Arizona research and operations. In their technical marketing and lobbying they work primarily with ERDA, FEA, and Four Corners Regional Commission; they also have an educational function throughout the state, and with state officials.

Arizona considers itself to be in a very vulnerable energy position, as it imports 85 percent of its energy. The tremendous solar resource of the state is seen as its hope for energy security..and solar power plants are "our hope for the future". Other state energy offices include a Power Authority with responsibility for hydroelectric and an ability to gain use of public lands (only 15 percent of Arizona is privately held) for power plant use, an Energy

Commission, and an AEC. There has been a tremendous reaction against the planned nuclear plant, but most of that opposition has "come in from California". [There is also an Energy Conservation Commission, however, it has been functionally downgraded to a fuel allocation operation and inhabits a small window-less office in the core of the new state office building, as contrasted with the sunny--though crowded--corner location of the Commission.]

One of the most important areas for research as far as Arizona solar use is concerned is in cooling--economically on a small scale. The interviewee is currently very interested in the possibilities of the MEC desiccant system (IGT holds the patents in this country). The Sun City demonstration model uses an Arkla-Servel system, although there is some question about the adequacy of this unit to handle the summer cooling requirements. A representative of Arkla from Los Angeles has said that the firm will be coming out this fall with a unit which will be able to do the job. The old Hay Sky-Therm demonstration has been dismantled, but a number of new Sky-Therm buildings are planned for construction in the area soon. He also listed cooling options involving pumping air through nite-cooled storage rock with or without evaporative cooling.

He then listed a number of parties in the area who have expressed an interest in solar, either sales or use, including many swimming pool heating operations (including one that is already out of business--it is said that in the greater Phoenix area there are 300,000 families and 100,000 pools); a number of private residential uses for heating, including some Israeli-type collectors and a small "home brew" system, parabolic-shaped collectors; some cooling systems; a car wash in Mesa which heats all its water by solar; possible use of solar in part of the Sentry Insurance complex in Scottsdale; possible use of solar for process water heating by Armour-Dial Research Labs; and development of "an

incredibly strong parabolic collector involving inexpensive construction" by Hexcel in Casa Grande, the manufacturer of honeycomb structural materials. The state is also planning to use solar for hot water in state institutions and the Department of Transportation is looking for Federal aid for solar heat and hot water for roadside rest areas and the GSA building on the road to Grand Canyon will be solar.

Most of the solar applications seem to be residential in nature. Those commercial operations and industries which have interests in solar tend to develop their plans out of in-house expertise.

While there is the solar tax incentive, Arizona also has a modest graduated income tax and comparatively modest welfare programs--which could all contribute to making the state a welcome place for commercial and industrial firms..if the energy availability and cost problems can be eased by solar opportunities.

SOLAR ENERGY RESEARCH--There are a lot of pressures which are making solar not only attractive, but progressively more essential. There is the shortage of natural gas, and the fact that it can no longer be expected to be cheap--in fact it could double in price without causing any grumbling at this point. By 1980 ASU can expect to be cut off and it uses its fuel for hot water and steam in a central plant. Electricity is also expected to go up in price, and has been at the rate of eight to ten percent per year.

Cooling is, of course the major consideration in Arizona; summers can exceed 120° for a total of 15-20 days. This means that collectors left in a stagnation state can reach temperatures of 270° easily--and this presents substantial problems in collector materials selection, design and construction.

Since this is a right to work state, the unions are not as important as they could be. Also, they shouldn't have jurisdictional problems simply because we get along. Innkeepers have a great deal of clout, and certainly this fact would count if it came down to priorities for energy service of any kind.

In solar research there are a lot of people working on their own. There is a great deal of disillusion with ERDA and HUD..mostly for their slow response or non-response to inquiries and proposals. In spite of the seeming amount of activity here regarding solar, there is a lot more interest than ever gets into any form of action.

There is a lot of interest in solar expressed in the School of Architecture and currently 12 students are going for Masters degrees with an emphasis on solar. Thomason technology is very appropriate for northern Arizona and Hay's system is good here. There will be two Hay examples soon in Tucson; they will require only electric heaters as occasional back-up. The cost will run \$25 per square foot, including the heaters. The weight involved in the Hay system is approximately 40 pounds per square foot, and the materials should last as long as a house.

The Decade 80 Revere house is in an exclusive area which restricts their use for publicity and advertising; there are some doubts to be expressed about the application, both on the grounds of cost and whether or not the exposed copper roof collection system can withstand local temperature extremes. There are still a lot of "swamp coolers" around here--inexpensive evaporative cooling systems for residential use--so many that it is claimed that they can raise the humidity on a hot summer day for the whole area, and of course they work less effectively with any increase in humidity. We're testing an Australian rock

bed regenerative cooler at the University now. Absorption is realistic if you use the Northrup concentrating collector to get the necessary higher temperatures. Desiccant systems are not practical because they are so complicated; they're no better than absorption.

The GSA is putting solar on the Williams building on the road to Grand Canyon; it's a kind of visitors center. There are also Indian hospitals in the northern part of the state which will be fitted with solar. Soleri, who's a genius at getting dedicated young men to work for him free just like Frank Lloyd Wright did, has a lot to say about land use and design for solar--but like most geniuses, he's not particularly appreciated in his own land. A lot more effort could be put into conservation in this area; it's just beginning to have advertising value for builders and the new ASHRAE requirements will have impact.

The first 10,000 kilowatt prototype of a solar electric power plant is likely to be located near Yuma, where the optimal climate conditions exist; it will utilize the Martin Marietta technology. The nuke now being planned will be approved; my only problems with nuclear energy have to do with breeders, handling and storage of fuels--these problems must be solved. Coal as an alternative presents environmental problems and low sulphur is required (whether it be coal or oil). The Salt River and peaking plants used to burn natural gas, but it's getting very expensive. GE tried a methane production project some time back but it didn't work; there's a lot of steer manure available and we running out of landfills.

There are environmental groups around, such as the Sierra Club, but they are not as many or as active and committed as in California. The state Solar Energy Commission is looking for sustaining funds and it could run out;

New Mexico and Florida are spending a great deal on solar--particularly Florida. I don't think surveys will be effective; you take the survey around a second time and they all answer differently.

UTILITIES--The utility we were able to approach through a non-Solar Committee member considers itself to be deeply involved in research (although figures for assignment of this investment did not seem to be available). Research is funded directly, in cooperation with specific other institutions and through the Electric Power Research Institute. Several projects which are national in scope involve statistical analysis of the potential interface of the power grid system with solar. A consortium including this utility has proposed the 10 megawatt solar electric power plant. At this point the utility does not know if there will be a way for it to get into the solar market at an individual user level; some of the potential problems are now being studied. There are an FEA grant, ERDA, RPI and ADL studies to model the characteristics of utilities and demand patterns; in Arizona there is a very severe summer peaking problem and in the near term solar water and space heating can deplete baseload while increasing peaking demands.

Solar water heating is commercially available now, feasible and probably competitive because natural gas is no longer available to new construction; however, it hasn't penetrated the marketplace because of the high capital costs of the systems and their doubtful reliability--at least in some cases. The ability of the systems to payback is marginal, although they could be economical against electric if they would last 15 years, which is not likely in this climate. When combined with space heating the systems can be economical, but they don't integrate well for total systems and aren't available in this area. In any case, they will have to demonstrate reliability and reasonably long equipment life.

Studies of potential solar impact in this area have not been different from the original NSF studies indicating 1-2 percent in the '80s and 7-10 percent by the end of the century. We are interested in three solar applications which represent what seem to be the best likelihoods of getting into solar at level below that of power plant generation: Since summer loads are twice the winter load, we're interested in solar assisted heat pump applications. We can't promote technologies which we aren't certain will work, so we have two or three research projects in concentrating collectors. Also, in the far distance, we have hopes for total energy systems.

It takes six years to build a coal plant and ten years, a nuclear plant. It will be ten years before we can expect solar to have enough impact to mitigate power demand appreciably. In the meantime we have the choice of coal or nuclear, and we need both. There is also the possibility of solar power generation, but not to replace baseload generation. If the California nuclear initiative passes and a similar action develops here, we will be in deep trouble--particularly because coal has the same problems for environmentalists. People will be out of work and the lights will be out. The planned nuke will supply one-third of the energy for the two largest utilities in the state; there is no way we can replace that generation by 1982 if the project fails. If we go to oil here we're talking about tripling utilities costs. With the nuke, there should be enough electricity to fill what would have been the natural gas needs of new users.

There is also an important option which is not being developed and that is conservation, specifically through improving construction (from an energy saving point of view it has been abominable for the last 20 years, because of increasing costs of construction materials). Conservation offers the single largest potential impact on the energy savings problem.

The utility now serves the different sectors with electricity as follows: residential, 30%; commercial, 32%; industrial, 21%; irrigation, 5%; and wholesale and public authorities, 12%. About 15% of their natural gas service is to commercial (retail stores, hotels and restaurants); irrigation also uses natural gas and was on low priority last year but has currently been given a breather. Almost all residences use gas and of those industries which use it most were non-priority and were cut off during most of last winter. Three companies handle gas and their supplies are all interruptible; the main supplier--El Paso--simply doesn't have the gas and operates at a 1974 level of restriction. There is no hope for gas becoming available from additional sources.

SOLAR LAW--Solar makes a great deal of sense and it should be developing at a rate ten times faster than now. We can always make special exceptions for pilot projects, but in the long run there are definite legal problems which will have to be dealt with if solar is to have a place in the energy market.

For thousands of years it was assumed that the owner of land owned down deep into the earth and up into the heavens, but modern law has modified this so that an airplane is not considered to trespass when it passes over land at a reasonable altitude. However, present law does not address the 30-60° angle of sunlight which neighboring buildings or trees could obstruct--buildings or trees which would not violate present law. The creation of easements whereby the first solar landowner would be protected could deal with the problem--somewhat in the manner of water law in some states protecting the first established user. Such an approach could apply equally to a one story building or a 25 story building, whether the tall building were the solar one or the blocking one. There are alternatives to the approach also involving easements or

zoning, but without the establishment of prior use rights. One approach could involve conflicting claims to a resource, such as the precedent of businesses being given secondary rights to limited natural gas supplies as compared to homeowners' rights.

Another interesting question involves availability of storage capacity for solar during evening and clouded days; this would concern land and other accommodations and possibly wholesaling and distributing relationships. Reflective or glaring glass could affect neighbors (there is a local example in which a building across the street from a tall building with lots of glass claims that it needs more air conditioning because of reflected heat, matters of comfort and safety, deprivation of views and invasions of privacy are all related to this consideration.

Solar offers many opportunities, as we have seen above, for the creation and destruction of "a bundle of rights". When this can happen, you are asking for lawsuits and for actions of the legislature.

Regarding the proposal that monetary damages, such as reimbursement of utilities costs if access to the sun were obstructed--this solution would not help solar to grow in the marketplace because it would not solve the basic legal and land- and sun-use problems. Also, in the law, each piece of property is deemed unique, and payment of dollar damages might not be considered adequate. The specific property can be demanded, or protected, or the original state can be demanded to be restored.

These legal problems should be soluble and legal models should be developed. Therefore, solar should be in use as soon as costs get in line.

INSURANCE--Neither of the two operating agencies contacted anticipated or had experienced any problems related to insuring solar operations. It was believed

that solar would present the same or less than traditional systems hazards. Rating advice would be sought from the Insurance Services Office, an independent service funded by the industry and located in Phoenix. With experience, a specific fire rate would be published for a public building based on occupancy, use, protective measures, water availability, etc.

The inquiry about coverage for the fire station was not remembered; however, the agent did not think that a special rate was involved, but rather that the system was treated as a standard "domestic" system. In the case of the Sun City model home, there were no problems or delay in arranging coverage and the same rate is being used as with traditional systems, which is the Insurance Services Office estimated average rate. (This would normally be based on five year periods of experience; however, ISO would have "absolutely no experience with solar in Arizona".) The state insurance office has to approve all rates, also.

The Insurance Services Office interviewee could see no "bad prospects" for fire insurance based on the concepts employed in solar technology or the equipment at any level of use. At the level of power production, utility generation is now under a national rating schedule and he expects that solar plants will be covered, and even these rates should not be higher than traditional plants. The rates would be figured on similarities with the present plants and of course some assumptions would have to be made until experience could be a basis for rating; the plant's developers could also furnish information on costs and time needed to replace equipment to assist in formulating coverage for equipment and business interruption.

In the case of home and smaller commercial users, he would want to watch any use of compressors beyond that level already present in refrigeration. At the present time fire insurance coverage of gas, electric and heat

pump operations on a small scale does not involve different rates. Any losses that occur are more likely to be from human error than equipment error. Of course, equipment for solar can be expensive--involving a lot of copper and glass--so more coverage would probably be necessary; however, hopefully the user's savings from solar would offset any extra coverage cost. [This interviewee was very interested in solar and optimistic about its widespread use in the future.]

As far as damage to glass goes, hail is rather rare in this area, although wind storms are encountered more often. Greenhouses tend to require a rather high insurance rate, but deductibles are available and frequency is rare enough that hail or even wind damage might not necessarily be covered.

As far as leakage goes, water damage from water heaters is a possible problem which could be handled by special exclusions with an option to buy back. Most piping, however, can be placed outside the building, leaving the risk as no worse than that of leakage from rain. Therefore, it would be necessary to look at how much potential leakage could occur within the building.

In suggesting a rate for a system, he would make notations regarding the proposed system, would compare it with the traditional alternatives, and would go out to the site and check it out. This should take no appreciable extra time to arrange coverage.

ENVIRONMENTALISTS AND CONSERVATIONISTS--Unlike in many other areas of the country, these two groups do not maintain offices or phone numbers in the state capital (Phoenix), nor are there any listings given in Scottsdale for any local groups. A directory published by the Governor's Commission on Arizona Environment did not prove useful, in that the few entries of

interest proved to be for past club presidents who were no longer located at the listed phones. Even the hearings being held for the nuclear plant failed to bring any local environmentalists to the surface (the plant is to be located just on the far side of Phoenix from Scottsdale). One conservation group does have offices in Phoenix, the Arizona Wildlife Federation, which is basically a sportsmen's organization. It is staffed by two ('but tomorrow we'll be only one').

The Wildlife Federation has not directly considered solar at this time; however, from the point of view of its being an alternative to strip mining, it is reasonable to expect that it will be looked on with some favor. If a solar power generator, however, were to require land that is now considered to be valuable or extensive wildlife habitat, there would be the possibility of opposition.

Individuals with whom the nuclear plant was discussed frequently indicated strong opposition--although it would seem that no group was voicing this opposition formally for them. It was not difficult to find someone to volunteer comments such as "Personally, I think the nuke will be an environmental disaster..if we had only spent half as much on solar..." It is also said that an initiative petition opposing nuclear in Arizona is being circulated.

[In connection with both discussions of the nuclear energy alternative and legal requirements for solar use, interesting comments occurred regarding Arizonans' attitudes towards California. Evidently there is a sensitivity toward the louder, quicker and sometimes pushier neighbor which could be expected from a state which finds itself following in the footsteps of someone else when it had thought it would be leading.]

DIVERSE SOLAR INTERESTS--The attached copies of clippings from local papers indicate something of the range of solar interests generated by the high insolation and clear air of the valley; however, some evidences of solar enthusiasm seldom reach the media. 'There are lots of solar putterers around, but I don't have time to get in touch with them' one such hobbieist stated. A surgeon, he had recently dismantled his concentrating collector which has burnt itself out after reaching high rates of steam production. He had never hooked this up to perform any mechanical tasks or produce power. When we toured his backyard he was setting up a flat plate collector incorporating a grid of copper tubing he himself had welded together, which would be raised some inches from a reflecting back panel insulated with styrofoam. An aluminum reflector at the base of the approximately 3 foot by 8 foot panel would be about the same size as the collector.

His many storage batteries were bought from the telephone company-- which is converting to a different type of battery--for \$3-4 (originally about \$50), and he had also acquired some other used equipment bargains. Numerous water tanks were ready for hot water storage. A single windmill was rattling out power for a stereo system and some lights. An alternator in the wind generator would permit direct use of this power; however, as he is located at the foot of a mountain which blocks off much of the available wind, he uses storage batteries and presently runs only the stereo and a few lights on DC. He has just obtained a small converter to eventually product 10 amps of AC.

People from the universities sometimes come by, he says, to see 'the kinds of things they only plan on paper'

There are numerous solar-related industries currently in operation in the area, ranging from the solar experimenter who sells a collector when he can, to the Motorola Lab where among their projects is a government-sponsored one which is expected to bring the cost of photovoltaic cells down to a fiftieth of their present cost.

Two world-famous architectural influences are also present in the area, and can increase interest in solar through their products and the publicity they receive--although their greatest impact is bound to be felt in the larger world. Frank Lloyd Wright's Taliesin West continues as a group of working architects and apprentices, more and more frequently incorporating solar in their designs. And, also in Scottsdale, Paolo Soleri's residence and Cosanti Foundation facility on Doubletree Road welcomes tourists and residents to view the buildings and purchase the products of the foundry and pottery workshops. There is an extensive plastic model of the prototype "arcological" (Architecture + Ecology) design for the 860 acre Cordes Junction "Arcosanti" 60 miles north of Phoenix. This community is under construction and planned to be capable of housing 3,000 people in a self-sufficient structure 25 stories high which, including the giant attached greenhouse farming operation, will cover only 10 acres of the otherwise natural site.

Desert Sunshine Exposure Tests Inc. a solar equipment and materials testing operation which has been in operation for 27 years, is also located in the valley. The company has tested 40 collectors--and found that some are more likely to last days than years, a finding that they expect to result in substantial lawsuits from disgruntled users. It is recommended based on this experience,

that purchasers of solar equipment require third party test data on units they consider. Under an ERDA program they are now doing extensive materials testing using their unique accelerated outdoor weathering techniques.

ENGINEERING, DESIGN, AND CONSTRUCTION FIRMS--One consulting engineer who operates essentially a one-man business was chosen to design the solar heating and cooling system on a model home in the Phoenix area for one of the country's largest developers of retirement communities (a discussion of this model home is given elsewhere in this report). This engineer saw the current barriers to rapid solar use to be high costs and the lack of standard, off-the-shelf absorption refrigeration units for cooling of homes. Indeed, he mentioned that at least one of the manufacturers of these refrigeration units for industrial use (driven by conventional fuels) thought that solar-driven refrigeration was ten years off. However, this engineer said that other manufacturers of absorption units were working hard to adapt their units for solar use.

This engineer felt that widespread solar use was not far off. He estimated that in five years about 50 percent of the new homes would have solar heating and cooling. He observed that overall electricity costs had risen about 33-35 percent in the last year. He felt that he would be successful in designing solar systems for the same reasons that he was successful in designing conventional HVAC systems--good work. (We were eating in a modern new restaurant that he had worked on.) He was not too worried about reliability of solar systems because he felt he would be able to choose reliable components because, when necessary, he has his own evaluation and testing techniques.

A second, larger engineering firm indicated that they had significant in-house capability for doing solar work (two registered professional engineers and one design technician) and had recently been involved at the design stage in several solar projects. One involved the use of solar for heating and domestic hot water for a "water safety facility" on the Colorado River, for the State of Colorado. It was decided not to use solar because of high initial costs. Another solar design for cooling for a Post Office Department application was also rejected based on high costs. He felt that the reason was the absorption machinery was still too inefficient and, therefore, had to be ordered two to three times too large. A third solar design project for the Arizona Air National Guard was still being debated. This was a 75-80 ton cooling system with perhaps two large absorption machines and a 130,000 gallon underground storage tank. The application was a soon-to-be-built large, single-story combined training facility and maintenance shop. [A call was made to the Arizona National Guard about this application. The use of solar was investigated because the National Guard Bureau in Washington requested that they do a feasibility study on this application. They hope to receive some ERDA funding via DOD. However, because the funds have not been forthcoming as yet, the project will probably go out to bid shortly without a solar system or with just solar hot water heating.] This engineering firm has been receiving many inquiries on solar but their position (and response to these inquiries) is that solar still needs to get a little more economical. They estimate current payback periods as 10-20 years for heating and 25-30 years, or more, for cooling applications.

A third engineering firm was interviewed because it had a reputation among engineering firms of being more conservative in its general outlook. They had done no solar work and didn't anticipate widespread use of solar for 20 years. They likened the current solar activity to the earlier "fallout shelter syndrome"--it was actually getting to be unpatriotic to be conservative about solar applications. He said he hadn't seen much improvement in solar system designs over the last 15-20 years and that "we will have plenty of relatively cheap fuel available from coal, nuclear, geothermal, and gas in West Texas."

He was especially concerned about "flim-flam" types of smaller solar system suppliers that seemed to be appearing. He felt there was a strong need to license solar system suppliers. Otherwise, solar is going to get a bad name when many of these systems perform badly. He also said he gets questions on solar very often from architects. Another concern was that some suppliers of solar components (e.g., collectors) were supplying misleading information based on false extrapolations of data, etc. And, even payouts of 5-7 years on paper were not necessarily convincing because of the dangers of such things as high maintenance costs and vandalism.

He observed that he knew of a local architect who had a very difficult time getting bank financing for a new home to cover a \$10,000 solar system. [The architect was contacted. He claimed that his was the first home in the United States involving solar heating and cooling to be paid for by the homeowner himself. He had to try three banks before he could get financing. The first two banks were "afraid" and overly concerned about reliability. They said that if they had to repossess the

home and had trouble with the solar system, where could they go for service? The third bank had made another solar loan and was therefore not so afraid. Also, the architect stressed to this bank that the house had complete heating and cooling system backups for the solar system.

REAL ESTATE INVESTORS AND DEVELOPERS--The chief appraiser for a large bank in the Phoenix area had not been involved in any solar loans yet. The bank makes about 75 percent of its loans to single family homes and the remainder to small commercial buildings such as medical buildings. His evaluation of solar would be on a purely economic basis--up front cost vs. savings in operating costs. He would have to obtain outside help in his evaluations, possibly from the manufacturer of the solar system or from an engineering firm. He had recently heard a lecture on solar at an appraisers' meeting by a local engineering consultant. He recalls that dependability and first cost were presented as potential problems. He is completely confused over whether solar is just around the corner or a long way off, due to conflicting opinions he hears--so now he really doesn't believe anyone.

The real estate loan officer of a large life insurance corporation also had made no solar loans. He recalled that about one year ago home developers from the state of Washington had proposed using solar on a large office complex (\$15 MM), but the entire project fell through, for other reasons. His company typically loans only on large properties (\$1-10 MM). The mortgage brokers always prepare a detailed "package" for him to evaluate, so they would have to present convincing

cost/benefit data if they proposed solar. For his own evaluation he would need outside help, either from experts in his company in New York or San Francisco or from a local engineer.

He saw the main barriers as reliability and first cost. He saw no widespread use for at least five years. He had heard about a model solar home in a local retirement community, but he understood that no results were yet available because it was just being tested.

A local mortgage broker, again, had no solar experience to date. A typical project for them might be a \$2 MM shopping center. He claimed that the developer had to prepare the package to present to potential lenders. His attitude was that solar systems presented no problem from a loan point of view if no "unusual expenses" were involved. His major criteria for evaluating a loan package were the credit of the company signing the lease, the location and business potential of the property, and the local competition. His major exposure to solar has been newspaper articles.

The manager of residential architecture for one of the world's largest developers of retirement communities pointed out his solar heated and cooled model home (one of about ten model homes) with great pride. It was, indeed, a professional and reliable-looking demonstration with everything nicely built and well painted. The home is a standard flat-roofed home with mansard roof with about 960 sq. ft. of collectors (32 collectors) on the roof. The model house has about 1670 sq. ft. of living space with standard R22 insulation in the ceiling and R11 in the walls. [Insulation of walls is a relatively new concept in the Phoenix area.] A three ton Solaire (Arkla) absorption unit

is used for cooling; it is recognized to be undersized by about 0.5 tons but was the only unit available. The solar home went on display in January 1976 and thus hasn't seen a hot summer. Insulating glass was used on the solar home, but this is optional on the other homes. The architect noted with some humor that one week before the solar home opened, he went to an Arizona State University seminar on solar energy and learned that solar heating and cooling was ten years away.

A note on the size of the retirement community as relevant at this point. It is twelve years old. They are about finished developing their first 11,000 acre section involving about 15,000 homes and are now starting on their second 11,000 acre section. They sell about 2,000-3,000 units per year. Prices range from \$25,000-55,000. The homes are all electric. They sell to anyone over fifty years of age. Most people pay cash for their homes. About 2,000-3,000 visitors per day pass through their reception center.

The collectors were developed by a local engineer. They are 39" high. Newer collectors are being developed for a sloping roof, which will be only 16" high. The solar house costs \$9,950 more than the equivalent conventional homes. He estimated the payout at "more than" ten years. He estimated that the solar part of the model home actually cost the corporation about \$15,000. They plan to build about ten more solar model homes with different solar systems, to evaluate them. The first day the solar home went on display about 6,000 people viewed it, but no one has yet bought a solar system. In fact, they advise potential purchasers not to buy because new and better systems will be

coming. Many people from other parts of the country have been calling him about the solar home.

The solar system is included as part of the thirty year mortgage. The banks have indicated that this is no problem. The retirement community's homes have doubled in value in the last five years. Also, the solar home is insured with no trouble. The insurance company estimates the potential hazard to be no greater than that for gas heating.

The vice president for planning and construction of a large real estate development firm said that his firm had undertaken no solar projects to date. They were currently considering development of a large regional shopping center in Colorado which would cost about \$25 MM. The feasibility study for the project will cost about \$25 K and will investigate such factors as marketing, engineering, leasing, etc. Solar heating or cooling was never considered. He said that solar was "mythical" to most developers and builders and certainly wasn't practical now, maybe in 5-10 years. He saw the major barriers as possible excessive maintenance, high initial costs, and the conservativeness of most lenders (due to lack of information). He was quite aware of the solar model home being tested in the retirement community.

The owner of a small real estate development corporation (custom homes and small shopping centers) said he was attending a seminar on solar at Arizona State University and was very interested in solar. He was surprised that not one refrigeration (air conditioning) contractor was attending the seminar. He was planning to build a small

solar energy office building for his own use. The bank that would be financing the building refused to cover the solar system in the mortgage (a Savings and Loan Association). The potential barriers to solar use were thought to be excessive storage tank size, too complex for residential use, and difficult architectural problems from an appearance viewpoint. He felt that the luxurious Decade 80 solar home presented solar in an expensive light. He questioned whether people were in a proper frame of mind to accept the first costs of solar because in his custom homes they generally refused to install thermopane windows (\$1,400 extra cost) even though the utility savings were high.

UNIONS--Only 400 out of 970 members of the sheet metal workers union in the Phoenix area were currently employed due to the shortage of work. A representative of the union mentioned that there was a 1956 national agreement between the sheet metal workers and the United Association (plumbers and pipefitters) which stipulated that work done on packaged heating and cooling units would be done on a composite basis. By "composite basis" meant that an equal number of sheet metal workers and UA people would always work on the job. Thus the sheet metal people would be involved whether or not the system had ducts. With regard to solar panels, he felt that the sheet metal workers would build and install the panels and also the panel supports.

He observed that the typical procedure for settling an inter-union grievance was first to try to settle it locally, then to have the

national representative from Washington come out, and finally to take it to the jurisdictional dispute board in Washington. He felt that this board was not fair to sheet metal workers. He produced a small green book which recorded the decisions of this board on specific cases ("Plan for Settlement of Jurisdictional Disputes in the Construction Industry", June 1975, Building and Construction Trades Dept., AFL-CIO). However, he said those decisions applied only to those specific cases and did not necessarily set any precedents. For example, if two locals got together and agreed to a certain settlement, it would override the green book and the national union offices would not interfere. Also he would not care that unions elsewhere (e.g., Texas) had settled a dispute in a certain way; if he felt it was wrong, he would not respect the settlement as a precedent for him.

He mentioned the longstanding and still unsettled dispute between the sheet metal workers and the UA over terminal reheat boxes (ducting box with a heat exchange coil inside). The sheet metal workers feel that these boxes should be completely under their jurisdiction whereas the UA members feel that it should be done on a composite basis. He mentioned several historical precedents that are not necessarily derived by "rational" analysis, e.g., in evaporator-coolers the sheet metal worker always puts on the pipe to tubing adapter. He had no experience on any solar systems.

The plumbers and steamfitters union (UA) representative claimed that jurisdiction on the terminal reheat boxes was defined in the 1956 agreement. He claimed that the box is not part of the ducting but part of the heating equipment. He didn't anticipate any problems

in connection with solar systems, but he had no experience to date in this area and hadn't thought too much about them. In any case, lacking any specific information, he was prepared to try to stake out a claim for the UA members if he could. Again he stressed that the Washington jurisdiction board settlements do not necessarily set any local precedent. The union employment level was down about 50 percent from three years ago.

The roofers' union representative had no solar experience. He did not see any work for roofers for the systems where the solar panels were sitting on the roof. However, in the cases where the panels become an integral part of the roof structure itself, then his union should probably be involved in the installation.

POTENTIAL SOLAR SYSTEM USERS--One manager of energy conservation for a large corporation mentioned that his firm had considered installing a solar cooling system on a recently-built large research facility in the Phoenix area. One incentive was that their total electric bill for the facility was about one-third higher than they had anticipated. However, they decided not to utilize solar because the coefficient of performance with lithium bromide absorption refrigeration was only about 0.6. Their suppliers also told them that solar cooling was not cost effective. They would have been very happy to use solar if an ERDA grant had been available.

With regard to who might initiate solar projects in the corporation, the projects would most logically start in his group

although they could be initiated by a plant manager who would then presumably come to his group for help, e.g., a feasibility study. They had no solar experience to date, but were looking at several process water heating applications. Again, they were trying to get financial support from ERDA for these applications.