InterTechnology Corporation
Proposed
Systems Level Plan for Solar Heating and Cooling
Commercial Buildings
National Solar Demonstration Program

ERDA Report No. COO-2688-76-6

ITC Report No. 030576

Contract No. E(11-1)2688

May 1976

VOLUME 1

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

fy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

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. The "InterTechnology Corporation, Proposed Systems Level Plan for Solar Heating and Cooling, Commercial Buildings, National Solar Demonstration Program", 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.

TABLE OF CONTENTS

VOLUME ONE

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
	List of Tables	i
	List of Figures	iii
I	<u>Introduction</u>	I-1
I.A.	Objective of the National Demonstration Program	I-1
I.B.	Purpose of This Systems Level Plan	I-2
I.C.	Systems Level Plan Scope	I-2
II.	<u>Demonstration Site Matrix</u>	
	<u>Development</u>	II-1
II.A.	Program Design Philosophy	II-1
II.A.1	Introduction	II-1
II.A.2	Design Strategies	II-4
II.A.3	Strategy Implementation Priorities	II-25
II.A.4	Plan Design Guidelines	II-27
II.B.	Matrix Design	II-34
II.B.1	Technical Design	II-34
II.B.2	Economic Design	II-59
II.B.3	Institutional, Societal, and Environmental Design	II-68
II.B.4	Summary of Commercial Demonstration Site Recommendations	II-76
III.	<u>Site Selection Methodology</u>	III-1
III.A.	Objective	III-1
III.B.	Approach	III-1
III.C.	Methodology	III-1
III.D.	Technical Measure of Effectiveness	III-4
III.E.	Committee Evaluation	III-6
IV.	<u>Test and Evaluation Plan</u>	IV-1
IV.A.	Introduction	IV-1
IV.B.	Philosophy	IV-2

TABLE OF CONTENTS (CONT'D)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
IV.C.	National Requirements	IV-2
IV.D.	Data Processing	IV-4
IV.E.	Site Specifics	IV-4
IV.F.	Site Equipment	IV-6
V.	<u>Information Dissemination Plan</u>	V-1
V.A.	Technical Approach to Information Dissemination Planning	V-1
V.A.1	Identification of Users	V-1
V.A.2	Developing Dissemination Strategies	V-7
V.A.3	Communication Strategies	V-8
V.B.	Implementation of Dissemination	V-10
V.B.1	Selection of Alternate Dissemination Packages	V-10
V.B.2	Preparation of Dissemination Packages	V-11
V.B.3	Response to Inquiries	V-11
VI	<u>Program Management Plan</u>	VI-1
VI.A.	Introduction	VI-1
VI.B.	Objectives	VI-1
VI.C.	Management Organization	VI-2
VI.D.	Program Management Costs	VI-13
VII.	<u>Program Coordination and Implementation</u>	VII-1
VII.A.	Introduction	VII-1
VII.B.	Construction Scheduling and Phasing of the 200 Demonstrations	VII-1
VII.B.1	Construction Constraints	VII-1
VII.B.2	Summary of Schedules	VII-3
VII.C.	Schedule of Primary Tasks and Decision Points	VII-3
VII.C.1	Overall Program Management	VII-3

TABLE OF CONTENTS (CONT'D)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
VII.C.2	Demonstration Site Management	VII-16
VII.C.3	Test and Evaluation Management, Software Development Tasks	VII-16
VII.C.4	Information Dissemination Management and Implementation Tasks	VII-16
VIII.	<u>Phase II Deliverable Items</u>	VIII-1
VIII.A.	Introduction	VIII-2
VIII.B.	Deliverable Items for Demonstrations	VIII-3
VIII.C.	Test and Evaluation Plan Requirements	VIII-4
VIII.D.	Final Site Report	VIII-5
VIII.E.	Information Utilization and Dissemination Requirements	VIII-5
VIII.F.	National Demonstration Program Final Report	VIII-6
VIII.G.	SHACOB Guideline/Design Manual	VIII-7
IX	<u>Resources Required</u>	IX-1
IX.A.	System Installation	IX-1
IX.B.	Management, Test and Evaluation Hardware	IX-4
IX.C.	Total Resources Required	IX-5
	<u>APPENDICES</u>	
<u>VOLUME TWO</u>		
A.	Matrix Screening Program, Documentation	
<u>VOLUME THREE</u>		
B.	Non-Residential Building Data	
C.	Development of Solar Performance Data	
D.	Two Hundred (200) Demonstration Site Installation Schedules	
E.	Climatic Regions and Characteristic Cities	
F.	Parametric Study Alternatives	
G.	Solar Heating and Cooling Demonstration Act of 1974	

LIST OF TABLES

- II-1. Summary of Strategy Tasks
- II-2. Promising Technology Applications
- II-3. Estimated Fractions of U. S. Population Within 12 Climatic Regions
- II-4. 1975 Non-Residential Building Inventory
- II-5. Heating Only Candidates for a Typical Parametric Study Matrix Element
- II-6. Parametric Study Requirements for Heating Only (Primary Set)
- II-7. Parametric Study Requirements for Heating Only (Replicate Set)
- II-8. Heating and Cooling Candidates for a Typical Parametric Study Matrix Element
- II-9. Parametric Study Requirements for Heating and Cooling (Primary Set)
- II-10. Parametric Study Requirements for Heating and Cooling (Replicate Set)
- II-11. Heating Only Parametric Study - Number of Demonstrations
- II-12. Heating and Cooling Parametric Study - Number of Demonstrations
- II-13. Promising Technology Studies - Number of Demonstrations
- II-14. Economy of Scale Studies - Number of Demonstrations
- II-15. Installation Learning Studies - Number of Demonstrations
- II-16. Direct Local Industry Stimulation Study - Number of Demonstrations
- II-17. Example Distribution of Stores
- II-18. Additional Institutional, Environmental, Societal Studies - Number of Demonstrations
- II-19. Site Distributions - Overview
- II-20. Distribution of Demonstrations by Region and Purpose
- II-21. Distribution of Demonstrations by Region and Building Type
- II-22. Heating Only Demonstrations
- II-23. Heating And Cooling
- II-24. Retrofit, Heating Only Demonstrations
- II-25. New, Heating Only Demonstrations
- II-26. Retrofit, Heating and Cooling Demonstrations
- II-27. New, Heating and Cooling Demonstrations
- III-1. Technical and Plan Constraints
- III-2. Committee Ranking Criteria
- IV-1. Engineering Data Needed for T&E Purposes

LIST OF TABLES (CONT'D)

- V-1. Building Community Information Requirements
- VI-1. Management Manpower Requirements
- VII-1. Estimated Construction Times
- VII-2. Contract Starts
- VII-3. Management
- VII-4. T&E Installations
- VII-5. T&E Operations
- VIII. None
- IX-1. Average Building Size for Various Building Categories
- IX-2. Estimated Installed System Cost by Region and Fiscal Year
- IX-3. Management Cost
- IX-4. Total Plan Cost

LIST OF FIGURES

- I-1. Climatic Regions
- II-1. Strategy/Goal Matrix
- II-2. Generation of Usable Solar Energy
- II-3. Determination of Economic Savings from Solar Energy
- II-4. Range of Insolation Available During Heating Season
- II-5. Range of Total Annual Horizontal Insolation
- II-6. Regional Variation of Heat Pump Coefficient of Performance (COP) for Typical Residential Applications
- II-7. Schematic of Basic Rankine Cycle Powered Vapor Compression Refrigeration Cycle
- II-8. Schematic of Desiccant Type Heat-Powered Air-Conditioning System
- III-1. Site Selection Procedure
- III-2. Solar Heating and Cooling Demonstration Project Preliminary Information Request Form
- IV-1. Test and Evaluation Plan: Data Flow
- IV-2. Local Monitoring System
- V. None

LIST OF FIGURES (CONT'D)

- VI-1. Focal Point Management, Functional Organization
- VI-2. Uniform Test and Evaluation: Management Structure
- VII-1. PMO Management Schedule
- VII-2. Site Management Schedule
- VII-3. Test and Evaluation Management and Operation Schedule
- VII-4. Information Dissemination Management
- VIII. None
- IX. None

I. Introduction

A. Objective of the National Demonstration Program

The Arab oil embargo of 1973 dramatically illustrated the fact that the United States did not have, and probably never will have, domestic oil supplies which are sufficient to satisfy all energy demands of the United States. In recognition of this fact, Congress conducted a series of subcommittee hearings in late 1973 and 1974 intended to identify the role the federal government should play in stimulating and creating a market for solar space heating and cooling systems. These hearings resulted in the passage of the Conference Report entitled "Solar Heating and Cooling Demonstration Act of 1974", and was signed into law on September 3, 1974. A copy of this act may be found in Appendix H. In addition to recognizing the severity of the domestic oil supply/demand situation, Congress observed that no technical problems are known which would prohibit the use of solar heating and cooling of buildings. Congress reasoned that commercial applications of solar heating and combined heating and cooling technologies could be expedited by early commercial demonstration under practical conditions. The outcome of these findings was the adoption of a federal policy (outlined in the Act) which provides for the demonstration of solar heating systems by the end of fiscal year 1977 and the demonstration of combined solar heating and cooling by the end of fiscal year 1979.

The Energy Research and Development Administration, whose mandate is to implement the commercial portion of the demonstration program, identified the program's objectives and developed an overall plan for implementation (refer to document ERDA-23A, "National Program for Solar Heating and Cooling", Oct. 1975). The essence of these interrelated goals are embodied in the following:

1. Demonstrate ultimate economic and technical feasibility of solar heating and combined heating and cooling;
2. Stimulate industry to produce, distribute, sell and service solar equipment; and
3. Stimulate a commercial market for solar systems.

B. Purpose of This Systems Level Plan (SLP)

The systems level plan presented here is designed to address the above stated goals as they relate to the building community associated with the commercial sector of the economy. The SLP is viewed as a complete package which will provide ERDA with the following:

1. A flexible, time-phased, multi-purpose, integrated matrix of 200 demonstration sites designed to most cost effectively address the goals identified above;
2. A cost-effective management plan (including structure and function) which will effectively implement the demonstration program and which will provide opportunity for small business participation;
3. The fundamental information required by various sectors of the building community and the most effective media for the dissemination of information gathered during the program;
4. An estimate of the total resources required to implement the program;
5. Opportunity to test and evaluate promising solar technologies and developments resulting from NASA R & D programs; and
6. Management and resource coordination of this plan with a systems test and evaluation plan currently being developed under a separate Phase I task.

C. Systems Level Plan Scope

The purpose of this section is to briefly define terms and discuss the scope of the proposed program.

Primarily for the purposes of determining program management manpower requirements, funding levels, and program coordination, a heating only demonstration has been defined to be complete upon collection of one full heating season of operational data and, for a combined heating and cooling demonstration, both a

full heating and cooling season of operational data. Implicit in this definition is the assumption that any solar system down times and/or test and evaluation equipment outages lasting no more than several days during a given season will not preclude acceptable determination of system performance and operating costs.

The sites recommended for the program employ 13 building types representing over 80 percent of the total commercial floor space inventory (apartments, dormitories, manufacturing, etc. excluded). The relative importance of each building type to the program is a function of the technical feasibility, estimated cost savings, and potential energy savings offered by all buildings of that type when equipped with a solar heating and cooling system.

The technical feasibility, cost savings, and potential for energy savings discussed above are calculated for each building type for a city characteristic of each of 12 climatic regions. The 12 regions, originally identified by General Electric in their Phase 0 contract with ERDA, have been modified to include the New York City area with the Washington, D. C. region. Figure I-1 defines the boundaries of these modified regions*. The characteristics of these regions then provide a basis for comparison of solar system performance, energy costs, building energy loads, etc.

The purpose of this study was not to determine the number of demonstrations necessary to stimulate a self-perpetuating solar technology industry and market. The basic purpose was rather to recommend the most effective way to address the program's goals. In order to develop an approach to this study, a plan containing 200 demonstration sites was agreed-upon by ERDA/ITC program management.

This plan addresses both a new and a retrofit market with about equal emphasis in terms of numbers of demonstrations. The reasoning behind this emphasis is

*Although the regional boundaries have remained the same, the designators for the regions have changed subsequent to the development of this report. The reader is referred to Appendix E for a description of the new designators.

Figure I-1: Climatic Regions

Source: General Electric/ERDA Phase 0 Study,
 "Phase 0 Feasibility and Planning Study Final
 Report, Volume 2, Technical Report", NSR-RA-N-74-021B

discussed in a later section, the important idea being that over the next 15 years, the market of new and retrofit opportunities will be about the same. Furthermore, the current retrofit market offers significant opportunity for reducing demand for fossil fuels.

As required by law, this plan provides for the demonstration of heating only by the end of fiscal 1977 and the demonstration of heating and cooling by the end of fiscal 1979. The plan provides for more heating and cooling demonstrations than heating only demonstrations for two basic reasons: first, program funding and timing considerations constrain the number which can be accomplished by the end of fiscal 1977, and second, the complexity of heating and cooling requires that more factors be addressed than is necessary for heating only.

Systems employing a flat plate water collector in conjunction with an absorption chiller when cooling is required form the "backbone" of this program. The underlying criteria for selecting sites are based upon solar performance and costs associated with these systems. However, the program is not limited to the systems described above. We have incorporated flat plate air collectors and seven additional promising subsystems into about 22 percent of the 200 sites. Flexibility of the plan also allows for incorporation of additional promising concepts and subsystems should the technical feasibility and economics justify it.

Program timing considerations are a serious problem. The law requires solar heating to be "demonstrated" by the end of fiscal 1977. In most regions of the country, the heating season begins in October. If this represents the beginning of one full heating season (consistent with our definition of a demonstration), then actual system installation must begin about May, 1976. Any installations on new buildings must begin even earlier. From these considerations, it is clear that in most cases, one full season of heating only data is not practically feasible. In order to provide a more tenable program, many of the heating only demonstrations have been scheduled so that operational data will be available for at least one month of the fiscal 1977 season.

II. Demonstration Site Matrix Development

A. Program Design Philosophy

1. Introduction

The overall program goals identified in the Introduction to this report were analyzed to determine the specific issues which must be addressed in order to expeditiously and cost effectively achieve the stated goals. Having identified these issues, it has been observed that each could be assigned to one of three broad categories - technical, economic, or institutional/societal. These issues are related to the three categories and the program goals in Figure II-1. Each of these categories was then viewed as representing a strategic approach for the attainment of the program's goals. In order to implement each strategy, a set of specific objectives must be associated with each demonstration site or set of sites. The specific objectives are developed in subsection 2. The remainder of this section will clarify the concepts behind each strategy.

a. Technical Strategy

In order to predict the long-term economic position solar heating and cooling of buildings (SHACOB) technology will achieve relative to that held by various conventional methods of heating and cooling, the attainable engineering performance of these systems must be thoroughly understood. The measured system performance must then be correlated with engineering formulae so that system design procedures can be substantiated. Once system performance is understood, extrapolation of future performance will be feasible and relationships identifying optimum systems and subsystems will be understood. To achieve this understanding, all parameters which describe the performance of each subsystem of the complete solar heating and cooling system as well as building energy loads, and pertinent climatic variables must be documented.

b. Economic Strategy

Knowledge of the technical performance obtained via the technical strategy can be combined with system design costs, equipment costs, operation and maintenance costs, and costs associated with conventional equipment and energy to determine the economics of SHACOB technology. By exploring suggested future labor installation costs through installation learning studies, and by observing economies

FIGURE II-1
STRATEGY/GOAL MATRIX

<div>GOAL</div> <div>STRATEGY</div>	PREDICT LONG-TERM ECONOMIC VIABILITY	STIMULATE MARKET	CREATE INDUSTRY
TECHNICAL	MEASURE TECHNICAL PERFORMANCE	ESTABLISH SYSTEM DESIGN PROCEDURES	IDENTIFY MOST PROMISING DESIGNS
ECONOMIC	DETERMINE ECONOMIC PARAMETERS	EVALUATE FINANCIAL INCENTIVES	EXPLOIT PRESENT ECONOMIC VIABILITY
INSTITUTIONAL	DETERMINE COSTS OF BARRIERS, METHODS FOR MITIGATING THEM	DEVELOP PROCEDURES TO PROTECT CONSUMER	ACCEPTANCE BY BUILDING COMMUNITY

of scale, a reliable forecast can be made of the future of SHACOB technology economics relative to that held by conventional heating and cooling systems. Additional inputs to this forecast will be obtained by exploiting currently existing financial incentives.

c. Institutional/Societal/Environmental

By identifying those factors which add unnecessary costs to solar equipment, installation, or operation, efforts can be made to eliminate them, thereby improving the forecasted economic position of SHACOB technology. These factors may involve overly restrictive building codes, zoning laws, labor jurisdictional arrangements or simply the infrastructure fee charges.

On the other hand, a lack of proper regulation may also present a barrier to the acceptance of solar technology since the buyer or user of solar equipment may not be protected. Thus, the identification of those issues likely to leave the consumer unprotected need to be identified and proposed regulations to alleviate these conditions evaluated.

In order to assess the program's impact on the attitudes of decision makers and the degree to which solar technology has diffused into the market place, surveys will be conducted initially to establish a baseline and at the end of the program to identify the net result. These surveys will also solicit suggestions to improve information exchange and determine which major barriers (if any) still require investigation.

2. Design Strategies

a. Overview

The purpose of the following sections is to discuss the rationale behind the tasks which have been identified as appropriate for carrying out the three basic strategies: technical, economic, and institutional/societal/environmental. A brief overview has been provided in order to relate each discussion to the program as a whole.

A summary of the tasks required to conduct each strategy and their associated primary purposes or objectives are presented in Table II-1. Two tasks are needed to conduct the technical strategy. The parametric studies are designed to provide a thorough investigation of all engineering aspects of the more widely available systems. The promising technology studies are intended to provide an opportunity to investigate engineering aspects of recently introduced but less well understood SHAC systems.

Three tasks are associated with the economic strategy. One study will explore those aspects associated with the installation of SHAC systems. Another study will explore cost factors associated with the size of the SHAC system. Another study is aimed directly at stimulating the creation of a local industry.

Three tasks are also associated with the institutional/societal/environmental strategy. One study actually consists of many studies conducted on a site-by-site basis. In these studies, each site is selected because it will address one of the many issues associated with this strategy. Another study consists of surveying several locations participating in the program. Surveys before and after the program will identify any changes in the attitudes of the public and the decision makers. The final task is the dissemination of information as it is obtained during the program. Through the process of education, many issues associated with this strategy will hopefully cease to exist or be resolved.

TABLE II-1
SUMMARY OF STRATEGY TASKS

<u>STRATEGY</u>	<u>TASKS</u>	<u>PRIMARY PURPOSE</u>
Technical	1 Parametric Studies (PS) (Nucleus)	Document engineering performance over broad operating ranges
		Identify design procedures
		Identify ranges of applicability
		Assess reliability and identify technical problem areas
Economic	2 Promising Technology Studies (PT) (Nucleus)	Combine with cost data to forecast Life Cycle Costs
		Measure and compare performance for many concepts
		Provide for anticipated R&D cycles
		Identify regions of applicability
Institutional/ Societal/ Environmental	1 Installation Learning Studies (ILS)	Investigate potential for reduction of installation costs
		Forecast Life Cycle Costs based on results of study
		Investigate capital and maintenance costs as function of SHAC System size
		Forecast Life Cycle Costs based on results of study
	2 Economy of Scale Studies (EOS)	Provide sufficient incentive to start industry on a local scale
	3 Local Industry Stimulation (LIS)	Establish labor jurisdictions, identify and develop appropriate building codes, identify and mitigate zoning problems, determine level of risk as expressed in financial arrangements, etc.
	1 Site Specific Studies I/E	Assess effect of program on decision-maker attitudes
	2 Conduct Surveys	Modify attitudes, overcome barriers through education.
	3 Disseminate Information	

It is important to emphasize that every demonstration will address certain technical, economic, and institutional/societal/environmental issues. However, an "ad hoc" program will not assure that the important issues are being properly addressed. Thus, the purpose of these strategies is to provide a mechanism to ensure that the primary issues are covered by the program.

b. Technical Strategy

(1) Parametric Studies - the Nucleus

As previously discussed, the parametric study is intended to address the key technical parameters necessary to establish engineering performance. These parameters are the building heating and cooling loads, the ratio of these two loads, and insulation levels. Because the forecasting of changes in cost factors is more of an art than a science, and because they can be ignored from the standpoint of establishing system engineering performance, it is convenient to focus attention on the program's technical objective - the conservation of conventional fuels through the widespread application of SHAC Systems.

The usable energy generated by the SHAC System, ES, depends on many factors, as suggested in Figure II-2.

$$\text{EQ.1} \quad \text{ES} = \text{Function (insolation, SHAC system, building-climate interaction)}$$

The basic design objective may be stated as formulating that set of demonstrations (building type, site and SHAC system) which will make it possible to determine the proper form for this equation and determine the appropriate coefficients. For example, one mathematical 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 ($r_j B_j$). The form of this equation follows:

$$\text{EQ.2} \quad \text{ES}_j = \bar{E}_j + a_j I_j + \sum_{i=1}^n s_j b_{ij} Z + r_j B_j$$

where

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

$j = 1$ (heating season), 2 (cooling season)

FIGURE II-2

GENERATION OF USABLE SOLAR ENERGY

$$\text{ENERGY REQUIRED} = \text{USABLE SOLAR ENERGY (ES)} + \text{SUPPLEMENTAL CONVENTIONAL ENERGY}$$

$\bar{E}_j$ = 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 ($i = 1, 2, 3, \dots, N$)
 (e.g., $s_i = 1$ for flat plate water system for heating only
 0 otherwise
 b_{ij} = Coefficient to be determined (MBTU for reference system
 Z_0 of the j^{th} type)
 Z = Size of the SHAC system relative to reference system, Z_0
 r_j = Coefficient to be determined
 (MBTU/MBTU for j^{th} season)
 B_j = Building energy requirement for j^{th} season
 (BMTU/season)

The key elements on which ES_j depend, namely insolation, SHAC system, and building requirement, are present as first order effects. By measuring (ES_j , I_j , Z , B_j) for each demonstration, it will be possible to determine (E_j , a_j , b_{ij} , r_j) by standard statistical techniques and to 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 EQ.2 is a task to be carried out during and after the demonstration. What is required of the design is that it be general enough to cover the likely ranges of interest.

When the proper form for EQ.1 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 II-3.

(a) Approach

The approach to the basic design objective can be divided into two steps. The first step requires that the basic factors be defined, and for each, define the parameter ranges of interest. Onto this set of categories, map the elements of the building type/climatic region matrix.

FIGURE II-3

DETERMINATION OF ECONOMIC
SAVINGS FROM SOLAR ENERGY

6-II

$$\text{SOLAR SAVINGS} = \text{EQUIVALENT CONVENTIONAL COST} - \text{SOLAR SYSTEM COST}$$

Second, for each category, eliminate those matrix elements for which achievable collector areas will not provide a significant percentage (say >20%) of the building's energy requirements. From among those remaining, select a pair offering the greatest economic advantage (for the site) and fuel savings (for the region).

The implementation of these steps is discussed below.

(b) Definition

Figure II-2 indicates that a great many elements affect the amount of usable solar energy; too many indeed for a reasonable demonstration design. The figure also suggests that they can be compressed into three basic factors:

1. Building energy requirement. All of the climatic factors, building factors and their interactions result in one pair of numbers: the total energy required to heat the building over a heating season, and the total energy required to cool the building over the cooling season.
2. Insolation. The solar energy available at the site is the basic measure of the available energy and is needed to help characterize SHAC system performance.
3. SHAC. The factor of primary interest in this demonstration program is the SHAC system.

Since one of our objectives is to identify and validate system design rules, as well as to represent all cases of potential economic interest, the choice of parameter ranges must assure coverage of the widest range of possible parametric values. Thus the ranges for building loads and insolation were obtained by defining the broadest range of possible interest and dividing it into three categories so that each category has approximately one-third of the total matrix population (13 building types x 12 regions = 156 sites). The SHAC systems were categorized on a slightly different basis, namely, that of basic system configuration. Because a number of configurations are currently available, and because performance of these systems are likely to vary among systems, five categories were selected.

1. Direct heating only: water as working fluid
2. Direct heating only: air as working fluid
3. Heating and cooling systems (water based):
Heating load $> 2X$ Cooling load
4. Heating and cooling systems (water based):
Heating load $\leq 2X$ Cooling load
5. Heating and cooling systems (water based):
Heating load $\leq 1/2$ Cooling load

The resulting design consists of a separate 3 X 3 matrix for each system configuration whose elements are identified by insolation range, heating load range, cooling load range, and ratio of heating to cooling load. Measurement of the performance for demonstrations in each matrix element (where they exist) constitutes the basic irreducible minimum set of demonstrations (nucleus) required to forecast ultimate economic viability and establish design rules valid over the widest possible ranges of interest.

(2) Promising Technology Studies

Flat plate air and water systems are by no means the only currently available subsystems for collecting solar energy; neither are absorption chillers the only cooling systems which can utilize solar energy. Task IV under this Phase I contract assessed the state of the art of the most promising techniques for utilizing solar energy. These reports concluded that the systems indicated in Table II-2 represent those systems likely to possess the potential to become cost effective alternatives over the next 5 - 10 years. Table II-2 also suggests the current advantage or disadvantage over flat plate systems. The great advantage of flat plate systems is that they are applicable in virtually every region of the country, whereas many of the other systems require special solar radiation characteristics, mild winters, or mild summers to provide a substantial portion of the heating or cooling load.

The plan presented here does, however, attempt to provide ample opportunity for the testing and evaluation of these promising concepts. The criteria

TABLE II-2
PROMISING TECHNOLOGY APPLICATIONS

System Type	Most Probable Application	Technical Requirement	Comparison with Flat Plate Water/Absorption System	Development Status
Solar Assisted Heat Pump	Heating in Northern Regions	Can Utilize Poorer Insolation Levels than Other Systems	Ability to Effectively Utilize Lower Temp. Energy	Currently Available
Tubular Collectors	Heating and Cooling	Basically Same as Flat Plate Systems	Higher Capital Costs, Higher Efficiency at Higher Temp. Operation	Currently Available
Passive Heating	Heating in S. and S.W.	Moderate Heating Loads Integrated into Building	Variable Costs, Not Applicable over Entire Country	Currently Available
Radiative Cooling	Cooling in S.W. and W.	Clear Night Skies, Moderate Cooling Loads for Greatest Effectiveness.	Appears to Compare Favorably with Absorption Systems in Some Regions	Currently Available
Concentrator Collectors	Heating and Cooling	Direct Radiation	Produces Very High Temperatures at High Efficiency, Higher Capital Costs, Current System Requires Sun-tracking	Mid Term
Rankine/Vapor Compression	Cooling	Sunny Climates to Achieve Sufficient Usable Btu from the Sun	Can be More Efficient Than Absorption System, Higher Capital Costs	Mid Term
Solar-assisted Dessicant Dehumidification	Cooling and Dehumidification	Most Effective in Humid Areas Having Moderate Cooling Loads	Simple System, Costs Unknown	Far Term

employed in selecting sites is to choose those combinations of system type, climatic region, and building type which will provide the greatest demonstration value in terms of energy savings potential and cost effectiveness. The criteria imply that any special technical or climatic requirements are taken into account when evaluating sites. A detailed discussion of this selection process and the resulting recommendations are presented in subsection B.1.

c. Economic Strategy

(1) Economy of Scale Studies (EOS)

In order to determine the effect of system size on the system's capital cost per usable Btu, a number of studies should be undertaken using three different system sizes employing an identical system concept to be installed on buildings of three different sizes. Three demonstrations per study are the minimum number required to reveal non-linearities in the parameter of interest. Clearly, more than three would be preferable. However, the potential for response to an RFP to construct more than three identical system concepts was believed to be too low to justify only a marginal increase in information. In addition to the evaluation of system cost as a function of size, the collection of pertinent data will also permit an evaluation of operating and maintenance costs as a function of system size.

Rationale for specific site selection and Economy of Scale study recommendations are described in detail in subsection B.2.

(2) Installation Learning Studies (ILS)

Since the solar market is still in its infancy, few construction crews can claim solar installation experience. Consequently, the potential for reduction of installation costs are not currently known. While the construction techniques will probably not be foreign to the installation crew, the equipment to be installed and its associated jargon will initially at least, create some confusion and communication breakdown. However, as with any profession experience will undoubtedly resolve these problems resulting in greater efficiency of installation.

In order to determine the extent to which installation efficiencies and construction practices can be improved with experience, several studies are recommended, each to consist of six equivalent solar systems installed on six equivalent buildings by the same installation crew. It is important to emphasize two points; namely, that the six systems must be equivalent so that there are "no surprises" to the installation crew, and the same crew must install all six systems.

The selection of six demonstrations per study was believed to provide a reasonable tradeoff between the probability of sufficient RFP response and the desire to provide the installation crew with a sufficient number of repetitive sites. In the case of these studies, system size is not a first order parameter. Thus, the most cost effective study is one which employs small systems, as may be applicable on small chain stores or small offices. The rationale for selecting these sites and ILS recommendations are contained in subsection B.2.

The conduct of six sites appears also to be a meaningful number in practice. The first two installations will provide an opportunity for the crew to understand the jargon and any differences associated with the reading of working drawings. In addition, any construction equipment needed, but which may not have been foreseen during design, can be determined. The next several installations appear to be suitable for improving the handling of equipment, and modifying construction procedures. The final two demonstrations will provide an opportunity for refinement of most of the above items which, hopefully, will result in significantly reduced man-hours to complete the final job.

Some of the ramifications of performing several installation learning studies are listed below.

1. The performance of these studies in several regions will permit the effects of differences in construction practices and labor/management arrangements on the desired "man-hour curve" to be evaluated. It is generally agreed that labor responsibilities are more finely defined and structured in the Northern and Eastern portions of the United States than in the Southern and Western areas of the United States. Performance of the studies in these areas should provide the information necessary to assess the effects of these differences on labor costs and installation man-hour requirements.
2. The installation of six equivalent systems will permit variations in system performance (if any) to be evaluated. Performance of several sets comprising different concepts or operating ranges will permit valuable analysis of any differences in performance. These studies will be valid, however, only if workmanship on each site is of the same quality and only if no substitutions of construction materials are required from site to site. The implication here is that changes in system performance may also be evaluated as a function of workmanship or substitution of materials.
3. Performance of a number of equivalent total systems will permit preliminary assessment of system reliability to be determined. Should alterations in construction materials or techniques be required from site to site, their effect on system operation can also be determined (on a preliminary basis).
4. Fluctuations in required maintenance and operating costs should also surface during these studies.
5. As with the economy of scale studies, the installation learning studies will provide a number of construction crews and builders with valuable

experience which, hopefully, will reduce local timidity to the consideration of solar systems.

6. Persistent problems in construction techniques should become apparent during the final sites. Evaluation of construction logs and interviews with members of the construction crew may reveal suggestions for improvement in system design and manufacture.

(3) Local Industry Stimulation Study (LIS or LMS)

One of the goals of the National Demonstration Program is the stimulation of the creation of an industrial capability to produce and distribute SHAC systems. While it is hoped that the entire program taken as a whole will accomplish this, cost/benefit analyses in support of this Phase I contract suggest that a more definitive approach may be taken to accomplish this goal on a local level. The essential result of that study suggests that significant incentive to "tool-up" could be provided to local industry in the Phoenix climatic region since the economics of SHACOB technology hold a competitive position when compared to conventional systems using electrical energy in this region. This competitive position is particularly true for space heating. Our approach is, therefore, to concentrate a relatively large number of heating only demonstrations within the Phoenix climatic region. It is difficult to determine precisely the number required to "trigger" the industry, however, early studies suggest that eighteen sites should require a production of about 100,000 ft² of collector, a production level generally considered in the study as minimal to justify investment in the industry.

The difficulty in implementing this study is ensuring that those heating only demonstrations in the Phoenix region employ systems produced by industry within this region. It is not clear whether the federal government can legally restrict participants in the program to employing locally produced systems. Another difficulty in assessing the impact of this study is the fact that program participants in other climatic regions may choose to employ systems produced within the Phoenix climatic region. This complication does not, however, negate the desired objective. Indeed, all orders placed for systems produced within the Phoenix region will have a positive impact on industry located in that region.

d. Institutional/Societal/Environmental (I/S/E) Strategies

(1) Introduction

Three tasks have been identified as required in order to fully conduct the Institutional/Societal/Environmental (I/S/E) strategy. One of these tasks is site specific in the sense that a site may be selected because it may provide an opportunity to test a new building code, to test a state tax law, to identify labor jurisdictions, etc. The second task deals with evaluating the impact of the demonstration program on decision-maker attitudes, the ability of HVAC/solar engineers to apply information which has been obtained, etc. This evaluation will consist of surveys taken at several sites both before initiation of the demonstration program (to establish the baseline or current attitudes) and at some time after the program has concluded. The third task involves the effective dissemination of information which is intended to break down barriers and stimulate discussion through education. The purpose of this section is to discuss in more detail, the concepts behind each task.

(2) Site Specific Considerations

Considerable debate ensued over whether the Demonstration Program should actually seek out potential problem areas, thereby (hopefully) precipitating a solution, or whether a conservative approach, designed to avoid problem areas, would put solar's "best foot forward" thereby minimizing adverse publicity during this critical stage of market development. The advantage of the first approach is that a number of issues currently inhibiting the expansion of a solar market may be resolved. The disadvantages of this approach are twofold: first, failure to resolve important issues would undermine the small, currently existing but timid market base; and second, delays resulting from negotiations, and systems testing which must be undertaken to resolve these issues could jeopardize the successful participation of this site in the demonstration program. The advantage of the second approach is greater assurance that the program will progress smoothly with solar technology effecting a favorable impression on decision makers. The disadvantage of this approach is obviously that issues are never really resolved until test cases are conducted, and the program could be criticized as being ineffective or even deceptive.

It is recommended, therefore, that the identification and resolution of Institutional/Environmental/Societal issues be handled on a case-by-case basis. Thus, each response to Program Opportunity Notices and Requests for Proposals should be evaluated with consideration given to the following:

1. The issue to be resolved is not unique to that particular site but is representative of the type of issue likely to be encountered many times. That is, be sure the topic deserves attention under the demonstration program.

2. The proposed resolution of an issue is indeed the proper approach or that the proposed plan to resolve an issue can be accomplished under the time, funding, and managerial constraints of the program.

3. A variety of building codes, labor/management arrangements, financial arrangements, etc. are being addressed. That is, effort should be made to avoid selecting multiple demonstrations within the same locale which address the same basic issues.

These considerations can only be addressed when evaluating candidate real sites. By providing a forum for resolving a variety of issues related to building and zoning code jurisdictions, labor/management arrangements, financial arrangements, etc., others are likely to find their particular problem has been resolved by the demonstration program.

(a) State Tax Incentives

As of October, 1975, eight states have tax laws affecting the treatment of solar heating and cooling systems for property tax assessment purposes. These states are Indiana, Colorado, Maryland, Montana, New Hampshire, North Dakota, Oregon, and South Dakota. Generally, these laws allow solar equipment to be assessed at a rate which is lower than normally employed for conventional HVAC systems for property tax purposes. We recommend that where possible, demonstrations be conducted on sites located in these states so that the effect of these laws on system life cycle cost may be evaluated to determine their effectiveness in encouraging a market for solar equipment.

(b) Building Codes

Generally, states and localities adopt one of the following as their basic code and make modifications to suit local needs:

1. Uniform Building/Mechanical/Plumbing Codes
2. Standard Building/Mechanical/Plumbing Codes
3. Basic Building Codes
4. National Building Code

On July 22, 1975, the County Board of Commissioners of Pinellas County, Florida adopted what was then believed to be the first code governing the installation of solar heating systems. Manufacturers of solar water heating systems must submit basic design criteria, materials used, average weight/ft², type of circulating pump and procedures for hook-up to the building official. Solar heaters connected to potable water systems are to be installed according to the Standard Plumbing Code. These solar water heaters are classified as plumbing fixtures and must be installed and connected by a certified master plumber. Solar heaters connected to conventional heating systems are classified as mechanical equipment and are to be installed by a certified mechanical contractor. Electrical work must be installed by a master electrician. Any plastic pipe used must be CPVC (chlorinated polyvinyl chloride); copper pipe must be of Type "L" or better, and "iron" pipe may be wrought iron, galvanized steel, or brass. In addition, various flow control, temperature and pressure relief valves, air vents, shut-offs, and drains are specified. The accepted code appears to offer protection to the consumer while not being overly restrictive.

While the foregoing is an example primarily applicable to residences, it does represent an approach which may be taken by local building code officials. Most communities adopt one form of the major model codes previously listed, however, considerable variations evolve because legislation adopted by each community permits variances and exceptions to the model forms. Thus, we fully expect that local codes affecting solar systems will vary widely across the country. However, there are currently no known requirements associated with any of the model codes which would prohibit the use of solar collectors on roofs. Present building codes will not prohibit installation of solar systems.

(c) Labor/Management Arrangements

Attempting to second guess labor jurisdictional arrangements is almost a futile task. Telephone interviews with several members of national labor unions also indicated that it would be futile to attempt to identify and resolve areas of potential dispute. The process of solving jurisdictional disputes is a reactive one--the problem is solved when it arises. It is simply not feasible to negotiate jurisdictional issues without an actual test case. Furthermore, labor jurisdiction issues are worked out on the local level.

(3) Survey Task

This task attempts to enhance the credibility of assessing I/S/E impacts while at the same time fostering the ERDA goals of promoting a market for solar energy technology for SHACOB. A great range of approaches could be pursued to assess these impacts depending on the definition of societal/institutional impacts: the impacts considered here are those which will affect acceptance of solar and, therefore, the development of a market. At the present time many of the "impacts" are based on opinions and attitudes of the people associated with the following groups: engineers/architects, contractors/builders, manufacturers, unions, building code officials, banks, insurance groups, advertising/marketing, venture capitalists, lawmakers, administrators, regulators, planners, researchers.

By assessing the attitudes held by these groups, the magnitude of many potential impacts will become apparent. Credibility of the assessment will be established by determining and relying on the relevance of each participant's background.

The SLP involves a two phase approach to impact assessment, each phase designed to accomplish several objectives.

(a) Baseline Assessment Phase

This phase will collect site specific data about selected demonstration projects and data of a broader nature which will have regional or nationwide implications. Collection of site specific data will utilize local people directly and indirectly involved in the demonstrations; general information will be obtained from regional committees, set up to support this Phase I work, which serve as a broad information base, provide direction relative to individual areas of expertise, and provide a credible source for identification of potential problems.

Any problems identified during the baseline assessment, and others independently identified during the later tasks of Phase I will serve as the basis to determine what and where experiments should be conducted to answer institutional/societal/environmental problems.

(b) Followup Phase

This second phase is also slated to accomplish a two-fold purpose. The most unusual aspect of program assessment strategy is the ability to collect comparative "before" and "after" data. As part of the Test and Evaluation Plan being prepared as a separate report under Phase I will be recommended a plan to collect this "after" data.

As demonstration installations are completed and placed in operation, followup studies will commence. As all projects will not be completed simultaneously, the followup 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 for answering technical, as well as institutional/societal/environmental questions, will be continuously provided by this approach.

The following is a list of some of the key issues that will be addressed in the study. It is not all-inclusive of the issues which will be addressed, nor are the issues associated with the appropriate group at this time.

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, climatic 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

Thus, the approach is designed to meet the requirements of credibility, utility for developing solar energy use, and projections based on empirical results by concentrating on the participants in selected demonstration projects themselves and complemented by information from their peers not directly involved in the demonstrations.

(4) Information Dissemination Task

It is important that the demonstration program do more than study Institutional/Societal/Environmental issues or assess the impact the program has had on attitudes of members of the building community. The program must aggressively attempt to modify attitudes and break down barriers to the application of SHAC technology. This can be most effectively accomplished through the dissemination of information to all sectors of the building community.

A detailed discussion of our proposed plan to disseminate information is reserved for Section V. The essence of our recommendations are summarized as follows:

1. Foster discussion, analysis, and acceptance of SHAC technology through publication of demonstration results in trade and technical journals,
2. Provide the building community with the necessary tools to apply SHAC technology through the development of design handbooks, cost estimation handbooks, performance specifications handbooks, etc.,
3. Provide design, construction, and installation training programs,
4. Encourage the development of university and trade school educational programs through the development of educational films and materials.

Accomplishment of these information dissemination tasks will result in significant diffusion of this technology into the building community. Based upon discussions with HVAC engineers and contractors, the development of design handbooks, construction cost estimation and specifications manuals may very well be the single most important product of the information dissemination program.

The reader is referred to Section V for a discussion of additional aspects associated with the dissemination of information.

3. Strategy Implementation Priorities

This section discusses the relative levels of importance we have assigned to each strategy. This should provide ERDA program management with a decision tool through which maximum benefit may be obtained as funding levels are established.

While we have allocated a number of demonstrations whose primary purpose is to explore institutional/societal/environmental (I/S/E) issues, we view every demonstration as providing some opportunity to also address these issues. We thus view this grouping of demonstrations as providing the program with maximum flexibility. Program funding levels should affect the number in this group first. In addition, no stringent requirements are placed on the SHAC systems proposed for these demonstrations, although preference should be given to flat plate water and air systems. Being loosely defined, this group cannot be depended upon to provide all the necessary technical and economic data required by the program and has thus been assigned lowest priority.

Similarly, we view the documentation of costs associated with the demonstrations as being primarily that - documentation. These costs will be combined with the measured engineering performance to assess one of the program's primary goals - ultimate economic viability. There are, however, a number of economic studies which will provide information and insight into probable future labor costs (ILS), the existence of economics of scale (EOS), and one which will provide incentive for the establishment of a local industry. These issues are important. However, they are not as critical to the attainment of the program's goals as the need to measure and document technical performance. Therefore, we have assigned second priority to the economic strategy.

Achievement of the program's goals hinges on the parametric studies. We think of these studies as forming the nucleus of the entire program. The development of technical performance data over a wide range of operating conditions is critical to the understanding of design rules and the development of handbooks; regional life cycle cost analyses; and the identification of those technical areas requiring further study, etc. Easily documented cost data will be of no value if engineering performance data is not obtained. Similarly, the promising

technology studies provide a preliminary assessment of the regions of applicability and relative performance and costs of the recommended system. The group of demonstrations associated with the parametric studies and promising technologies study represent the absolute minimum set in order to obtain any significant benefit from the program and are thus assigned highest priority.

4. Plan Design Guidelines

a. Overview

Section 2 above discusses the various strategies designed to achieve the program's goals. In theory, there are many possible plan designs employing these strategies which could conceivably achieve these goals under certain limited situations. For example, the plan could address only retrofit demonstrations and thus accomplish the objectives for this market. The plan could emphasize the heating and cooling portion of the program by providing say 180 heating and cooling sites and only 20 heating only sites. The plan could provide equal numbers of demonstrations for many technically feasible SHAC systems and sub-systems, and so on.

Our approach has been to maximize the program's impact on each of the factors discussed below. The impact of solar energy utilization on the United States' precarious energy position will be maximized if both a new and retrofit market are stimulated. The ultimate economics of both markets (in terms of life cycle costs) appear to justify a program which considers each. A near term market for heating only systems is likely to be triggered by the program more readily than the heating and cooling market simply from an economic standpoint. Thus, the program should not overlook the opportunity to ensure the creation of this market by providing a substantial heating only demonstration program. These are just two of the many factors considered to provide a well-rounded program which exploits all avenues open to the application of solar energy for the heating and cooling of buildings. The following is a discussion of these factors.

b. New Versus Retrofit Applications

In 1975, the United States general non-residential building inventory included approximately $26,517 \times 10^6$ ft² of building. During the next 15 years, it has been estimated that nearly $25,000 \times 10^6$ ft² of building will be added and $5,000 \times 10^6$ ft² of building will be removed from the commercial building inventory.

From these figures it is estimated that in a fifteen year time frame, which is approximately equal to the expected lifetime of a solar system, the retrofit and new commercial building markets for SHAC systems will be about the same. This reasoning lends support to a program which considers about equal numbers of new and retrofit demonstrations. Of course, the entire inventory of existing buildings is not suitable for retrofit SHAC systems. However, many of the new buildings which will be erected in the future will have a potential for retrofit SHAC systems, since not all new buildings will be built with SHAC systems. Furthermore, if we are to save appreciable amounts of energy by 1985, the retrofit market must be addressed now. Other factors which tend to balance the program in favor of new applications are that retrofit applications cost on the order of \$3/ft² of collector more than for new buildings, and assuming energy conserving procedures are employed in new construction, it should be possible to economically meet a larger fraction of the energy requirements for space heating and cooling in a new building. One additional factor which enters into the discussion is the time necessary for a retrofit application to be completed versus the time required for a SHAC application for a new building. A retrofit application may only require a few months, whereas a new application can take from one to two years. The Solar Heating and Cooling Demonstration Act of 1974 mandates that heating only be demonstrated by the end of fiscal 1977. This severe timing constraint precludes demonstration of heating only on most types of new buildings. Thus, retrofit applications are required in order to comply with the law. Our program design guideline has been to recommend a program which treats the new and retrofit market with equal emphasis - 100 new, 100 retrofit demonstrations.

c. Heating vs. Heating and Cooling Demonstrations

In the Solar Heating and Cooling Demonstration Act of 1974, Congress recognized the fact that heating plus cooling is not currently economically viable in most climatic regions and thus, while the heating only portion of the program is underway, the NASA program and private industry will hopefully develop more economically viable cooling systems which are designed specifically for solar applications.

The number of heating only demonstrations which have been recommended represents a careful trade-off between the number required to address all of the technical, economic, and institutional issues described in Subsection A.2 and the anticipated or probable funding levels which will be available during the heating only portion of the program. In designing the plan, it has been our approach to determine the minimum number of heating only demonstrations and heating and cooling demonstrations which are required to execute the technical, economic and institutional strategies. Then, based upon the probable funding levels, management requirements, and timing constraints, determine how many of any remaining demonstrations would practically fit the heating only portion of the plan and allocate any remaining demonstrations to the heating and cooling portion.

d. Regional Coverage

In order to adequately determine those conditions under which solar technology is most applicable, many climatic regions should be investigated during the demonstration program. Indeed, as will be shown in Subsection B, identification of those demonstrations which appropriately fit the parametric study require that every climatic region, except Miami, contain at least one demonstration. The Miami climatic region appears to be a special one since heating loads in this region are essentially nonexistent for commercial buildings, whereas cooling loads are so large that tremendous collector areas are required to supply even a relatively small fraction of this load.

Our approach has been to recommend a number of demonstrations for each region in approximate proportion to the fraction of population contained within that climatic region (see Table II-3). However, as will become apparent in Section B, those regions which appear to be exceptionally good for solar applications generally receive a number of demonstrations larger than the regional fraction of population would suggest. Those regions which appear to be economically marginal at this time receive significantly fewer demonstrations than would be indicated by their regional population fractions. Because the cost of electrical energy in particular fluctuates widely on a local level within a given region and because the performance of solar equipment can vary significantly within a given region, we cannot justify excluding any region from the demonstration program altogether.

In summary, we have attempted to provide regional coverage in the number of demonstrations based upon the population associated with that region, the numbers being perturbed primarily as a result of the current general economic picture for this region.

e. Building Types, Sizes and Floor Space Inventories

The types of buildings chosen for this study were based primarily upon the categories identified in the Dodge Construction Potentials published by the F. W. Dodge Company. In addition to representing a very complete breakdown of commercial building types, this data is consistent with the categories published in the Federal Energy Administration Project Independence Report, Commercial and Residential Energy Use Patterns dated November, 1974. This report contains the most complete floor space inventory available to date and presents 1970 building floor space inventories for offices, retail, schools, hospitals, and an "other" category containing religious buildings, social buildings and nursing homes. In addition, this report projects a growth in building inventory to the year 1990. Through the use of Dodge Construction Potential reports for the years 1963, 1964, 1968 and 1969, we were able to estimate the average sizes of buildings which have been constructed and to estimate the inventory of specific building types which are contained within the general categories previously listed. The resulting inventory of building types employed in this study, the associated number of buildings, and an estimate of the average size are shown in Table II-4. We estimate that the floor space presented in Table II-4 represents in excess of 80 percent of the total commercial inventory that existed in 1975, the remaining inventory being comprised of manufacturing establishments, railroad, airplane, and bus terminals, refrigerated warehouses, etc. Appendix B contains a complete regional description of the building types, sizes, and inventories which were employed in this study. It should be pointed out that the Dodge Construction Potentials are produced specifically for use by the building community and thus these categories represent those most useful to this community.

TABLE II-3

ESTIMATED FRACTIONS OF U. S. POPULATION
WITHIN 12 CLIMATIC REGIONS

<u>Climatic Region</u>	<u>1975 Population (10⁶)</u>	<u>Fraction</u>	<u>Theoretical No. of Demonstrations</u>
1. Boston	62.8	.292	58.4
2. Washington, D.C.	29.2	.136	27.2
3. Madison	21.9	.102	20.4
4. Los Angeles	21.3	.099	19.8
5. Charleston	18.5	.086	17.2
6. Bismarck	11.4	.053	10.6
7. Nashville	17.8	.083	16.6
8. Fort Worth	10.8	.050	10.0
9. Omaha	9.9	.046	9.2
10. Seattle	3.2	.015	3.0
11. Phoenix	4.1	.019	3.8
12. Miami	4.1	.019	3.8

f. SHAC System Types

The plan has been designed employing the most readily available systems, namely flat plate air and water collectors and, for the case of cooling, coupled with the absorption chiller system. We are confident in designing a plan employing these systems for two reasons. First, considerably more experience has been gained with these systems and thus their costs and technical performance are more clearly identified. Second, the Solar Heating and Cooling Demonstration Act of 1974 places high emphasis on the demonstration of ultimate economic viability. Since flat plate air or water systems, coupled with an absorption system to provide cooling appear to be the only systems which are at least marginally economic for some regions at this time, a program which emphasizes other more expensive, less well understood collector systems will run the risk of failing to demonstrate the necessary economic viability.

We believe however, that the program should be flexible and for those cases in which significant new concepts arise which appear to be promising both from a technical and economic standpoint, an opportunity for demonstration would be provided. One additional argument can be made for not providing equal numbers of demonstrations for many different subsystem concepts. This is simply the idea that a minimum market is required in order to stimulate manufacturers to "tool up" to produce systems. It is beginning to appear from cost/benefit studies that a program employing only flat plate air, water and absorption systems may require more than 200 demonstrations in order to trigger widespread industrial production. Thus, the program recommended here, while providing ample opportunity to test and evaluate promising new concepts and systems, places emphasis on one primary system - the flat plate water/absorption system.

g. Cost Savings vs. Energy Savings Considerations

The parameters which have guided our choice of sites are (1) the cost savings attainable for a given site and (2) the estimated energy consumption for space heating or cooling for that building type in a given climatic region. The last parameter provides a measure of the market which is available for that particular building type and thus represents the potential impact that a demonstration of that type might have within a given region.

TABLE II-4
1975 NON-RESIDENTIAL BUILDING INVENTORY

	<u>10⁶ft²</u>	<u>10³ Bldgs</u>	Average Size (10 ³ ft ²)	
			<u>W/O Basement</u>	<u>W/Basement</u>
OFFICES	4382	366	12.0	16.0
RETAIL				
Supermarkets	312	25	12.5	-
Restaurants	448	318	1.4	-
Stores & Serv. sta.	3432	817	4.2	-
Shopping Centers	847	13	63.0	-
EDUCATIONAL				
K, 1-12, College Classrooms	5153	202	25.6	-
LIBRARIES, MUSEUMS	293	18	16.3	25.0
HEALTH				
Hospitals, Clinics Mental Institutions	1717	34	50.0	60.0
WAREHOUSES	3224	248	13.0	-
RELIGIOUS, SOCIAL, RECREATIONAL	2437	303	8.04	16.1
HOTELS (> 3 stories)	531	13	40.0	50.0
MOTELS, NURSING HOMES	<u>689</u>	<u>34</u>	<u>20.5</u>	-
Totals	23,465	2,391	9.81	

The cost savings and potential energy savings for a given building for each region has been calculated employing a computer algorithm which is described in detail in Appendix A. Regional averages have been assumed for energy costs and the performance attainable from the SHAC systems (direct heating with flat-plate water collectors; absorption chiller employed for cooling). A thorough discussion of the performance assumed by the solar system for these hypothetical buildings for each region are discussed in Appendix C. Briefly, the computer algorithm described in Appendix A produces an output which contains the following:

1. The cost savings, potential regional energy savings and collector area required for the case in which solar system supplies 35 percent of the space heating load.
2. Cost savings, potential regional energy savings and collector area required for the case in which solar system is designed to provide 70 percent of the space heating load while the percent of the cooling load supplied by solar is allowed to vary, depending on the climatic region and building type.

As may be anticipated, situations arise in which, for a given region, one building type may represent a small potential for a total energy savings while showing large cost savings, whereas a different building in the same region may present a potential for a tremendous energy savings but indicate only small relative cost savings. In these cases, preferential treatment was given to the building which showed the greatest promise for cost savings (a measure of relative economic viability) where consideration of regional coverage of demonstrations by distribution of building types did not prohibit its selection. Examples of this selection process are described in detail in Subsection B.

B. Matrix Design

1. Technical Design

a. Recommended Sites for Parametric Study

FIGURE II-4
Range of Insolation Available
During Heating Season,
1000 Langleys

(1) Introduction

As discussed in Subsection A.2, the parametric studies are designed to provide a thorough but minimum assessment of the technical performance of solar energy for heating and cooling of commercial buildings. The studies will characterize the engineering performance over the spectrum of SHAC systems and parameter values likely to be encountered. The following two sections present the rationale employed to select sites and the resulting recommended sites.

(2) Heating Only Parametric Study

Subsection A.2 discusses the selection of parameters and their associated ranges to be studied. For heating loads, this process consists of simply plotting the distribution of the number of buildings versus incremental heat loads. The data employed in this simple analysis is presented in Appendix B. Approximately equal numbers of buildings are found to be represented for building heating load ranges of 0-50, 50-100, >100 (1000 Btu/ft²). The three ranges of solar insolation available during the heating season were chosen by observing that the United States can be divided into three broad regions if iso-Langley lines of 10,000, 60,000, and 80,000 are taken as the boundaries of these regions (see Figure II-4).

For a given system (direct heating employing flat plate air or water collectors) the design consists of identifying those buildings which appropriately fit within a matrix element identified by the range of heating load and the range of solar insolation. These candidates are identified in Appendix F. Technically, any of these sites can participate as a member of the parametric study, and should any difficulties arise in the implementation of the plan, this list should be consulted for appropriate substitutes.

Estimated cost savings for each site and potential regional energy savings data for 35 percent replacement of heating load by solar are available in both Appendices A and F. Of those candidate buildings occupying a parametric study matrix element, we have chosen those which indicate the greater cost savings and potential for regional energy savings, provided the ratio of collector area to roof area is less than one. While the economics of air systems are likely

to differ from that of water systems, our assumption in selecting sites for air systems has been that the relative economics among the candidates are likely to be nearly the same.

As an example of this selection process, consider the data presented in Table II-5 for a typical matrix element. Those candidates indicating clear cost advantages are located in the Charleston and Fort Worth climatic regions. In addition, these sites present a large potential to impact energy savings in these regions. However, four sites are needed to demonstrate two water systems (including one replicate) and two air systems (including one replicate). Thus, we select a Charleston store, a Fort Worth store and church, and also a Nashville office. The Nashville office was chosen over other buildings for two reasons: first, the need to approximate the building populations by type and second, to recommend a building which provides a large potential for energy savings. It should be mentioned that little weight is placed on the third decimal place for cost savings since this analysis is a non-optimized design for hypothetical buildings. Thus, we fully expect the cost savings for actual buildings to fluctuate in the third decimal place.

This selection process is repeated for every matrix element. In many cases the ideal choices are clear and no judgment is required. In other cases, trade-off judgments must be made when one site maximizes the potential for regional energy savings while another site maximizes cost savings. Unless other plan constraints dictate the choice, preference has been given to the site which maximizes cost savings. The resulting heating only parametric study including its replicate is presented in Tables II-6 and II-7.

Several observations should be noted concerning the recommended matrix of heating only sites. First, Miami is not represented in the study. This results from the fact that heating loads are virtually non-existent for most commercial buildings in this region. Second, we have recommended one site in the Seattle region. Our standard criteria would have eliminated this region due to its negative cost savings. However, no other building choices were available for this matrix element, and since we felt that this region should be represented by the program,

TABLE II-5

HEATING ONLY CANDIDATES FOR A TYPICAL PARAMETRIC
STUDY MATRIX ELEMENT

Insolation Range: 10000 - 60000 Langleys

Heat Load Range: 45000 - 90000 Btu/ft²

<u>Region</u>	<u>Building Type</u>	<u>Cost Savings*</u> <u>\$/ft² - Bldg.</u>	<u>Regional Energy**</u> <u>Savings, 10⁹ Btu</u>
Nashville	School	.024	8.62
	Office	.024	6.78
	Hospital ^a	.026	1.85
	Church	.029	4.60
	Social	.029	4.60
	Motel	.021	3.32
	Nursing Home	.021	3.32
	Supermarket	.024	0.48
Charleston	Store	.065	6.07
Ft. Worth	Store	.075	4.83
	Church	.05	2.60
	Social	.05	2.60

*Comparison with regional average electrical energy costs and an amortized solar cost of 1 \$/ft² - Year, for 35% replacement by solar.

**For 35% replacement by Solar.

^aThis candidate eliminated because ratio of collector area to roof area of an average hospital is greater than one.

Building Heating Loads, 10^3 Btu/ft²TABLE II-6: PARAMETRIC STUDY REQUIREMENTS FOR HEATING ONLY
(Flat Plate Collectors Recommended)

Primary Set

WORKING FLUID: WATER 10^3 Langleys/Heating Season

	10 - 60	60 - 80	>80
0 - 45	Fort Worth: Office	Los Angeles: School	Seattle: Shopping Center
45 - 90	Fort Worth: Church	Washington, D.C.: Office	Madison: Shopping Center
> 90	Fort Worth: Restaurant	Boston: Store	Madison: Store

WORKING FLUID: AIR 10^3 Langleys/Heating Season

	10 - 60	60 - 80	>80
0 - 45	Charleston: Church	Phoenix: Church	None Available
45 - 90	Charleston: Store	Boston: School	Madison: Library
> 90	Charleston: Restaurant	Washington, D.C.: Restaurant	Bismarck: Store

TABLE II-7: PARAMETRIC STUDY REQUIREMENTS FOR HEATING ONLY
(Flat Plate Collectors Recommended)

Replicate Set

WORKING FLUID: WATER

10^3 Langleys/Heating Season

	10 - 60	60 - 80	>80
0 - 45	Fort Worth: Motel	Phoenix: Hospital	Incompatible with Plan Constraints
45 - 90	Fort Worth: Store	Boston: Nursing Home	Omaha: Motel
> 90	Nashville: Restaurant	Phoenix: Restaurant	Madison: School

WORKING FLUID: AIR

10^3 Langleys/Heating Season

	10 - 60	60 - 80	>80
0 - 45	Fort Worth: School	Phoenix: Office	None Available
45 - 90	Nashville: Office	Los Angeles: Store	Omaha: Warehouse
> 90	Nashville: Store	Madison: Store	Omaha: Store

II-40

Building Heating Loads, 10^3 Btu/ft²

we felt comfortable in recommending a shopping center in the Seattle region. Third, we have restricted the recommendation of air systems to either the smaller building types or to those types having greater architectural flexibility. The reason for this restriction resides in the uncertainty associated with the design of air systems for very large buildings such as shopping centers or hospitals.

(3) Heating and Cooling Parametric Study

Employing the same technique just described for designing the heating only parametric study, ranges of the seasonal cooling load which contain approximately equal numbers of sites are 0-50, 50-100, and >100 (1000 Btu/ft²). As discussed in Subsection A.2, the ratio of heating to cooling load is also a parameter having a first order effect on the system's design criteria and performance. Employing the same technique here also, three ranges of this ratio are determined to be 0-0.5, 0.5-2, >2. Values for the ranges of annual insolation (the remaining parameter required to define the heating and cooling parametric study) are observed from Figure II-5 to be 100-130, 130-160, and 160-200 (1000 Langleys). The parametric study for heating plus cooling can now be identified as three, three by three matrices, each matrix representing a range of the heating to cooling load ratio.

The criteria and methodology employed to select sites for this parametric study are analogous to those described for the design of the heating only parametric study. In this case, however, the cost savings and potential for energy savings are calculated for a flat plate water/absorption chiller solar system designed to supply 70 percent of the heating load while allowing the fraction of the cooling load supplied by solar to vary, depending on the building type and climatic region. Again, those buildings for which the ratio of required collector to roof area is greater than one were not considered. Appendix F describes the solar performance data employed in the computer ranking algorithm, the results of which are presented in Appendix A.

To clarify the process employed in selecting sites for the heating and cooling parametric study, consider those buildings which belong to a typical matrix element as indicated in Table II-8. The warehouse is the only building type

which has not been considered for heating and cooling demonstrations. It has been our experience that warehouses are generally heated but not cooled, refrigerated warehouses excluded. As may also be seen, several buildings violate the collector area to roof area ratio criteria, and are thus eliminated. Furthermore, the Nashville region presents a cost penalty for heating and cooling applications of solar energy. Cost penalties were also indicated for the entire Miami and Seattle climatic regions. We have chosen to eliminate sites in these regions from consideration as participants in this study. Of the remaining candidate building types, a school and office in the Los Angeles region clearly offer the better cost savings and potential for regional energy savings, and are thus the sites chosen for this heating and cooling parametric study matrix element.

The selection process is exercised for all the buildings pertinent to each matrix cell (see Appendix F) to yield a parametric study which maximizes cost savings and the potential for energy savings. The set of recommended sites are presented in Tables II-9 and II-10. Those matrix elements containing the phrase "incompatible with Plan Constraints" comprise those candidate building types, which, in relation to the plan as a whole, are not favorable demonstrations. Thus, for example, four shopping centers located in the Los Angeles region would be required to complete the matrix elements identified by a heating to cooling load ratio of 0-.5 and whose cooling load range is 0-50 (1000 Btu/ft²) in those areas where the solar insolation ranges from 130,000 to 200,000 Langleys. Under regional coverage and building type population constraints, four shopping centers are too many. Thus, only two shopping centers are recommended for inclusion in the primary set. While a one-for-one replication of this parametric study matrix element would be ideal, it is not essential to successfully evaluate the energy savings function (ES) discussed in Section A, provided the other sites recommended in the replicate set are carried out.

(4) Summary

The relationships of the above recommended sites for these studies to the climatic regions and types of buildings under consideration for this program are illustrated in Tables II-11 and II-12. As can be seen, 11 of the 12 climatic regions are represented as well as 12 of the 13 building types listed.

TABLE II-8

HEATING AND COOLING CANDIDATES FOR A
TYPICAL PARAMETRIC STUDY MATRIX ELEMENT

Insolation Range: 130-160

Cooling Load Range: 0-50

Heating to Cooling Load Ratio Range: .5-2.0

Region	Building Type	Cost Savings* \$/ft ² -bldg.	Region Energy Savings, 10 ⁹ Btu
Los Angeles	Library	.074	.84
	Warehouse ^b	.052	9.03
	Office	.119	19.10
	School	.110	23.08
Nashville	Warehouse ^b	-.011	17.16
Omaha	Library ^a	.099	.97
	Shopping Center	.094	2.58
	Office ^a	.144	20.62
Wash., D.C.	Warehouse ^b	.134	31.02
	Church ^a	.211	28.72
	Social ^a	.211	28.72

*Calculated using regional average electrical energy costs and 1\$/ft² amortized collector cost for system designed to supply 70% of the heating load, % of cooling load allowed to vary, depending on region and building type.

^aThese buildings eliminated based on ratio of required collector area to roof areas > 1.

^bWarehouses not considered for heating and cooling since most warehouses not cooled.

TABLE II-9: PARAMETRIC STUDY REQUIREMENTS FOR HEATING AND COOLING
(Flat Plate Water/Absorption Cooling Recommended)

Primary Set

Range of Annual Insolation

1000 Langleys

Range of Building Cooling Loads
1000 Btu/ft²

	100 - 130	130 - 160	160 - 200	
0 - 50	None available	Los Angeles: Shopping Ctr.	Los Angeles: Shopping Ctr.	0 - 5
50 - 100	None available	Fort Worth: Office	Fort Worth: Office	
> 100	None available	Charleston: Restaurant	Phoenix: Store	
0 - 50	Boston: Shopping Center	Los Angeles: Office	Los Angeles: Office	0.5 - 2
50 - 100	Wash. D.C.: School	Los Angeles: Store	Los Angeles: Store	
> 100	Wash. D.C.: Store	Wash. D.C.: Store	Fort Worth: Restaurant	
0 - 50	Boston: School	Omaha: School	Los Angeles: Church	>2
50 - 100	None available	Omaha: Store	None available	
> 100	None available	None available	None available	

Range of heating to cooling load ratio

TABLE II-10: PARAMETRIC STUDY REQUIREMENTS FOR HEATING & COOLING
(Flat Plate Water/Absorption Cooling Recommended)
Replicate Set

Range of Annual Insolation
1000 Langleys

Range of Building Cooling Loads
1000 Btu/ft²

	100 - 130	130 - 160	160 - 200	
0 - 50	None available	Incompatible with Plan constraints	Incompatible with plan constraints	0 - 0.5
50 - 100	None available	Fort Worth: School	Phoenix: Office	
> 100	None available	Fort Worth: Store	Phoenix: Store	
0 - 50	Boston: Office	Los Angeles: School	Phoenix: Church	0.5 - 2
50 - 100	Wash. D.C.: Motel	Wash. D.C.: Supermarket	Fort Worth: Church	
> 100	Wash. D.C.: Store	Fort Worth: Restaurant	Phoenix: Restaurant	
0 - 50	Madison: Shopping Center	Bismarck: School	None available	> 2
50 - 100	None available	Incompatible with plan constraints	None available	
> 100	None available	None available	None available	

Range of Heating to Cooling Load Ratio

TABLE II-11
HEATING ONLY PARAMETRIC STUDY (PS)
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	1		1								1			3
2.	Washington, D.C.		1					1							2
3.	Madison	1 ^a		2	1									1	5
4.	Los Angeles	1		1											2
5.	Charleston			1			1	1							3
6.	Bismarck			1											1
7.	Nashville		1	1				1							3
8.	Ft. Worth	1	1	1			1	1	1						6
9.	Omaha			1					1	1					3
10.	Seattle				1										1
11.	Phoenix ^b		1			1	1	1							4
12.	Miami														0
TOTALS		4	4	9	2	1	3	5	2	1		1		1	33

a. Also serves with economy of scale study.

b. Also serves in local market stimulation.

TABLE II-12

HEATING AND COOLING PARAMETRIC STUDY (PS)
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	1	1 ^a		1										3
2.	Washington, D.C.	1		3					1		1				6
3.	Madison				1										1
4.	Los Angeles	1	2	2 ^a	2		1								8
5.	Charleston							1							1
6.	Bismarck	1													1
7.	Nashville														0
8.	Ft. Worth	1	2	1			1	2							7
9.	Omaha	1		1											2
10.	Seattle														0
11.	Phoenix		1	2			1	1							5
12.	Miami														0
TOTALS		6	6	9	4	0	3	4	1	0	1	0	0	0	34

a. Also serves with installation learning curve studies.

Also note that several of these sites serve to satisfy the economic strategy as well. This overlap is discussed in Section 4. In summary, 67 of the 200 demonstrations serve as critical participants of the parametric studies.

b. Recommended Sites for Promising Technology Applications

(1) Introduction

The parametric studies developed in the previous section have been designed to employ those concepts which are currently available, which appear to be most technically and economically feasible at this time, and which are applicable over wide variations in solar and climatic conditions. There are also a number of systems which are currently available, but which are limited by climatic or solar insolation conditions. Furthermore, a number of general concepts have not been provided an opportunity for full scale testing but these appear to be both technically feasible and economically promising. The purpose of this section is to develop and recommend sites which will provide for the demonstration, testing, and evaluation of a number of currently available but less widely applicable promising subsystems and also a number of new concepts requiring a little development before they are likely to be economical and technically viable.

(2) Solar Assisted Heat Pumps

A solar assisted heat pump is defined to be any configuration whereby a solar system supplies energy to the evaporator component of a conventional water-air or air-air heat pump during operation in the heating mode. The advantages in doing this are twofold: 1) a high coefficient of performance of the heat pump can be realized by maintaining the evaporator at high temperatures relative to very low ambient temperatures, and 2) high solar collector efficiencies can be maintained since the heat pump evaporator requires lower temperature energy than would be required for direct space heating with solar energy. An improvement in collector efficiency translates to a need for less collector area to supply a given amount of heat, and thus, lower capital cost for solar related equipment can be expected. While the technical advantages of solar assisted

heat pumps are clear, we have not placed great emphasis on this concept for the demonstration program for the following reasons:

1. A past history of reliability problems and misleading advertising has resulted in a market penetration problem in the commercial sector. While this situation will undoubtedly correct itself in the future, we believe that a demonstration program which emphasizes solar assisted heat pumps may be fraught with the problems associated with penetrating two markets.
2. Because heat pumps have not fully penetrated the commercial market, the availability of trained maintenance personnel may also be a problem.
3. The required level of technology associated with solar collectors employed to assist heat pumps may not be sufficient to also permit application of these collectors with absorption cooling. Thus, an emphasis on this application may not stimulate development and production of collectors suitable for application with absorption systems.

A number of sites have been recommended for the demonstration of solar assisted heat pumps. While these systems are technically applicable across the entire country, effort has been made here to recommend only those sites which will provide the greatest demonstration value and which will provide the greatest impact on heat pump operation. The greatest impact, both in terms of demonstration value and economic viability will be realized by employing demonstrations in those regions where typical non-solar heat pump operation results in coefficients of performance (COP) less than about two. The demonstrations recommended are obtained by finding the intersection of those building types having heating load to cooling load ratios greater than one (see Appendix B) with those regions having typical non-solar assisted COPs less than or equal to two as suggested by the map shown in Figure II-6. The resulting sites recommended for the solar assisted heat pump application are then shown in Table II-13.

(3) Tubular Collectors

In terms of regions of applicability, the tubular collectors are more difficult to define. Tubular collectors work well for both direct and diffuse radiation. Under conditions of direct radiation, their efficiencies are higher than flat plate collectors in the morning and late evening, but are less efficient around mid-day. Most tubular collectors in use are evacuated. Consequently the heat loss associated with convection and conduction is much less than with a flat plate collector. Therefore, in terms of technical applications, there is no reason why tubular collectors cannot be applied over the entire country. However, the economics of tubular collectors are a definite drawback; recently quoted prices being on the order of \$25 per square foot of collector, not installed. The criteria which have been employed to select the recommended sites for the demonstration for tubular collector systems are that a major fraction of the cooling load (greater than 70 percent) can be supplied and that the costs for electrical energy are among the highest in the country. Our analysis of flat plate collector performance indicates that 100 percent of the cooling load can be supplied by collectors sized to provide 70 percent of the heating load in the regions of Bismarck, Seattle, Madison and Omaha. A flat plate collector sized to provide 70 percent of the heating load can also provide a significant fraction of the cooling load in both Boston and Washington (say 35 to 100 percent). Boston and Washington also are known for their high electrical energy costs and thus may be good candidates for tubular collector applications. Because solar applications in the Seattle region are marginally economic based on flat plate collector system cost, and because tubular collectors at this time are significantly more expensive, the Seattle region has not been recommended as a viable site to demonstrate tubular collector performance. Thus, we have recommended, as indicated in Table II-13, that the regions of Bismarck, Madison, Omaha, Boston and Washington, D. C. contain at least one demonstration of tubular collectors, preferably for a heating and cooling application.

(4) Passive Heating

If solar energy can be used to provide a significant fraction of the heating load requirements for a structure without the need for auxiliary energy input to the solar system (e.g., pumps, control system, etc.), then this form of solar heating is referred to as passive heating. The application of passive

heating requires innovative architectural design and significant energy conservation measures. A number of recent architectural innovations and construction techniques have indicated, that passive heating can be a viable system in those regions having moderate to low heating loads, and substantial solar insolation. Since conventional construction materials can generally be employed in these systems, and since no elaborate technology is involved, the economics of passive heating appear to be very good in those areas where a significant fraction of the heating load can be supplied. For these reasons, we have chosen the regions of Los Angeles, Fort Worth, Phoenix, and Charleston as representing those areas where passive heating can play a significant role in reducing dependence on conventional fuels by commercial buildings. Table II-13 indicates those sites we believe will provide opportunity for flexible architectural innovation.

(5) Radiative Cooling

As the name implies, radiative cooling systems employ the mechanism of radiative heat transfer to remove heat (or cool) either a building or a working fluid employed to cool a building. Application of radiative cooling systems range from the use of water type ponds on roofs to flat plate collectors which have no covers. The primary requirements for effective operation of these systems are clear night skies, moderate cooling loads and low relative humidity. In terms of effective demonstration of these systems, Charleston and Miami are eliminated immediately, due to their extremely high cooling loads. Those regions whose night skies are not sufficiently clear (due to haze and cloud cover) to permit high levels of radiative heat transfer include Seattle, Madison, Boston, Washington, D. C., Nashville, and Charleston. In addition, the regions of Bismarck, Seattle, Madison and Omaha are known to have very high heating loads. It is not clear at this time that the technology most appropriate to satisfy the cooling loads in these regions will also be satisfactory for passive heating, particularly when selective coatings are used on collector plates and simple water ponds are placed on the roof. Therefore, these regions have not been included in our recommendations. The regions which appear most appropriate for the successful demonstration of radiative cooling systems are Los Angeles, Fort Worth, and Phoenix. The recommended sites are illustrated in Table II-13.

(6) Concentrator Collectors

Concentrator collectors are particularly useful for high temperature applications. Their ability to focus low-intensity radiation onto a small area greatly improves efficiency of collection. These collectors thus appear to be particularly applicable when used in conjunction with the Rankine/vapor compression cycle discussed in the next section.

The basic requirement for optimum performance of concentrator collectors is direct radiation. Generally, concentrator collectors cannot make use of diffuse radiation, and therefore, they appear to be economically and technically feasible only in the regions where clear skies and direct radiation prevail. While portions of other climatic regions may be suitable for the application of concentrator collectors, in terms of demonstration value, we have recommended demonstration sites employing concentrator collectors (probably to be used for heating and cooling applications) only in the regions of Los Angeles, Fort Worth, Phoenix, and Miami. The first cost associated with concentrator collectors currently on the market appear to be good. However, the performance of these systems under rigorous climatic conditions and the lifetimes associated with some of the materials currently being used suggest that further study is needed. We consider the recommended applications to be mid-term in nature; that is, these demonstrations should be carried out in the mid to late portion of the demonstration program. The recommended sites are illustrated in Table II-12.

(7) Rankine/Vapor Compression Systems

A Rankine/vapor compression cycle is one of only two truly solar powered cooling systems, the other being the absorption system. A block diagram of this system concept is illustrated in Figure II-7. This concept can be viewed as two separate cycles. The Rankine cycle is used to produce shaft power via the expansion of an organic vapor through a turbine. Solar energy is collected at temperatures greater than 200°F. The shaft work produced by the Rankine cycle is then used to drive a standard vapor compression cooling system. The production of shaft power by the Rankine cycle opens up a wide range of applications. For example, when air conditioning or cooling is not required, the

shaft work can be used to drive an electrical generator which in turn can be used to power the lighting system of a building. Another distinguishing and positive feature of this system is the fact that the back-up system can be supplied by an electric motor hooked up directly to the standard vapor compression refrigeration system. This system is simple and no additional back-up refrigeration is required. Furthermore, the shaft power generated by the Rankine cycle can be used to drive a heat pump and thus supply heating in the wintertime and by reversing the heat pump, supply cooling in the summertime. The technical advantages of the Rankine cycle/vapor compression system are that the overall coefficient of performance can be made higher than that of the absorption system provided higher grade heat (on the order of 600°F) can be supplied to the boiler. Furthermore, the Rankine cycle can be made to operate efficiently over a wider temperature range than an absorption system. Widespread application of the Rankine cycle vapor compression system is currently inhibited primarily because the Rankine cycle operating with low-grade heat is still in the development stage. Consequently, the potential costs associated with its application are not known.

Because these systems appear promising, particularly with higher grade solar heat obtainable with the application of concentrator collectors, we have recommended that a number of demonstrations be carried out. Rankine cycle/vapor compression systems appear to offer significant economies of scale, and thus the demonstration sites recommended have been chosen for both their size and their high cooling loads: hospitals, schools, and shopping centers. Should the concentrator collector prove to be a viable solar collection system, additional improvements in the coefficient of performance of this system can be realized provided regions of intense and direct solar insolation are chosen.

Based upon these considerations, we recommended demonstration of the Rankine cycle/vapor compression system in the Los Angeles, Fort Worth, Phoenix, and Charleston regions for the following reasons: First, these regions offer higher cooling loads than can generally be found in other regions of the country; and second, these regions receive the high intensity solar insolation needed to

$$COP = \frac{\text{Evaporator Heat Input Rate}}{\text{Boiler Heat Input Rate}}$$

Schematic of Basic Rankine Cycle Powered Vapor Compression Refrigeration Cycle

FIGURE II-7

generate high temperature energy required by the Rankine Cycle vapor compression system. Table II-13 indicates those sites which have been recommended for the demonstration of the Rankine cycle/vapor compression refrigeration concept.

(8) Solar Assisted Desiccant Dehumidification

The absorption or desiccant system is another type of heat powered air conditioning system which appears to show promise for some applications. This system, which is illustrated in Figure II-8, employs moisture exchange and heat exchange between the air entering and leaving the cooled space in a combination that results in cooled and dehumidified air entering the space to be conditioned. The moisture exchange is accomplished through the use of a desiccant wheel and the heat power input is used to regenerate the desiccant by heating it, thereby driving out the moisture absorbed from the recirculating air stream. Technically, these systems operate best under conditions of high relative humidity and moderate cooling loads. However, only a few of these systems employing solar assist have been demonstrated on a prototype basis. Thus, we consider this particular concept still in basically the development stage. While uninstalled costs of these systems, less the solar collector portion, have been reported in literature to be competitive with conventional vapor compression systems, systems specifically designed for solar application are not in mass production and therefore, accurate costs are not yet known.

Because of these unknowns concerning the technical performance and costs when used with solar, we have recommended that only three demonstrations be carried out toward the end of the demonstration program in the regions of Boston, Washington, D. C. and Nashville. These regions have been chosen primarily because the cooling loads are moderate while receiving sufficient insolation for this application. The regions of Bismarck, Seattle, Madison, Omaha, Fort Worth, and Phoenix all having cooling loads which are considered too low to justify demonstration, low humidity levels, or very poor solar insolation characteristics. The regions of Los Angeles, Charleston, and Miami are regions having very high cooling loads, and thus, may require desiccant systems which are either too large or too expensive, suggesting that successful demonstration

Note: Numbers in parentheses are typical dry bulb over wet bulb temperature

II-58

Schematic Of Desiccant Type Heat-Powered Air-Conditioning System,

FIGURE II-8

in these regions may not be impossible. We thus recommend the demonstration of this system on a library, store and church, because the cooling loads generally associated with these building types are moderate, and because the typical building size likely to be encountered during the demonstration will result in moderate cost to the government. Table II-3 illustrates the recommended sites.

2. Economic Design

a. Economy of Scale Studies (EOS)

The first requirement for an economy of scale study is that the size of building chosen for the study are the ones most likely to generate the information desired, namely that the capital cost/usable Btu delivered decreases as system size increases. It is difficult to be certain that the building sizes chosen do indeed meet this requirement and thus a number of studies conducted on different size ranges is suggested. This requirement eliminates such building candidates as hospitals, shopping centers, warehouses, and motels, since it is unlikely building sizes will be found below about 30,000 to 40,000 square feet. Offices and schools surface as the most promising candidates since their common sizes range from 5,000 to well over 100,000 square feet.

To insure that sufficient response will be generated to perform such a study, a second requirement for an economy of scale study is that the building types selected are readily available in a wide range of sizes. The data in Table II-4 indicate that schools, offices and stores are indeed the most widely available. Stores, however, do not provide the range of sizes required. Therefore, we have recommended offices and schools as the prime candidates for the economy of scale study.

Because of program timing constraints, we have chosen one heating only economy of scale study. Based upon our analysis of the potential cost savings which may be obtained when solar replaces 35 percent of the heating load, a school and office in the Madison region appear to be the best candidates. The office in the Madison region is eliminated from consideration because the collector

TABLE II-13
PROMISING TECHNOLOGY STUDIES (PT)
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	TC		SAHP										SADD	3
2.	Washington, D.C.		SADD	TC											2
3.	Madison			TC		SAHP									2
4.	Los Angeles	RC	CC			RVC	PH								4
5.	Charleston	RVC	PH												2
6.	Bismarck		SAHP				TC								2
7.	Nashville			TC											1
8.	Ft. Worth	RVC		CC								PH		RC	4
9.	Omaha			SAHP							TC				2
10.	Seattle													SAHP	1
11.	Phoenix				CC	RVC				PH				RC	4
12.	Miami	CC													1
TOTALS		5	4	6	1	3	2	0	0	1	1	1	0	4	28

Legend: SAHP, Solar Assisted Heat Pump
PH, Passive Heating
RC, Radiative Cooling
TC, Tubular Collectors
CC, Concentrator Collectors
RVC, Rankine/Vapor Compression
SADD, Solar Assisted Dessicant Dehumidification

area to roof area ratio is greater than one. We thus recommend that a heating only economy of scale study be conducted in the Madison region employing three schools. The size ranges which are likely to be applicable for this study are probably around 50,000, 100,000, and 150,000 square feet.

We have recommended that the heating and cooling portion of the program contain three economy of scale studies. The recommendation of three studies was basically a judgmental decision based upon the following considerations:

1. The minimum number which will most likely address the size ranges of interest,
2. The potential difficulty in sufficient RFP response,
3. The regional availability of sites which had not previously been specified for other studies,
4. The desire to provide opportunity to explore economy of scale for a number of solar/HVAC configurations.

Where possible, we have also categorized schools as having a relatively low priority for participation in these studies for several reasons. First, the profit oriented portion of the commercial sector does not appear to view data obtained from schools as being as credible as data obtained from demonstrations on buildings associated with the profit oriented sector. Second, in every region except the Charleston climatic regions schools provide less cost savings than offices. Thus, we conclude that three economy of scale studies under the heating and cooling portion of the demonstration should be conducted on office buildings.

Those regions in which offices present the greatest possible cost savings are Boston, Washington, D. C., Omaha, and Madison, ranked in order of decreasing cost savings. Furthermore, these regions were the only ones available from the standpoint of providing appropriate regional distribution based upon population. If the collector area required to provide 70 percent of the heating load while permitting the percent of cooling load to vary is considered for each region, then the standard four-story office is not technically feasible. However,

single story offices are technically feasible in those regions and are thus viable candidates for economy of scale studies.

Furthermore, recent in-house studies suggest that the collector area which will provide minimum life cycle cost will also provide less than 70 percent of the heating load and thus this relaxation of the collector area to roof area constraint will not be detrimental to the success of the program. Those ranges of building size which are likely to be of interest for these economy of scale studies are the following:

1. One study containing 5,000, 10,000 and 15,000 square foot buildings.
2. One study containing 10,000, 20,000 and 30,000 square foot buildings.
3. One study containing 20,000, 40,000 and 60,000 square foot buildings.

A summary of the recommended economy of scale studies can be found in Table II-14.

b. Installation Learning Studies (ILS)

A primary consideration of the design of the installation learning studies has been to select those building types which have a large representation. As previously discussed, the installation learning study requires that six equivalent solar systems be installed on six equivalent buildings with the same construction crew, and thus it is important to select those building types for which it is known that equivalent buildings can be found. In terms of cost versus benefit, it is also important that oversized buildings are not chosen. Those building types which have been eliminated because of the potential lack of availability due to the general uniqueness are the following: Libraries, social and recreational buildings, nursing homes, and churches. Those buildings which are considered to be far too large for the application of an installation learning study are the following: Schools, shopping centers, hospitals, motels, and warehouses. While there are a large number of chain restaurants, their numbers are relatively few in comparison with other building types, and in addition, the collector area required to supply significant fraction of the

TABLE II-14
ECONOMY OF SCALE STUDIES (EOS)
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston		3H/C												3
2.	Washington, D.C.		3H/C												3
3.	Madison	3H*													3
4.	Los Angeles														
5.	Charleston														
6.	Bismarck														
7.	Nashville														
8.	Ft. Worth														
9.	Omaha		3H/C												3
10.	Seattle														
11.	Phoenix														
12.	Miami														
TOTALS		3	9												12

* Includes one element in the parametric study.

Note: H represents a heating only demonstration, H/C, a heating and cooling demonstration.

heating and cooling loads are generally much greater than the floor area. Thus, restaurants have been eliminated as potential candidates. The remaining building types (offices and stores) are good candidates for these studies both from the standpoint of availability of buildings and the availability of similar buildings. For example, it is well known that there are a large number of branch banks, chain shoe stores, chain electronics stores, chain leather goods stores and food stores which employ the same design and construction.

Here again, we have recommended one installation learning study under the heating only portion of the program due to program timing constraints. We have considered the most logical candidate for this heating only ILS to be the Phoenix region in support of the local market stimulation studies which are described in the next section. Because five offices had been previously selected for further studies and because stores offer the greater cost savings than offices in the Phoenix region, we have recommended that six stores be employed to conduct the installation learning study for the heating only program in the Phoenix region.

Those regions for which stores are technically feasible and for which additional sites are required to maintain the proper regional distribution based on population are Los Angeles and Charleston. Offices were eliminated from consideration as candidates in these regions for two reasons. First, stores present higher cost savings than offices in these regions, and second a large number of offices have been recommended in the economy of scale study design previously discussed. The only other region which contained sufficient number of sites not yet designated for participation in other studies is the Boston region. In this region stores are eliminated from consideration due to the collector area to floor area ratio constraint. Thus, we have recommended that an installation learning study in Boston be conducted on offices. A summary of the recommended installation learning studies is illustrated in Table II-15.

It should be noted that the installation learning studies recommended in the Boston region and the Los Angeles region have been combined with previously

TABLE II-15
INSTALLATION LEARNING STUDIES (ILS)
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston		6H/C*												6
2.	Washington, D.C.														
3.	Madison														
4.	Los Angeles			6H/C*											6
5.	Charleston			6H/C											6
6.	Bismarck														
7.	Nashville														
8.	Ft. Worth														
9.	Omaha														
10.	Seattle														
11.	Phoenix			6H ^a											6
12.	Miami														
TOTALS			6	18											24

a Also serves in local market stimulation

* Includes one element of the parametric study.

Note: H represents a heating only demonstration, H/C, a heating & cooling demonstration.

selected sites for the parametric studies. Since the installation learning studies are conducted on equivalent buildings employing equivalent solar systems, the data obtained from the performance of these systems will provide valuable additional statistical information. In addition to providing support for the local industry stimulation studies conducted in the Phoenix region and described in the next section, the installation learning study conducted there will also provide that region with an installation crew which can claim valuable experience in installation of solar hardware.

c. Local Industry Stimulation Studies

As previously discussed in Subsection A.2.c. (3), cost benefit studies have indicated that the economic picture is most favorable in the Phoenix climatic region. With some government support, this region is likely to develop a self-perpetuating local industry sooner than any of the other climatic regions. Our studies have suggested that government funding of approximately 18 heating only demonstrations in the Phoenix region should suffice to stimulate a local industry there, and this forms the basis for our recommendations.

We have considered that all heating only demonstrations which participate in the technical and economic studies in the Phoenix region also participate in the local industry stimulation study. Since ten heating only demonstrations have been recommended for these studies, only eight additional heating only sites must be recommended for this region. The building types as ranked in order of decreasing cost savings are the following: restaurants, stores, churches, social, hospitals, offices, schools, motels, nursing homes, supermarkets, libraries, warehouses, and shopping centers. The primary rationale for selecting the remaining eight sites has been to select those building types which provide the greatest cost savings, while at the same time, rounding out the estimated building type distribution for the Phoenix region. This distribution of building types can be found in Table II-4. Some additional emphasis has been placed on restaurants in the Phoenix region since this building offers the greatest cost savings of any building in the Phoenix region. The resulting distribution of sites recommended for the direct local industry stimulation study are illustrated in Table II-16.

TABLE II-16
DIRECT LOCAL INDUSTRY STIMULATION STUDY
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston														
2.	Washington, D.C.														
3.	Madison														
4.	Los Angeles														
5.	Charleston														
6.	Bismarck														
7.	Nashville														
8.	Ft. Worth														
9.	Omaha														
10.	Seattle														
11.	Phoenix *		4	7		1	3	3							18
12.	Miami														
	TOTALS		4	7		1	3	3							18

*NOTE: Ten members of this study are included with the heating only parametric study and the institutional learning study

3. Institutional, Societal, and Environmental Design

a. The Selection of Sites

The sites recommended in the previous sections will undoubtedly identify many local institutional, societal, and environmental issues which may require resolution before solar will be fully accepted in that local area. It is clearly impossible for 200 demonstrations to fully address all the issues that may exist within the approximately 30,000 local building code variations. Neither is it possible to identify all the local issues affecting labor unions, financial institutions, social acceptance for aesthetic reasons, environmental effects on solar system, and the effect of solar systems on the environment, etc.

Because these issues exist "where the buildings are", we maximize the potential for gaining information by recommending the number of buildings by type basically in proportion to the estimated building populations by type. We also approximate the numbers of sites per region based upon the actual population as normalized to 200, as illustrated in Table II-3. While this design consideration was taken into account in a number of cases when designing the technical and economic studies, the nature of the primary criteria employed in designing these studies precluded the distribution consideration from being closely followed.

The design of the technical and economic studies required the selection of 136 sites of which 58 sites were required to address issues associated with heating only. Because of the nature of the selection process, however, a number of very promising sites were not selected. Thus, for example, no office in the Madison climatic region was selected to participate in either the technical or economic studies. However, under heating only conditions for offices in all regions, those in the Madison climatic region show the greatest

potential for cost savings. This building was rejected from consideration in the technical and economic studies because the collector area required did not conform to the constraints imposed, namely the requirements for a typical four-story office building. A single-story office in the Madison region is technically feasible, however, so for these reasons, we recommend an office be demonstrated in the Madison region. Similarly, only two shopping centers were recommended for participation in the technical and economic studies. These building types are, however, among the fastest growing, and thus, we judged that additional representation is desirable. Among shopping centers, those located in the Boston, Madison, Bismarck, and Washington, D.C. regions offer the greatest potential for cost savings and total energy savings. Before a selection could be made, however, consideration was given for those regions already represented by shopping centers participating in the technical strategy. These regions are Madison, Seattle, Boston, Los Angeles, and Phoenix. Our selection was narrowed to the Washington, D.C. and Bismarck climatic regions. While shopping centers offer slightly better cost savings for heating only in the Bismarck region, the Washington, D.C. region was selected because the potential impact on energy savings was greater in the Washington, D.C. region. Furthermore, the rate of shopping center construction is greater in the Washington, D. C. region.

Only two sites have been selected in the Seattle region for participation in the technical and economical studies. Because of low cooling load requirements and poor insolation characteristics, Seattle was not considered for heating and cooling demonstrations, therefore, we concluded that Seattle should have additional heating only representation, even though local utility rates suggest that the economics in Seattle are poor. The three sites which offer the least economic penalty in this region are libraries, shopping centers and warehouses. The library and shopping center have been previously selected as participants in the technical studies. Thus, the warehouse represented the next most promising candidate and was selected as a site for the Seattle region.

Adding these three additional heating only sites to the 158 sites recommended for the technical and economic studies results in a total of 61 heating only demonstrations. As discussed in Subsection A.4, timing and funding considerations suggested a cut-off at about 50 heating only demonstrations, thus the decision was made to finalize the heating only portion of the demonstration program at 61 sites.

At this stage in the plan design, 61 sites had not been selected. Since the heating only portion of the program has been finalized, these remaining 61 sites of necessity must be heating and cooling demonstrations. The basic guidelines which are used in selecting the 61 sites are as follows:

1. The number of sites recommended for each region should follow as closely as possible the population distribution for that region.
2. The number of sites recommended by building type should follow as closely as possible the overall national distribution of buildings by type.
3. Each building type should be concentrated in the region or regions in which that type shows the greatest potential for cost savings and energy savings. However, each type should not be assigned exclusively to the region showing greatest promise.

The complex process by which sites have been selected for the institutional, environmental, and societal studies cannot be adequately described in one or two paragraphs. However, an attempt will be made to illustrate the general methodology for selecting these sites with the aid of Table II-17 and Table II-4. Table II-17 illustrates how stores are distributed among the various types of studies that have been discussed. The technical and economic studies were designed first. Once these studies were determined, each building type was analyzed in relationship to the required regional building population and the population of buildings

TABLE II-17

EXAMPLE DISTRIBUTION OF STORES

Climatic Region	H/C Cost Savings ^a	Heating Only		Heating & Cooling			Total
		Technical Studies	Economic Studies	Technical Studies	Economic Studies	Inst., Envir., Societal	
Phoenix	.326	6	1	2	0	0	9
Los Angeles	.267	1	0	1	6 ^b	1	9
Wash. D. C.	.262	0	0	4	0	2	6
Omaha*	.202	2	0	1	0	0	3
Boston*	.199	2	0	0	0	2	4
Madison*	.191	2	0	1	0	1	4
Charleston	.137	1	0	0	6	1	8
Ft. Worth	.116	1	0	2	0	0	3
Bismarck*	.06	1	0	0	0	0	1
Nashville	-.078	1	0	1	0	0	2
Miami*	-.747	0	0	0	0	0	0
Seattle*	-2.441	0	0	0	0	0	0
							<u>49</u>

*Collector area to roof area ratio > 1 for system designed to provide 70% of heating load.

a Cost savings for heating and cooling, \$/ft²-building, comparison with regional averaged electrical energy costs, 1 \$/ft²-collector amortized cost.

b Includes one store with dual purpose - Technical and Economic

by type to determine the number of buildings of each type within each region required in order to balance out the matrix. For the case of stores, approximately seven additional sites were required to balance the number of buildings by type. The next step was to determine which regions required additional sites in order to balance out regional populations. Of those regions which still required sites, those regions were identified which offered the greatest cost savings for stores, in this example. By virtue of the sites selected for the technical and economic studies portion of the program, the Fort Worth, Omaha, and Phoenix climatic regions required no additional sites to conform to regional populations. Since other building types offered less cost penalty than stores within the Nashville, Miami, and Seattle climatic regions, stores were not considered acceptable candidates in these regions. The number of stores which had been designated to participate in the institutional, societal, and environmental studies were then distributed among the Los Angeles, Washington, D.C., Boston, Madison and Charleston climatic regions. Since the Los Angeles climatic region required only two additional sites to comply with the regional population distribution, only one store was recommended, bringing the total number of stores to nine. Similar consideration resulted in the remaining selections indicated in Table II-18.

Another consideration which was kept in mind was the fact that other building types within a given region may offer greater cost savings than stores. For example, in the Charleston region restaurants offer considerably greater potential for cost savings than stores, and thus when selecting sites for the institutional, environmental and societal studies, three restaurants were recommended for the Charleston region as opposed to one store. The process just described is continued for each building type for all regions. Thus, through an iterative process, the best building type within each region, as well as the best region for a given building type were emphasized.

Furthermore, the collector area to building area ratio which was used to restrict the choices of building in the technical and economic studies portion of the program was relaxed when selecting sites for the institutional, environmental and societal studies. The relaxation of these constraints was made

on the basis that in many regions the optimal collector area may be considerably less than that required to supply 70% of the heating load. In addition, the constraint based upon the roof area or floor area of the building may be too restrictive, since in many cases parking lot areas and additional land space may also be available for solar collectors. Judgment was exercised, however, for those cases in which solar design data suggested that quite large collector areas would be required. Thus, for example, no heating and cooling demonstrations on hospitals were recommended for the region of Boston, Madison and Bismarck, and Omaha. Again, the basic data employed in selecting sites is found in the computer outputs in Appendix A. The results of this analysis are indicated in Table II-18.

b. Flexibility Considerations

It is worthwhile to point out again that the plan presented here, except for the promising technology studies and the air systems recommended for the heating only matrix study, is designed to employ direct heating, flat plate water systems. As was previously discussed, these systems appear to be the most widely applicable, the most readily available, and among the most economic. As discussed in Subsection B.1, many other systems will do the job although their costs are not well defined. We expect that many proposals will be made to conduct demonstrations which either do not conform with those suggested in this plan or which are of an entirely different concept. We also anticipate that a number of these proposed demonstrations will be worthy of serious consideration and possible selection. To ensure that the purposes for which the plan has been designed are not compromised, we recommend that any substitution of sites for the purpose of providing for the test of concepts not recommended in this plan be made among those listed in Table II-18. Similarly, we have viewed the institutional, societal, and environmental studies as offering the mechanism for incorporation of R&D cycles.

Within the U.S. alone, there are over 30,000 local building code variations. We thus suggest that when selecting actual demonstration sites for the institutional, societal, and environmental studies, every effort should be made to ensure that the sites selected will address issues which have not been

addressed by previous demonstrations within the given locality. Furthermore, since the states of Indiana, Colorado, Maryland, Montana, New Hampshire, North Dakota, Oregon, and South Dakota have state laws which affect the tax picture for solar heating and cooling systems, we recommend that the institutional, societal, and environmental studies group be used to conduct demonstrations within each of these states to evaluate the impact of these laws.

TABLE II-18

ADDITIONAL INSTITUTIONAL, ENVIRONMENTAL, AND SOCIETAL STUDIES
NUMBER OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	4	2	2	2		1	1	3		3	2	1	1	22
2.	Washington, D.C.	2	3	2	2	1	1				1	2	1		15
3.	Madison	1	3	1	1				2			1			9
4.	Los Angeles	1		1											2
5.	Charleston		1	1				3							5
6.	Bismarck	1	2		1										4
7.	Nashville	1	1								1			1	4
8.	Ft. Worth														0
9.	Omaha														0
10.	Seattle									1					1
11.	Phoenix														
12.	Miami	1												1	2
TOTALS		11	12	7	6	1	2	4	5	1	5	5	2	3	64

4. Summary of Commercial Demonstration Site Recommendations

The foregoing sections have explained in detail, through examples, the methodology by which demonstration sites have been selected. The purpose of this section is to provide an overview and summaries of these 200 recommended sites. A discussion of time phasing of the sites (when each demonstration should be conducted) is reserved for Section VII.B.

A general overview of the distribution of sites recommended for each of the basic categories - new, retrofit; heating, heating and cooling; SHAC system type - is illustrated in Table II-19. Several general points should be noted. Severe program timing constraints hamper the opportunity to demonstrate solar heating only on new buildings; thus the reason for the lopsided emphasis on retrofit heating only demonstrations. The heating and cooling portion of the program allows for greater flexibility to conduct demonstrations on new buildings. Our overall design guideline specifying a program containing equal numbers of new and retrofit demonstrations results in the requirement of a heating and cooling program which emphasizes applications on new buildings. This appears to be a logically favorable emphasis if the capital costs of installing solar systems on new buildings are indeed less than retrofitting existing buildings. Not only would the life-cycle cost of the system be lower, but the cost to the taxpayer may also be lower, depending on the extent of cost sharing by the program participants.

Table II-19 also indicates the emphasis placed on flat plate water systems. The reasoning behind this emphasis has been discussed in Subsection A.4. Note also that there is a greater variety of promising subsystems available for heating and cooling applications than for heating only applications.

TABLE II-19
SITE DISTRIBUTIONS
(OVERVIEW)

New vs Retrofit

	Heating Only	Heat & Cool	Total Numbers
New	15	84	99
Retrofit	46	55	101
Total Numbers	61	139	200

Critical SHAC Systems

	Heating Only	Heat & Cool	Total Numbers
Flat Plate Air	16	--	16
Water	36	120	156
Other	9	19	28
Total Numbers	61	139	200

TABLE II-20

DISTRIBUTION OF DEMONSTRATIONS BY REGION AND PURPOSE

Region Number	Representative City	Heating Only							Heating and Cooling						TOTALS ^f
		Parametric Studies	Promising Technologies	Economy of Scale Studies	Installation Learning Studies	Local Market Stimulation	Institutional/Envir./Societal	Sub-Totals ^f	Parametric Studies	Promising Technologies	Economy of Scale Studies	Installation Learning Studies	Institutional/Envir./Societal	Sub-Totals ^f	
1.	Boston	3	1					4	3 ^c	2	3	6 ^d	22	36	40
2.	Washington, D.C.	2					1	3	6	2	3		14	25	28
3.	Madison	5 ^a	1	3 ^d			1	10	1	1			8	10	20
4.	Los Angeles	2	1					3	8 ^c	3		6 ^d	2	19	22
5.	Charleston	3	1					4	1	1		6	5	13	17
6.	Bismarck	1	1					2	1	1			4	6	8
7.	Nashville	3						3		1			4	5	8
8.	Ft. Worth	6	1					7	7	3				10	17
9.	Omaha	3	1					4	2	1	3			6	10
10.	Seattle	1	1				1	3							3
11.	Phoenix	4 ^b	1		6 ^b	18 ^e		29	5	3				8	37
12.	Miami									1			2	3	3
TOTALS ^f		33	9	3	6	18	3	72	34	19	9	18	61	141	213

- a. Double counted with Economy of Scale Study
 b. Double counted with Local Industry Stimulation
 c. Double counted with Installation Learning Study
 d. One double count with associated Parametric Study

- e. Including Parametric Study and Installation Learning Study
 f. Including double counts

A summary of the recommended sites by climatic region and purpose is illustrated in Table II-20. As indicated, a number of demonstration sites are multi-purpose in nature. These demonstrations, which are identified by their reference to the footnotes in the table, are particularly critical in that failure of these to perform as designed will jeopardize the success of their associated purposes. Thus, it is important that those proposals to conduct these demonstrations be scrutinized with extra care to ensure that these demonstrations will be successful.

The total recommended set of 200 sites are shown in Table II-21 by building type by climatic region. This set is also presented from other viewpoints in Tables II-22, II-23, II-24, II-25, II-26, and II-27. Table II-21 illustrates a plan guideline to distribute sites according to regional population. This distribution is reasonably approximated when compared with Table II-3, except in the Phoenix region. As has been previously discussed, this region has received special attention due to the very favorable economic position SHACOB holds there. Table II-21 also illustrates the result of another design guideline - distribution of building types according to the fraction of each type's inventory in relationship to the total inventory of commercial buildings. This guideline was more difficult to attain for several reasons:

1. Relative economics (cost savings): Selection of buildings for the various strategies perturbed the distribution slightly.
2. Anticipated growth patterns in building types: While the inventory of shopping centers is small, this relatively new method of conducting retail business appears to be gaining increasing popularity. Thus, shopping centers are given some emphasis when compared with the inventory in Table II-4. Similarly, while the building inventory suggests a program containing 68 free-standing stores, these building types are losing favor to shopping centers. In addition, a program containing 68 stores was felt to place too much emphasis on one building type.

3. Exclusion of demonstrations on certain building types: We have not considered heating and cooling demonstrations on warehouses.
4. Provide coverage: According to the inventory of supermarkets, only two should be recommended in the program. However, supermarkets offer reasonable economics in more than two regions; thus, more than two were recommended.
5. Technical viability: While restaurants are historically large consumers of energy and may be considered as candidates for solar in this sense, they also require tremendous collector areas (far larger than the available floor space) in all but the most favorable regions. Thus, the number recommended is below that suggested by its inventory.

TABLE II-21
DISTRIBUTION OF DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	7	11	4	3		1	1	3		3	3	1	2	39
2.	Washington, D.C.	3	8	6	2	1	1	1	1		2	2	1		28
3.	Madison	4	3	4	3	1			2			1		1	19
4.	Los Angeles	4	3	9	2	1	2								21
5.	Charleston	1	2	8			1	5							17
6.	Bismarck	2	3	1	1		1								8
7.	Nashville	1	2	2				1			1			1	8
8.	Ft. Worth	3	3	3			2	3	1			1		1	17
9.	Omaha	1	3	3					1	1	1				10
10.	Seattle				1					1				1	3
11.	Phoenix		5	9	1	2	4	4		1				1	27
12.	Miami	2												1	3
TOTALS		28	43	49	13	5	12	15	8	3	7	7	2	8	200

TABLE II-22
HEATING ONLY DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	1		2								1			4
2.	Washington, D.C.		1		1			1							3
3.	Madison	3	1	2	1	1								1	9
4.	Los Angeles	1		1			1								3
5.	Charleston		1	1			1	1							4
6.	Bismarck		1	1											2
7.	Nashville		1	1				1							3
8.	Ft. Worth	1	1	1			1	1	1			1			7
9.	Omaha			2					1	1					4
10.	Seattle				1					1				1	3
11.	Phoenix		4	7		1	3	3		1					19
12.	Miami														0
TOTALS		6	10	18	3	2	6	7	2	3	0	2	0	2	61

TABLE II-23

HEATING AND COOLING DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	6	11	2	3		1	1	3		3	2	1	2	35
2.	Washington, D.C.	3	7	6	1	1	1		1		2	2	1		25
3.	Madison	1	2	2	2				2			1			10
4.	Los Angeles	3	3	8	2	1	1								18
5.	Charleston	1	1	7				4							13
6.	Bismarck	2	2		1		1								6
7.	Nashville	1	1	1							1			1	5
8.	Ft. Worth	2	2	2			1	2						1	10
9.	Omaha	1	3	1							1				6
10.	Seattle														0
11.	Phoenix		1	2	1	1	1	1						1	8
12.	Miami	2												1	3
TOTALS		22	33	31	10	3	6	8	6	0	7	5	2	6	139

TABLE II-24

RETROFIT, HEATING ONLY DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	1		1								1			3
2.	Washington, D.C.		1		1			1							3
3.	Madison	3	1	1	1	1								1	8
4.	Los Angeles	1					1								2
5.	Charleston		1				1								2
6.	Bismarck		1	1											2
7.	Nashville		1	1											2
8.	Ft. Worth	1	1				1		1			1			5
9.	Omaha			1					1						2
10.	Seattle				1									1	2
11.	Phoenix		4	6		1	3	1							15
12.	Miami														0
TOTALS		6	10	11	3	2	6	2	2			2		2	46

TABLE II-25

NEW, HEATING ONLY DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston			1											1
2.	Washington, D.C.														0
3.	Madison			1											1
4.	Los Angeles			1											1
5.	Charleston			1				1							2
6.	Bismarck														0
7.	Nashville							1							1
8.	Ft. Worth			1				1							2
9.	Omaha			1						1					2
10.	Seattle									1					1
11.	Phoenix			1				2		1					4
12.	Miami														0
TOTALS		0	0	7	0	0	0	5	0	3	0	0	0	0	15

TABLE II-26

RETROFIT, HEATING AND COOLING DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	2	6		3						1	1		1	14
2.	Washington, D.C.	1	2	2	1	1						1			8
3.	Madison		1	1	2				1						5
4.	Los Angeles	1	2	2	2	1									8
5.	Charleston		1	1				2							4
6.	Bismarck	1	1		1										3
7.	Nashville	1												1	2
8.	Ft. Worth	1	1				1	1							4
9.	Omaha		3												3
10.	Seattle														0
11.	Phoenix			1	1	1									3
12.	Miami	1													1
TOTALS		8	17	7	10	3	1	3	1	0	1	2	0	2	55

TABLE II-27
NEW, HEATING AND COOLING DEMONSTRATIONS

Region Number	Representative City	School	Office	Store	Shopping Center	Hospital	Church	Restaurant	Motel	Warehouse	Supermarket	Nursing Home	Social	Library	TOTALS
1.	Boston	4	5	2			1	1	3		2	1	1	1	21
2.	Washington, D.C.	2	5	4			1		1		2		1		17
3.	Madison	1	1	1					1			1			5
4.	Los Angeles	2	1	6			1								10
5.	Charleston	1		6				2							9
6.	Bismarck	1	1				1								3
7.	Nashville		1	1							1				3
8.	Ft. Worth	1	1	2				1						1	6
9.	Omaha	1		1							1				3
10.	Seattle														0
11.	Phoenix		1	1			1	1						1	5
12.	Miami	1												1	2
TOTALS		14	16	24	0	0	5	5	5	0	6	3	2	4	84

III. Site Selection Methodology

A. Objective

The two hundred demonstrations recommended in Section II.B represent hypothetical buildings and as such, cannot be implemented of itself. What must be done is to locate real buildings which conform to the sites recommended in the Systems Level Plan. The general mechanism ERDA has chosen to locate real candidate sites is the Program Opportunity Notice. Not all of these candidates will be permitted to participate in the program, however.

The objective of this section is to describe a process which can be employed to select real sites recommended for participation in the program from several hundred available candidate sites. Thus ERDA may wish to incorporate this process into their evaluation of responses to Program Opportunity Notices.

B. Approach

Real sites are selected to maximize the effectiveness of the demonstration by employing the goals of the program as general selection guidelines. These guidelines are, in part, expressed through the recommended two hundred hypothetical sites. Thus real sites must match those recommended in the plan. Many factors which determine whether a site will be a "good" demonstration cannot be incorporated into a generalized plan; they must be evaluated on a case by case basis. Furthermore, these site specific factors are divided into those which are amenable to numerical evaluation and those which are subjective and must be evaluated on their merits by a committee. Our overall approach is then to evaluate and rank a technical measure of effectiveness (See Subsection D) calculated by computer algorithm using the numerical values. The results of this evaluation will be submitted along with the qualitative factors for analysis by committee.

C. Methodology

The methodology by which several appropriate sites are selected from a large set of candidates is illustrated in Figure III-1 and described as follows:

FIGURE III-1: SITE SELECTION PROCEDURE

1. Site specific information is received either via a proposal in response to a Program Opportunity Notice or via an information gathering questionnaire, an example of which is illustrated in Figure III-2. It is anticipated that a large number of sites (on the order of several hundred) may be considered as a set of potential demonstration candidates.

2. Each potential demonstration candidate is manually checked against a set of technical constraints to determine which can be eliminated on a technical basis. As Table III-1 indicates, these technical constraints range from a building which is too old, to one which simply cannot be matched with the demonstration matrix. Thus, for example, if an existing warehouse in the Boston region is proposed as a potential demonstration candidate, but the demonstration matrix does not recommend a warehouse in this region, the candidate is eliminated from further consideration.

In addition, each candidate is considered as both a heating only and a heating and cooling candidate provided the requirements of timing, new vs retrofit, and recommended building types can be met. Site-specific constraints must also indicate the validity in considering each site for both. In this way, each site is provided maximum opportunity to participate in the program.

3. That set of sites having met the technical and plan constraints is then subjected to a computer algorithm (described in Appendix A) of the data amenable to numerical analysis and ranked by technical measure of effectiveness (see Subsection D). Since the probability is high that many sites might be acceptable as a heating only but not a heating/cooling demonstration and vice versa (as discussed above), the computer analysis and ranking is performed for each, the technical and plan constraints being taken into account in both cases.

4. The technical measure of effectiveness and ranking generated for each site as described above is combined with the qualitative ranking criteria. We visualize an interactive committee discussion to develop

the value of each criteria (the rating) for each site. Since the ratings may differ depending on the relative merits as a heating or heating/cooling demonstration, a separate rating is given for each demonstration type, where applicable. The weighting factors are applied to the rating given each criteria and the resulting product summed over all criteria for each site to yield a total site measure of effectiveness. All sites are then ranked in order of their total measures of effectiveness.

5. The ranking of the real sites then provides a guideline by which the better may be selected. Beginning at the top of the list, each site is checked with those demonstrations existing at the time of analysis to ensure that no duplication of that site will occur. By proceeding down the list, eliminating these sites already being conducted, the better sites of that total group of original candidates will be selected.

D. Technical Measure of Effectiveness

As mentioned in Subsection B, a computer algorithm combines several technical parameters into what is called the technical measure of effectiveness. These parameters are the annualized capital cost of the SHAC system normalized by the cost savings/year offered by the solar system, the ratio of collector area and total floor area, and the ratio of collector area and unshaded roof area (see Figure III-2). In addition, the ratio of the estimated fuel savings at that site to the national total estimated space heating and cooling load by that building type is computed. The product of the first three parameters yields the technical measure of effectiveness.

In order to calculate these numbers, the same basic methodology as described in Appendix A was employed. For these calculations, however, the fractions of heating and cooling loads to be supplied by solar resulting from minimum life cycle cost analyses were used. Thus we see that the higher the technical measure of effectiveness, the more cost effective will be the demonstration.

NAME: _____
ORGANIZATION: _____
ADDRESS: _____

FIGURE III-2

SUBMITTED BY: _____

ITC SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM
100 Main Street Warrenton, Virginia 22186 703 347 7900
ERDA Contract E (11-1)-2688

Solar Heating and Cooling Demonstration Project
Preliminary Information Request Form

Please circle appropriate answer or fill in where indicated.

1. Building type, School, Office, Manufacturing, Hospital, Library,
Other _____.
2. a. Orientation of long axis of building, degrees true _____ or
magnetic _____.
- b. Obstructions to the south? (Yes, No)
3. a. Is building proposed, in working drawings, an existing structure,
under construction, other _____.
- b. Construction schedule: estimated start date _____
estimated completion date _____.
- c. If existing building, what is estimated remaining lifetime (years)
_____.
4. a. If the building is not fully constructed, can the construction
schedule be delayed until solar is designed and construction
documents prepared. (Yes, No)
- b. Or, can building be prepared now for "Retro-Fit" of solar at a
future time. (Yes, No)
5. How many stories is building ____; square footage per floor _____.
6. If building is existing, how old is heating and cooling equipment? ____ yrs.
7. What type of heating and/or cooling system (chilled water, hot water,
direct expansion, heat pump, electric space heat, gas space heat, evapor-
ative cooling), other _____.
8. What is main source of power for cooling (electricity, gas, steam, oil),
other _____.
9. What is main source of heating (electricity, gas, steam, oil), other
_____.
10. What are present and expected fuel cost data, if readily available.
_____.
11. What square footage is available for collectors:
Unshaded roof area _____, unshaded parking area _____ and/or
unshaded land area _____.

Note: If assistance is needed in completing this form, please contact Robert
A. Padillo or Norris L. Beard of ITC at (703) 347-7900.

E. Committee Evaluation

The technical measure of effectiveness provides only one input to the total selection process. Some additional qualitative factors which must be considered are presented in Table III-2. Each of these factors is given a weight which provides a measure of the relative importance of each factor to the whole group of factors considered. Thus weights may be agreed upon by the committees or one individual may be delegated to assign the weights.

Each site is then evaluated by each committee member and values assigned to the factors. The values indicate how well the site addresses or affects each factor. The range of values which are to be assigned should be pre-set by committee to ensure that consistency will be maintained, and that the values assigned by one committee member will not over shadow those assigned by other members.

The product of the weight and value for each factor is taken and the resulting numbers are summed to yield an overall rating for that site, for each committee member. These overall ratings assigned by each member are then summed for all members to yield a "committee agreed upon" net rating for that site.

The above procedure is applied to each site and the resulting net ratings ranked in order of descending value. The final step simply involves checking each site to make sure no duplication of any of the two hundred sites will occur, and selecting those demonstrations which will participate in the program from the remaining candidates.

TECHNICAL AND PLAN CONSTRAINTS

- I. TYPE OF BUILDING FITS CATEGORIES CONSIDERED
- II. EXPECTED BUILDING LIFE > 15 YEARS
- III. OBSTRUCTIONS TO SOUTH
- IV. BUILDING IS LOW-RISE (3 STORIES)
- V. CONSTRUCTION TIME SCHEDULE WITHIN PROGRAM CONSTRAINTS
- VI. SYSTEMS LEVEL PLAN CONSTRAINTS

MATRIX

Region

Building Type

Heating or Heating and Cooling

New or Retrofit

Time Phasing

OBJECTIVES

Parametric Studies

Incorporate R & D and Promising Technology

Economy of Scale

Installation Learning Curve

Local Industry Stimulation

Identify Institutional Constraints

Variety of System Concepts

COMMITTEE RANKING CRITERIA

<u>CATEGORY</u>	<u>FACTOR</u>
Technical	<ul style="list-style-type: none"> ●Level of technical risk ●Usefulness of test and evaluation data ●Proposed technical innovation ●Employs mass-produced systems ●Uniqueness of application ●Replacement of scarce fuel
Economic/Financial	<ul style="list-style-type: none"> ●Level of financial risk ●Financial status of owner ●Extent of cost-sharing ●Owner intention to continue system use after program expires
Institutional/Societal/ Environmental	<ul style="list-style-type: none"> ●Extent of local visibility (impact) ●Extent of national visibility (impact) ●Owner status in community ●Revives local industrial capacity ●Small business involvement ●Stimulation of supply through systems selected ●Stimulation of demand through systems selected ●Address labor, code, or zoning issues ●Typicality of building ●Potential problems associated with haze, smog, or air quality ●History of deleterious weather conditions

IV. Test and Evaluation Plan

A. Introduction

The primary goal of the demonstration program is to show the ultimate economic viability of Solar Heating and Cooling. To do this in an efficient and effective manner requires a data collection procedure which is accurate, consistent, complete, timely and cost-effective. This is the purpose of the Test and Evaluation (T&E) Plan being prepared as a separate report. Presented here is a summary or outline of this plan which is intended to:

1. Provide adequate documentation at the end of the demonstration to permit
 - a. prediction of ultimate economic viability.
 - b. clarification of system design rules which minimize the cost/performance ratios for SHAC systems under different applications.
 - c. identification of those subsystems and components which offer best design and manufacturing opportunities
 - d. evaluation of the institutional, societal, and environmental impacts of the demonstration program
 - e. preparation and publication of final reports on each site and on the entire demonstration program.
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 program
 - b. the on-line performance of individual systems and subsystems
 - c. the effectiveness of various mechanisms for the identification and removal of institutional barriers.

B. Philosophy

To carry out these objectives, the T&E Plan requires thorough instrumentation at each site to measure and record specific engineering data as well as a national center to collect and process the site data. Specifically, we need a cost-effective way to accomplish the following:

1. Bring to a central point for processing all of the data necessary to describe and evaluate the engineering and economic performance of the SHAC system.
2. Provide on-site intelligence to assure the accurate, timely and complete collection of data from geographically scattered site locations.
3. Monitor each site and the entire demonstration program, comparing predicted and actual performance.
4. Promptly identify any operational problems at a site at the subsystem or component level.

C. National Requirements

To arrive at 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 Section II.A.2) $ES = E + aI + bZ + rB$, with the documented 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 and then solve for the 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 an accepted set of design rules. The T&E plan will contribute to this by examining the spectrum of system designs recommended for the program and characterizing their technical and economic performance, thereby indicating the optimal solutions and fostering the adoption of the most successful of these.

c. Component Evaluations

In a similar way, the components and subsystems will be evaluated. It should be possible to determine the more successful components as well as those for which further development is indicated.

2. Mid-Demonstration Analysis

a. Entire Demonstration Effectiveness

It is desirable at any time to be able to anticipate the effectiveness of the program 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 program 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 predicted and actual performances of subsystems and components will permit identification of incipient problems early enough to minimize their impact on the demonstration.

c. 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 early in the program to significantly improve the later sites in the program as well as to contribute to the creation of a future market.

D. 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, operational and economic data on the SHAC system and components as well as sufficient 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.

E. Site Specifics

As noted above, the site requirements include collecting the engineering, operational, and economic data to define the thermodynamics, economics, and operational history of the site.

Figure IV-1

TEST AND EVALUATION PLAN: DATA FLOW

The engineering data necessary to define the thermodynamic performance of the total site as well as the major SHAC system components is indicated in Table IV-1. The weather variables to be measured help determine the building load as well as the performance of the solar collector. The Building/SHAC listing is typical of the set of variables to be measured; a detailed list would vary from site to site. However, the required number of channels (64) is believed to be a likely lower limit*.

The operational data include maintenance logs, failure records, and analysis, and other factors which affect the SHAC system performance. Also of interest are variations in the patterns of weather or building usage. This data cannot be collected automatically, but will require T&E personnel to visit the site periodically if complete and accurate data is to be obtained about the reliability and maintenance experience with the SHAC equipment.

The desired economic data encompasses the site's economic experience: costs of installation, operation, maintenance and repair as well as the cost of alternate forms of energy. In addition to describing the current site experience, it may be appropriate to ascertain local trends in the relevant economic indicators and cost escalators to provide the national T&E management with material for the latter's economic predictions. Again, T&E personnel will have to visit the sites personally to collect this information.

F. Site Equipment

The T&E equipment installed at a site must be adequate to record engineering data like that outlined in Table IV-1 and will be chosen so as to meet the following constraints in a cost-effective way:

1. The T&E equipment must be capable of recording the data presented to it in both digital and analogue form with sufficient resolution and sampling rates to permit the desired engineering analysis to be performed subsequently. Data compression is a desirable characteristic.

* For details, the reader is referred to the Test & Evaluation Plan report being separately prepared.

TABLE IV-1
ENGINEERING DATA NEEDED FOR T&E PURPOSES (Preliminary)

Variable	# Channel	Range	Accuracy	Resident Storage Req (WDS) 6 x # Channels	Disk Storage (Bytes/Day) 96 x # Channels	Notes
<u>WEATHER VARIABLES</u>						
Ambient Temp.	8	-40 to 150°F	±0.5°F	48	768	Will include redundant channels for checking system Will require wet/dry bulb temp.(at .1°F accuracy)
Humidity	2	0 to 100%	±3%	12	192	
Barometric Pres.	1	26 to 31 MM	±0.2MM	6	96	
Insolation	8	0 to 250 Btu/ft²	±5 Btu/ft²	48	768	Will be measured for direct, diffuse, and orthoginal
Wind Speed	1	0 to 80 MPH	±1 MPH	6	96	
Wind Direction	1	0 to 360°	±2.5°	6	96	
<u>BUILDING/SHAC VARIABLES</u>						
Temp. at Crit. Energy Boundaries	24	30 to 400°F		144	2304	Velocity (0-800 ft/min) & cross area (ft) will be measured
Flow Rates Air	12	0 to 75K ft³/Min	±5 ft²/Min	72*	1152	
Flow Rates Fluid	6	0 to 60 GPH	.5 GPH	36*	576	Valve, pump & general control state. ID & Clock time for on state will be measured
System State	64	N/A	N/A	(Stored at end of on state)	6400	
				<u>378</u>	<u>12448</u>	

Assumptions for Storage Requirements

1. All variables will be sampled at 10 sec. intervals. This data will be accumulated in core for 15 min. calculations and compression will be performed.
2. At compression time the average and S.D. of all cited variables will be calculated and stored on disk.
3. Temporary core storage of X and X² will be required (X² will be double prec.) or six words of memory per channel.

2. Because the sites are geographically dispersed, the T&E equipment at each site must be very reliable and capable of remote diagnostic interrogation from a central site. Furthermore, the equipment must be capable of supporting the implied telecommunication requirements.

3. Because of the variability in SHAC equipment from site to site the T&E equipment should be modular and readily configured for a site to assure ease of installation. The latter characteristic underscores the desirability of a programmable unit.

4. Vendor selection should give particular attention to vendor reliability, widespread service and support organizations as well as an integrated product line to make system responsibility a meaningful possibility.

The first two constraints practically require on-site intelligence and it is fortunate that the advent of microcomputer systems have made this an economic possibility. In fact, for the channel requirements we estimate to be minimum (32 analogue channels @ 12 bit precision and 32 digital channels @ 1 bit precision), only a computer-based system is cost effective. With the capability of self checks as well as supporting the communication requirements, the computer based system is clearly the leading candidate as it can be used to:

1. Configure the system (via software) at a site in terms of the SHAC equipment to be monitored, the variable names, gains, units, and scan frequencies.

2. Scan the various channels, each at the rate specified in the configuration program.

3. Perform the indicated self checks on the SHAC equipment as well as the T&E hardware.

4. Support the telecommunication requirements (e.g., hand shaking and error control) with the Program Management Office for transmission of data to the central site and for test and reprogramming of the local system from the central site.

5. Provide local reports on site for use in maintenance and debugging, as specified in the configuration program.

Many of the major minicomputer manufacturers offer equipment that meet the above constraints. As explained in the separate Test and Evaluation Plan Report, we have selected Digital Equipment Corporation as the preferred vendor for a system consisting of:

1. Central Processing Unit (CPU) such as the DEC LSI-II (PDP 11/03) with 8K memory, expansion chassis, power supply.
2. Communication interface (1200 baud),
3. Disk storage such as DEC-RX-AA Floppy disc system (dual drive),
4. Two 16 bit parallel digital interfaces,
5. An analogue signal interface to convert the transducer outputs into computer-like (digital) signals such as the ADAC equipment designed for use with the LSI-II.

A schematic representation of the monitoring equipment is given in Figure IV-2.

A pilot experiment will be conducted to test the equipment and monitoring programs so that a complete software package will be available for the Phase II contractor. While limited in scope, this pilot program will be broad enough to evaluate all the essential elements of the T&E equipment at a site. The reader is referred to the Test and Evaluation Report for more details.

FIGURE IV-2: LOCAL MONITORING SYSTEM

V. Information Dissemination Plan

A. Technical Approach to Information Dissemination Planning

A plan to aggressively disseminate information to the public in general and the various segments of the building community is a primary objective of the national demonstration program. The purpose of the information dissemination plan is to expedite the diffusion of solar technology into the economy and to maximize to the fullest the benefits to be obtained from the demonstration program.

1. Identification of Users

The key step in information dissemination is the identification of potential users of information concerning solar heating and cooling technology. The results of a preliminary assessment of this subject, recorded in Table V-1, suggests several general classes of potential users and their response to the types of information they might require. It is important that the potential user base, or target audience, for ERDA demonstration information be carefully defined and classified to insure that all user groups of importance to ERDA are included and that user groups are logically stratified to allow specific dissemination and communication strategies to be developed for each group. The apparent similarity in types of information requirements suggests an arrangement of some of the users into groups, for example:

1. Architects and Planners;
2. Builders and Contractors;
3. Trade Unions and Trade Schools;
4. Developers and Real Estate Agents;
5. Engineers;
6. Financiers;
7. Insurance Underwriters; and
8. Lawyers and State, Local, and Federal Government Officers.

As appropriate, stratification will be done in accordance with existing classifications, such as the OMB Standard Industrial Classification Manual, to enhance compatibility.

Table V-1

BUILDING COMMUNITY INFORMATION REQUIREMENTS

Subgroup of Building Community	Information Requirements	Credible sources	Media	Suggestions and Comments
Architectural	(1) Specific design data and drawings preferably about buildings actually constructed	(1) Fellow <u>experienced</u> Architects and Engineers	(1) Architectural journals	Monthly news bulletins to architectural journals
	(2) Hardware suppliers	(2) <u>Sweet's</u> catalogue	(2) Sweet's catalogue	Educational films for universities
Engineering	(1) Solar design data	(1) HVAC/Solar engineers intimately associated with project	(1) Publications by HVAC industry	
	(2) Performance data	(2) Same as 1	(2) Same as 1	
	(3) Cost data (e.g. annualized capital cost of solar equipment per BTU delivered by solar, "Payback period")	(3) Same as 1	(3) Same as 1	
	(4) Design and performance guidelines	(4) American Society of Heating, Ventilating, Air Conditioning Engineers (ASHRAE)	(4) ASHRAE Guide	
	(5) Hardware suppliers equipment performance specs	(5a) <u>Sweet's</u> Catalogue (5b) Thomas Register and catalogue	(5a) <u>Sweet's</u> catalogue (5b) Thomas Register and catalogue	

Table V-1 (cont.)

BUILDING COMMUNITY INFORMATION REQUIREMENTS

Subgroup of Building Community	Information Requirements	Credible Sources	Media	Suggestions and Comments
General contracting	(1) Clear performance specs for solar energy systems, hardware suppliers, cost	(1) <u>Sweet's Catalogue</u>	(1) <u>Sweet's Catalogue</u> , Trade Magazines	Resolution at potential labor responsibility problems to insure that strikes are kept to a minimum
	(2) Construction specs	(2) Construction Specification Institute	(2) CSI Documents MP-2A, MP-2B (construction specifications)	
	(3) Mechanism to estimate construction costs and schedules	(3a) <u>Means Building Construction Cost Data</u>	(3a) <u>Means Building Construction Cost Data</u>	
		(3b) <u>Dodge Construction Scheduling Manual</u>	(3b) <u>Dodge Construction and Scheduling Manual</u>	
Financial	(1) Generally no different than any other business venture a. financial statement by building owner, credit worthiness b. cash flow analysis over projected life of building	(1) Certified Public Accountant		

Table V-1 (cont.)

BUILDING COMMUNITY INFORMATION REQUIREMENTS

Subgroup of Building Community	Information Requirements	Credible Sources	Media	Suggestions and Comments
Financial (cont.)	(2) General Exposure to solar system performance, reliability, cost	(2) Financial Mass Media	(2) Examples: <u>Fortune Magazine</u> , <u>Wall St. Journal</u> , <u>Business Week</u> , <u>Forbes</u>	
	(3) If requested, a certification of the solar energy equipment and performance	(3) requested professional engineer		
V-4 Trade and Technical schools	(1) General information on solar technology installation, main tenance. Solar technology only a subspeciality at this stage.	(1) Federal Government	(1) Films	Trades generally follow demand. Specialized training in solar only when sufficient demand generated
Public officials Federal, State, Local	(1) Economic Viability, primarily concerns a. Initial capital costs b. Life cycle costs c. Added costs for retrofit d. Costs of energy saved	(1) Experienced HVAC engineers.	(1) HVAC Industry Publications	Even though fuel costs rising sharply, public continues to be first cost sensitive because of low capital availability
	(2) System life expectancies	(2) Experienced HVAC engineers	(2) HVAC Industry Publications	

Table V-1 (cont.)

BUILDING COMMUNITY INFORMATION REQUIREMENTS

Subgroup of Building Community	Information Requirements	Credible Sources	Media	Suggestions and Comments
Public Officials; Federal, State, Local (cont.)	(3) Architectural aesthetics	(3) Federal, and in some cases, state art commissions must pass designs		
	(4) Technical system performance and operation	(4a) Experienced HVAC engineers (4b) ASHRAE	(4a) HVAC Industry publications (4b) ASHRAE guides	
Building owners, operators	(1) Maintenance records, ease of operation	(1a) Mass Media	(1a) Newspapers magazines television	
		(1b) Architects	(1b) personal contact	
		(1c) Mechanical Engineers	(1c) personal contact	
	(2) Performance as advertised	(2) Same as above	(2) Same as above	
Code Administrator	(1) Recommended code changes	(1) Anyone with substantial evidence that change will not present health, fire or other safety hazard	(1) Any, provided sufficient data presented to permit substantiation of recommended change code language prepared	

Table V-1 (cont.)

BUILDING COMMUNITY INFORMATION REQUIREMENTS

Subgroup of Building Community	Information Requirements	Credible Sources	Media	Suggestions and Comments
Code Administrator (cont.)	(2) manufacturer research reports providing sufficient data to permit performance analysis and code compliance of new product.	(2) Manufacturer's research division	(2) Research reports preferably in code language	(2) Three-four month process
	(3) Technical design and performance documents	(3) Government agencies, manufacturers, professional associations	(3) Any professionally prepared documents in standard code language	(3) Used as appendices to codes for new system
Labor and Trade Unions	Drawings of job which can be marked up	Architect/Engineer		Jurisdictional disputes generally resolved on local level. If trade jurisdiction unclear, time can be saved by holding a pre-job conference and mark-up called by contractor

Once user groups have been identified, national organizations representing these groups should be contacted to, first, verify assumptions and, later, to assay more precisely the information needs and the media appropriate to reach users. Examples of these national organizations might include the National Association of Builders, the American Institute of Architects, American Institute of Planners, The American Society of Heating, Ventilating and Air Conditioning Engineers, and so on. The approximate size of each segment of the potential user population will be established using statistics available from such sources as:

- (1) ERDA;
- (2) The HUD Statistical Yearbook;
- (3) The Statistical Abstract of the United States (U.S. Bureau of the Census);
- (4) Construction Report Series (Bureau of the Census); and
- (5) Current Housing Reports Series (Bureau of the Census).

2. Developing Dissemination Strategies

Analysis of the "Information Requirements" column in Table V-1, reveals the fact that there appear to be two quite distinct classes of information required by potential user groups. First, a general class of information is necessary to educate the lay public in any one group. Second, technical information is required to understand the actual steps in designing, installing and maintaining solar heating and cooling equipment. The information dissemination program must respond to requests for information and to aggressively seek out potential users to make them aware of the wealth of information available. It is assumed that once aware of information resources, users will respond with specific questions for technical information. Thus, it is mandatory that general information formats reference the more specific and technical information available.

Analysis of the "credible sources and media entries in Table V-1, suggests that some user groups rely on other potential user groups for information concerning solar technology. Building owners look to architects for designing systems into buildings, and architects depend on engineers to design solar-powered systems. The information dissemination program must ensure that potential users are made

aware of the decision processes of other potential groups especially where the decision process of one effects the other. While, in the interest of economy, dissemination responses can only be directed to limited information of interest to the potential user group, reference can be made to the information available to other user groups.

It is possible that during consultation with national organizations representing potential user groups, as suggested in the preceding section, the estimate of the scope of both technical and general information and a method for inter-relating the various classes of information required by the wide variety of potential users can be identified. In each user group, information needs should be defined in terms of user functional information parameters, such as priorities, content, timeliness, specificity, organization, and arrangement. Dissemination strategies will, in essence, allow potential users to learn of the range of available information and then make that total range of information available to them in an economical but comprehensive fashion.

3. Communication Strategies

It is necessary to identify a thorough but economic plan to use the available media to reach potential users and stimulate their use of the demonstration data base. Suggestions as to the proper media, as with information gathered in similar subtasks, can be solicited during the canvass of national organizations. Analysis of communication strategies for user groups should include:

1. Repackaging of highly technical information into more general and acceptable formats appropriate to categorized users;
2. Identification of optimum communication media for designated target groups; and
3. Development of innovative promotional media and formats to arouse general public interest in the field of solar heating and cooling.

A wide range of promotion techniques can be applied to meet the needs for communicating with each potential user group. These include:

- (1) Space advertising in general, consumer, technical, business, and trade media;

(2) Exchange advertising (publisher or publication provides free advertisements in return for published articles or other consideration);

(3) Cooperative promotion with other organizations;

(4) Direct Mail,

Supplement enclosure (enclose direct mail piece with shipment of a product supplement),

Enclosure mailing (use of business reply cards),

Cooperative enclosure (combining enclosures with those of another organization),

Selective list mailings;

(5) Press releases and feature stories placed in national and local communications media (e.g., radio, T.V., press, etc.);

(6) Multimedia presentations;

(7) Field/Phone solicitation (dedicated solicitation in the field and via telephone); and

(8) Trade show demonstrations, exhibits and handouts.

Trade journals, particularly the house organ of the national organizations representing potential user groups, are an especially credible source of information to various classes of users. Any communication plan should use this to its fullest, publishing short news fliers regularly and more technically substantial articles less frequently in those journals. Exhibits should also be planned for showing at national and regional conventions of user groups as an additional impact to articles in trade journals.

Mailing lists are commercially available based on almost any set of social, economic and demographic factors to target potential users. These mailing lists can be used initially in a very general way and, secondarily, to stimulate certain groups.

Each promotional technique should be evaluated and ranked based on criteria, such as:

1. Target Audience Priorities;
2. Relative Effectiveness of Technique;
3. Group Penetration Potential;
4. Group Motivation Potential; and, last but not least;
5. Cost.

B. Implementation of Dissemination

Since information from the demonstrations are not likely to be available early in the program, the information dissemination staff can effectively assess the parameters of dissemination as described in the technical approach section to design the actual approach to reach various user groups. Once this plan is found acceptable to ERDA and the Program Management Office (PMO, See Section VI), the information dissemination staff will commence to prepare dissemination packages as information is generated by the demonstration program. They will then disseminate information packages as planned and respond to requests for information as directed by the PMO.

1. Selection of Alternate Dissemination Packages

During the early months of the program the dissemination staff will carry out an analysis based on the technical discussion previous to this. Specific information packages will then be developed for each user group. Each package will be specific to:

1. Anticipated audience
2. Subject areas covered
3. Purpose
4. Content and source data
5. Frequency of issue
6. Mode of preparation
7. Media
8. Response time requirement

9. Method(s) of delivery
10. Method(s) of promotion
11. Anticipated utility
12. Anticipated cost

The variety of dissemination packages developed will be presented for review and approval to the PMO and ERDA.

2. Preparation of Dissemination Packages

As information becomes available in the course of the program, specific bits of that information will be translated with dissemination procedures into finished production-ready packages ready for dissemination. The input for these packages will be made available by the staff members of the PMO in charge of information dissemination. The finished work will include edited copy, completed artwork and layouts, renderings, illustrations, and exhibits.

3. Response to Inquiries

The information dissemination staff will respond to requests for information as the PMO directs. It is envisioned that these responses will be the routine supply of information from the stock of packages prepared in advance by the information dissemination program. In addition, the information dissemination staff will pass on responses received from outside the program to the PMO when the type of response does not fit the pre-established format.

VI. PROGRAM MANAGEMENT PLAN

A. INTRODUCTION

This section describes that organization which will provide ERDA with the program management necessary to ensure a successful Demonstration Program. The implementation of the National Solar Heating and Cooling Demonstration Program being a highly complex multi-purpose undertaking necessitates the establishment of an effective program management direction and control. In view of this fact, numerous management approaches, such as decentralized management and direct functional line management were reviewed, each being weighted against its effectiveness in achieving the management objectives. The Focal Point Program Management concept, structured to allow for multi-tiered subcontractor responsibilities, was finally chosen as being the most versatile approach in providing flexibility yet affording positive control. The use of optional multiple contracts, in addition, assures small business participation in one or all of the contracts.

B. OBJECTIVES

The management objectives which must be realized and which were considered in the final evaluation and selection of the proposed management organization, are best described as consisting of the following:

1. Provide ERDA with a flexible management plan for implementation of the National Solar Heating and Cooling Demonstration Program.
2. Provide focal point management, direction and control of demonstration site activities.
3. Provide a multi-contractor network to accomplish all facets of the Demonstration Program, stressing small business participation.
4. Insure independent data analysis of demonstration project results.
5. Provide procedures for accurate and timely dissemination of information.

C. MANAGEMENT ORGANIZATION

The organizational structure allows for distinct management levels, pseudo-independent such that while separate subcontracts are feasible, direction and control will be maintained through layered management functionally reporting through a line organization to the ERDA Program Manager. The proposed functional management levels are to be staffed, predominantly by HVAC experienced consulting engineering and architect-engineering firms selected by the standards and guides developed by General Services Administration and the American Institute of Architects. The specific management functions are Program Management (PM), Construction and Operation (C&O), Information and Dissemination (ID), and Test and Evaluation (T&E). The functional organization is depicted in Figure VI-1 and a general description of the management levels and their respective responsibilities follows.

1. Program Management Office (PMO): The PMO will provide the focal point management to ERDA. The PMO will be under the direction of a Program Manager supported by a technical staff and three functional element (tasks) managers. The tasks managers, as part of the PMO, will coordinate three functional elements within the PMO, namely, Construction and Operations (C&O), Information Dissemination (ID), and Test and Evaluation (T&E). The key areas of PMO responsibilities are summarized as follows:

1. Single point contact to ERDA, PON contractors and other Government agencies for site coordination activities.
2. Oversee progress to assure program success.
3. Technical and non-technical review, analysis and reporting, including preparation and delivery of all data items.
4. Assist ERDA as required in areas such as PON contractor/site selection, special reports, representation in meetings, PR press releases, etc.

FIGURE VI-1: FOCAL POINT MANAGEMENT FUNCTIONAL ORGANIZATION

2. Construction and Operation

a. General Approach

To be effective, the Construction and Operation phase must be carried out within an existing infrastructure, e.g., the building and trades industry. If the building and trades infrastructure is selected it is considered to be essential that the existing business structure; e.g., Architect-Engineer, Mechanical Contractor, builder, electrical, mechanical engineering design, and the various trades be utilized with a minimum disruption in the normal order of business. Elements of a construction management system that would be recognized by, and available to, the commercial construction industry were modified to meet the construction monitoring requirements of ERDA. The standard construction management system developed by the General Services Administration, and is known as the "Construction Management Control System (CMCS)", was evaluated and used where appropriate. In developing the CMCS for this plan, particular emphasis was placed on streamlining the organizational structure and emphasizing the need for qualified technical personnel with a background of broad participation in the mechanical/HVAC industry and solar energy application.

The organization and procedures that make up the CMCS must be streamlined and flexible to allow coordination of a variety of activities between ERDA and the PON demonstration teams, as well as permit improvement in monitoring methods as experience is gained from the demonstration construction work. The organization and procedures are covered in the following paragraphs.

b. Organization

(1) Construction and Operations Manager: The Construction and Operation Management is responsible for overall coordination of the construction and operational phases of the programs. The C&O management would oversee the demonstration sites field activities during the construction and operation phase and would perform the following functions:

1. Provide the interface between the PMO and the area/site activities.
2. Oversee site progress and provide technical and non-technical data inputs.
3. Provide PMO with consolidated status reports on demonstration projects, technical and non-technical data inputs as required, and special technical reports.
4. Execute proposed changes in demonstration projects, with remarks and recommendations, to the PMO.
5. Provide technical advice and assistance as required.
6. Participate, as PMO representative, in local meetings and recommend resolution of site oriented problems.

The Construction and Operations Management Office will be supported by the Area and Local managers, which represent multiple small business opportunities throughout the demonstration program.

(2) Area Manager: As presently envisioned, site construction management will be divided into three geographical areas, each managed by an A&E or Consulting Engineering firm with sufficient qualified staff to provide site construction support using local site construction management assistance as needed. Area Managers should be selected from consulting engineering or an architect-engineer firms with adequate staff and office(s) in their respective areas. The firms will be experienced in HVAC design and construction management. The Area Manager should have broad field construction inspection experience, management coordination experience in both field construction and construction contract negotiations. The Area Manager reports to and will perform functions similar to those of the Construction and Operation Management, for his assigned area, with the additional specific duties:

1. Provide for and assist local managers in on-site construction management.
2. Maintain consolidated records for all projects included in the contract with the Project Management Office.
3. Provide technical support for local managers, as required.

(3) Local Manager: The Local Manager, because of his close relationship with the Demonstration Team, represents the key element within the C&O management. His performance is necessarily sensitive to the success of the program and therefore his selection should be carefully considered. The Local Manager may be represented by a local consulting engineering firm with strong management interface experience in the HVAC/Construction industry. His qualifications and experience should parallel that of the Area Manager. The Local Manager reports directly to the Area Manager and will be responsible in performing the following functions:

1. Provide the interface between the Demonstration Team and the Program Management Organization.
2. Monitor the contractual performance of the Demonstration Team with respect to specific project objectives.
3. Provide technical advice and assistance to the technical team as required.
4. Review and comment on proposed contract changes as requested by the Area Manager.
5. Maintain active records on project status, problems, changes, etc., and submit periodic progress reports.
6. Coordinate activities associated with local meetings, presentations, etc.

c. Procedures

The following formal procedures must be established to ensure effective interface between ERDA, the PMO and the Demonstration Teams:

(1) Job Control: ERDA and the PMO shall jointly establish project schedules and cost controls that will account for the Federal assistance as well as assure timely completion of the project. The development of schedules will include consideration and timing for providing Federal assistance.

(2) Project Changes:

a) Changes in the construction project that affect the terms of the contract between ERDA and the Demonstration Team must be authorized by ERDA.

b) Value Engineering - Improvements in the project will be forwarded to ERDA through the PMO with comments and recommendations from the AREA and the C&O Managers.

c) Record of Changes - The C&O Manager will keep a duplicate record of all contract changes, including file copies of all documents concerned.

(3) Project Reporting System: If the contract between ERDA and the Demonstration Team does not include a description of the reporting system that will be used in order for ERDA to carry out its responsibilities in the Demonstration Project, the C&O Manager will develop such a system, using the GSA-developed CMCS as a guide. The C&O Manager will recommend the necessary arrangements for obtaining the data and information required to implement and maintain the reporting system.

The C&O Manager will prepare and forward to the PMO monthly progress reports for each Demonstration Project. Special reports on the Demonstration Projects will be prepared by the C&O as directed by the PMO.

(4) Project Records: The C&O Manager will maintain adequate files and/or records of all official correspondence, documents, and transactions pertaining to each Demonstration Project, in order that a complete project history will be available upon completion of construction of each project.

3. Information Management

a. General Approach

The Information Manager's primary responsibility is that of obtaining and distributing information which becomes available as a result of and during the

course of the demonstration program. The major activity of the Information Manager will be to coordinate the planning and work of the information task force (see Section V, the SLP plan) and to supply them with appropriate and timely information suitable for dissemination. In addition, the Information Manager will provide ERDA with responses to inquiries rising from the demonstration program and its information dissemination activity or he will direct the inquiry to the proper responding activity. Last, but not least, the Information Manager will, by established protocol, deliver information concerning the demonstration to either the HUD or ERDA data bank as applicable.

b. Organization

The Information Manager will have a small staff which will be responsible for handling and coordination of information to ensure its proper destination. That staff will primarily analyze information for its relevancy to potential user groups and ensure that it accurately represents the demonstration program. He will, in addition, provide the necessary liaison between all sources and users of information.

c. Procedure

(1) Program Initiation

The Information Management will establish two-way communication with the working dissemination task force. This communication is vital to initially establishing the Dissemination Plan as well as carrying out the dissemination program. The information management will, in a sense, provide a liaison between the working dissemination task force and the ERDA Program Manager, in securing approval of the Dissemination Plan, including individual dissemination packages, and in providing the Demonstration Program information for the working dissemination task force.

The first task of the information management is to initiate the dissemination planning discussed in detail in Section V of the Systems Level Plan. The Information Management will review the progress of the working Dissemination task force.

in identifying potential users, their needs and the appropriate means to reach them. With the authority of the Program Management Office, the Information Management will review dissemination plans and each of the proposed dissemination packages.

(2) Aggressive Data Dissemination

Several discreet groups of potential users of information from the demonstration projects will be identified as part of the dissemination planning discussed in Section A, Program Initiation. The information management will set up and maintain a data handling system which will allow various bits of information from the demonstrations to be categorized and filed according to potential user groups, then by schedule or demand, depending on the volume of information, the information dissemination staff will prepare individual files, one for architects, one for HVAC engineers, etc., for the working dissemination group. The information management will provide these dissemination packages to the ERDA Program Manager.

(3) Responsive Data Dissemination

The key to this effort is the liaison of the information dissemination staff (i.e., communication) with the different operations within the demonstration, ERDA via the Program Manager and the ERDA and HUD data banks. Thus, all requests for information pertaining to the demonstration should be relayed to the information management. It is envisioned that once received, requests will be handled in one of three general ways.

If the request for information can be answered with an information package prepared as part of the "aggressive" dissemination effort, the information dissemination staff will recommend that the request be answered with material in stock. If the request for information asks a question pertaining to some facet of the demonstration program but technically beyond the scope of stored information, then they will be referred to the ERDA Program Manager for direction. Lastly, requests for information beyond the Demonstration Program will be forwarded to the ERDA or HUD Solar Data Bank as appropriate.

4. Test and Evaluation

a. General Approach

The responsibility for T&E has been assigned as a totally independent function with a T&E manager reporting directly to the Program Manager. T&E Management will be supported by a sub-contractor(s) responsible for the implementation of the Uniform Test and Evaluation Plan. T&E Management will serve as the interface between the managers of the other functional elements, the Program Manager and the sub-contractor responsible for the five specific subtasks listed as follows:

1. Technical Data Collection
2. Data Processing
3. Analysis and Reporting
4. T&E System Equipment
5. Societal Data Collection

The Societal Data Collection subtask is one that may require the unique capabilities of firms experienced in the performance of opinion surveys. The "after" part of the Base Line Survey may be conducted by such a firm. The "before" part of the Base Line Survey will be performed as a requirement of the present Phase I contract.

b. Organization

The organization recommended to carry out the responsibilities of testing and evaluating each demonstration site in accordance with the UTE Plan is shown in Figure VI-2.

c. Procedure

A Uniform Test and Evaluation function will be performed under a separate sub-contract reporting to the Test and Evaluation section of the PMO. The UTE management will consist of five groups, as defined in the following sections.

(1) Data Collection: The role of this group is to assure that the necessary societal and technical data is collected. It will monitor (daily) the collection

FIGURE VI-2: UNIFORM TEST AND EVALUATION: MANAGEMENT STRUCTURE

of site data and take necessary actions to bring the T&E site systems back to the desired level of operation; visit sites periodically to collect reports on operational costs, maintenance logs, etc.; collect the needed statistical data on weather, insolation, conventional fuel systems and operating costing, building populations and use patterns; and amass bases for cost trend forecasts.

(2) Data Processing: 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. On a per site basis, consistency of data will be verified, smoothed, interpolated to fill in missing data as needed. The data will be normalized as required. Raw data will be compressed and reduced as much as possible. Upon completion of year's operation, life cycle cost analysis for each site will be performed. Statistical data base (from B/C above) will be developed and necessary scenarios for forecasts of performance prepared. Present and forecasted performance will be estimated monthly using available actual site data and remaining projected site data.

(3) Analysis and Reporting: 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. Sites needing attention will be identified by examining performance of demonstration sites and comparing with predicted performance. Problem areas will be diagnosed and proposed remedy recommended to T&E Program Manager for implementation. Subsystem performance will be studied and needed improvements identified. Recommendations will be published and the T&E manager advised on present and future installations. Reports on site performance will be prepared. This group will assist ERDA in collating and comparing results from various demonstrations and various conventional fuel alternatives.

(4) Systems Equipment: This group has the responsibility of providing the necessary hardware for the technical part of the T&E program. They will provide the necessary hardware for the data collection subsystems at the sites (as defined in the T&E plan); acquire basic equipment modules and dispose of as required; refurbish and modify equipment for re-use; and provide necessary

communications equipment. The group will supervise the equipment installation and removal; configure equipment needed and ship; install, debug systems and supervise attachment of transducers; disconnect and remove equipment at end of demonstration. This group is also responsible to provide assistance to Data Collection Group in case of hardware difficulties.

(5) Societal Data Collection: The completion of the Base Line Survey initiated during the Phase I contract will be one of the first tasks to be performed. A detailed plan for the performance of this survey will also be prepared during Phase I and made available. Additional surveys of "interested groups" will be designed and conducted as needed.

D. PROGRAM MANAGEMENT COSTS

Management costs by fiscal year to support the management level as outlined in Section VI are summarized in Table IX-3. Manpower requirements for each fiscal year are shown in Table VI-1. A schedule of major milestones for PMO management is enclosed as Figure VI-2.

TABLE VI-1
MANAGEMENT MANPOWER REQUIREMENTS
(Man-months)

<u>Contractor</u>	<u>Fiscal Year</u>				<u>Total</u>
	<u>1976-77Q</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	
Program Management Office	70	120	120	120	430
Site Management	39	111	108	64	322
Uniform Test & Evaluation	153	288	252	252	945
Information Dissemination	<u>11</u>	<u>30</u>	<u>30</u>	<u>30</u>	<u>101</u>
Total Man-months	273	549	510	466	1,798

FIGURE VI-2: PMO MANAGEMENT SCHEDULE

Milestone	Fiscal 1976					Fiscal 1977				Fiscal 1978				Fiscal 1979			
	1st	2nd	3rd	4th	TQ	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Sign Management Contract			▽														
2. Write RFP For Site Manager			▽														
3. Write RFP for UTE Manager			▽														
4. Write RFP for ID Manager			▽														
5. Review RFP Responses and Select Site Management Contr.				▽													
6. Review RFP Responses and Select UTE Management Contr.				▽													
7. Review RFP Responses and Select ID Management Contr.				▽													
8. Review PON Responses							▽				▽				▽		
9. Select Sites							▽				▽				▽		
10. Review Unsolicited Proposals															▽		
11. Technology Review and Feedback															▽		
12. UTE Operation and Data Analysis																	▽

VII. Program Coordination and Implementation

A. Introduction

Coordination between the various groups participating in the program is ensured by creating a focal point group - the Program Management Office (PMO). This group will coordinate the day to day operations of the Area Management, Information Dissemination Management and the Test and Evaluation Management. The purpose of this section is to describe in part, the primary interrelated management tasks which must be accomplished in order for the program to progress smoothly.

In addition to the management tasks, schedules associated with operation of the program itself (i.e., demonstration contract starts, deliveries of the test and evaluation equipment) are presented to provide the management function with planning tools.

B. Construction Scheduling and Phasing of the 200 Demonstrations

1. Construction Constraints

As mentioned in Section II.A.4, there are legal constraints which define separate scheduling requirements for the heating and the heating and cooling demonstrations. In addition, there are physical constraints which are generated by the time required to construct certain classes of buildings. Hospitals, for example, require a 36 to 48 month construction period. The total construction time required plus the additional lead time to include a solar energy alternative excludes new hospitals from the selection matrix. New schools pose a somewhat different problem in overall scheduling in that occupancy is required in late August or early September. It is much more desirable to have the bulk of the construction during the Spring, Summer, and Fall of the calendar year. However, adherence to this schedule cannot be maintained such that the buildings are completed at the desired time. We recognize that in some areas schedule slippages are likely to occur when construction activity and inclement weather happen at the same time. Construction times assumed for new buildings, including the solar alternative are shown in Table VII-1.

TABLE VII-1

ESTIMATED CONSTRUCTION TIMES

<u>Building Type</u>	<u>Actual Construction Times (Months)</u>	<u>Months Assumed For Study</u>
Low-Rise Office	6 - 12	12
Hospitals	24 - 36	36
Shopping Centers	12 - 24	18
Single Stores	3 - 6	7
Schools	12 - 24	14
Motel	6 - 12	9
Library	12 - 24	18
Church	6 - 12	9
Nursing Home	12 - 18	12
Social	3 - 12	8
Supermarket	12 - 24	18
Restaurant	3 - 6	7
Warehouse	6 - 12	8

Assumptions were also made regarding installation times for retrofit units. We assume that all retrofits can be installed within a five month period, regardless of the construction season. The basis for this is experience gained for the four NSF school projects in which both design and construction was accomplished for all cases in three months or less during the winter season of 1974.

Scheduling of the sites participating in the Institutional/Societal/Environmental Studies group were designed to produce a smoothing effect for site management so that the number of units requiring a level of effort by the site manager remained relatively constant. The smoothing has an additional benefit in that the number of test and evaluation installations is also smoothed.

2. Summary of Schedules

The actual schedules assigned to each site by climatic region have been reserved for Appendix D. However, a summary of the contract starts is presented in Table VII-2 by month, by region, and by purpose. A contract start represents the first month of installation except for the ILS, EOS, and duplication of purpose sites which are considered to be conducted under one contract.

C. Schedule of Primary Tasks and Decision Points

1. Overall Program Management

Since ERDA has limited manpower to manage a program of this scope, a management plan was developed which provides the required expertise to ERDA and at the same time is cost effective and flexible. Two early decisions are required: the selection of the National Demonstration Plan to be followed by the program management organization. Selection of the program manager office is required in February of 1976. This organization must immediately assist in the process of obtaining and contracting the other contractors to perform the PMO function. Simultaneously the PMO must work in concert with ERDA personnel in the actual site selections in accordance with the National Demonstration Plan. A schedule of the primary tasks assigned to the PMO is illustrated in Figure VII-1. Discussion of management organization and function is contained in Section VI.

FIGURE VII-1 PMO MANAGEMENT SCHEDULE

Milestone	Fiscal 1976				TQ	Fiscal 1977				Fiscal 1978				Fiscal 1979			
	1st	2nd	3rd	4th		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Sign Management Contract			▽														
2. Write RFP For Site Manager			▽														
3. Write RFP for UTE Manager			▽														
4. Write RFP for ID Manager			▽														
5. Review RFP Responses and Select Site Management Contr.				▽													
6. Review RFP Responses and Select UTE Management Contr.				▽													
7. Review RFP Responses and Select ID Management Contr.				▽													
8. Review PON Responses							▽				▽				▽		
9. Select Sites							▽				▽				▽		
10. Review Unsolicited Proposals															▽		
11. Technology Review and Feedback															▽		
12. UTE Operation and Data Analysis																	▽

REGION: BISMARCK		TABLE VII-2																								CONTRACT STARTS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	2									1							1																																
ILS																																																	
EOS																																																	
PT	2										1		1																																				
I/E	4																							1		1									1	1

QUARTERLY	0	0	1	2	0	1	0	1	1	0	0	0	2	0	0	0
YEARLY	3				2				1				2			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: FORT WORTH		TABLE VII-2																								CONTRACT STARTS																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	13								4				1		1		1	1			1				1		1			1	1																				
ILS																																																			
EOS																																																			
PT	4													1								1					1							1																	
I/E

QUARTERLY	0	0	4	1	3	1	2	1	2	2	1	0	0	0	0	0
YEARLY	5				7				5				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: CHARLESTON										TABLE VII-2										CONTRACT STARTS																					
		Fiscal 1976 & 1977T										Fiscal 1977										Fiscal 1978										Fiscal 1979									
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S				
PS	4									1		2			1																										
ILS	6																	1																							
EOS																																									
PT	2									1												1																			
I/E	5																										1	1	1				1		1

QUARTERLY	0	0	2	2	1	1	1	0	1	2	1	1	0	0	0	0
YEARLY	4				3				5				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: NASHVILLE										TABLE VII-2										CONTRACT STARTS																															
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	3									2	1																																								
ILS																																																			
EOS																																																			
PT	1																1																																		
I/E	4																	1				2										1

QUARTERLY	0	0	2	1	0	2	2	0	0	1	0	0	0	0	0	0
YEARLY	3				4				1				0			

(a) Purpose of demonstration
 (b) Number of demonstrations
 *One demo counted twice because of dual purpose.

PS - Parametric Study
 ILS - Installation Learning Study
 EOS - Economy of Scale

PT - Promising Technology
 I/E- Institutional, Environmental, Societal
 ■ - PS plus ILS plus EOS plus PT
 ▨ - I/E only

REGION: OMAHA		TABLE VII-2																								CONTRACT STARTS																									
		Fiscal 1976 & 1977												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	5						1				1	1									1	1																													
ILS																																																			
EOS	3																						1																												
PT	2										1										1																														
I/E

QUARTERLY	0	0	1	3	0	1	3	0	0	0	0	0	0	0	0	0
YEARLY	4				4				0				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MADISON		TABLE VII-2																								CONTRACT STARTS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
	*											1	2		1	*	1						1																										
PS	6											1	2		1	*	1						1																										
ILS																																																	
EOS	*															*	1																																
PT	2												1													1																							
I/E	9													1				1		1	1					1	1					1	1	1

QUARTERLY	0	0	0	4	3	1	3	0	3	0	1	2	0	0	0	0
YEARLY	4				7				6				0			

(a) Purpose of demonstration PS - Parametric Study PT - Promising Technology
 (b) Number of demonstrations ILS - Installation Learning Study I/E- Institutional, Environmental, Societal
 *One demo counted twice because of dual purpose. EOS - Economy of Scale

■ - PS plus ILS plus EOS plus PT
 ▨ - I/E only

REGION: PHOENIX										TABLE VII-2																CONTRACT STARTS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	9									*	1	* 2	*	1			1									1				2			1																
ILS	6											*	1																																				
EOS																																																	
PT	4									1					1				1								1																						
LMS *	18									*	1	* 3	* 4	3	1

QUARTERLY	0	0	2	10	3	1	1	0	2	2	0	1	0	0	0	0
YEARLY	12				5				5				0			

(a) Purpose of demonstration

(b) Number of demonstrations

* 5 double counted with heating only PS or ILS demos.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

LMS - Local Market Stimulation

■ - PS plus ILS plus EOS plus PT plus LMS

▨ - LMS only

REGION: BOSTON		TABLE VII-2																								CONTRACT STARTS																								
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	
PS	* 6								3									*	1			1	1																											
ILS	* 6																	*	1																															
EOS	3																									1																								
PT	3								1														1					1																						
I/E	22													2	1			3				4					1	1					1	2		2			2	3

QUARTERLY	0	0	4	0	3	4	7	0	3	1	3	2	2	3	0	0
YEARLY	4				14				9				5			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MIAMI		TABLE VII-2																								CONTRACT STARTS																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS																																																			
ILS																																																			
EOS																																																			
PT	1																																																		
I/E	2																	1																																	

MONTHLY TOTALS	10																																				
	8																																				
	6																																				
	4																																				
	2																																				

QUARTERLY	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
YEARLY	0				1				2				0			

(a) Purpose of demonstration
(b) Number of demonstrations

*One demo counted twice because
of dual purpose.

PS - Parametric Study
ILS - Installation Learning Study
EOS - Economy of Scale

PT - Promising Technology
I/E - Institutional, Environmental, Societal
■ - PS plus ILS plus EOS plus PT
▨ - I/E only

REGION: LOS ANGELES REGION										TABLE VII-2										CONTRACT STARTS																													
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	*10								1	1					1	1		1		1			1	1	1						*	1																	
ILS	*6																														*	1																	
EOS																																																	
PT	4								1										1						1						1																		
I/E	2																								1	1

QUARTERLY	0	0	3	0	1	2	2	3	3	2	0	0	0	0	0	0
YEARLY	3				8				5				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: SEATTLE		TABLE VII-2																								CONTRACT STARTS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	1											1																																					
ILS																																																	
EOS																																																	
PT	1												1																																				
I/E	1											1																																					

MONTHLY TOTALS	10																																				
	8																																				
	6																																				
	4																																				
	2																																				

QUARTERLY	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YEARLY	3				0				0				0				0				0				0				0				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: WASHINGTON, D.C.		TABLE VII-2																								CONTRACT STARTS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	8								2						2							1	1					1															1						
ILS																																																	
EOS	3															1																																	
PT	2																												1													1							
I/E	15								1			1			2		1	1	1	1	1	1	2	1			1														1	1

QUARTERLY	0	0	3	1	5	3	6	1	2	1	0	0	3	1	0	0
YEARLY	4				15				3				4			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

2. Demonstration Site Management

Site management is limited to the activities immediately associated with the solar portion of the system installation phase. In all cases, the assumption is made that this activity will center around the last five months of the construction activity. The management of sites can be coordinated with the help of Table VII-3 which indicates the number of sites in the last five months of construction. Tasks associated with site management are shown in Figure VII-2.

With the heavy emphasis upon the heating only experiments, the site management plan should be in operation by June of 1976. The Phoenix region requires a short duration, high level of effort not found in other management areas. There is no easy way to accomplish the goals of this part of the program and at the same time provide a uniform level of effort.

Selection of the area site manager contractor must be made in the April - May period of 1976 to provide them with sufficient time to staff their organization.

3. Testing and Evaluation (T&E) Management, Software Development Tasks

An early decision is required to select the Testing and Evaluation system manager. Software must also be developed early in the program so that equipment can be tested and delivered to the initial sites by October of 1976. This sub-contractor should be selected in mid-May. The schedule for this task is shown as Figure VII-3.

The management of both monitoring system installation and operation can be coordinated with the help of Tables VII-4 and VII-5, UTE Installations and UTE Operations. Installation of testing and evaluation equipment is assumed to occur during the final month of SHAC system installation, while operation (data collection) is assumed to occur for 12 full months beginning when SHAC system installation is complete. Furthermore, T&E equipment is assumed to be installed on all 200 demonstrations.

4. Information Dissemination Management and Implementation Tasks

These tasks are public relations oriented tasks. The primary objective is to collect information and to distribute it to an interested public. The public

body is composed of people with varied backgrounds, so the output must be geared to provide information which can be understood by all of these groups. This portion of the management task must start in advance of the demonstrations coming on line. It is necessary that this contract be let before construction of the first site is started. The schedule for the basic tasks are shown in Figure VII-4.

REGION: NASHVILLE		TABLE VII-3												MANAGEMENT											
		Fiscal 1976 & 1977T						Fiscal 1977						Fiscal 1978						Fiscal 1979					
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	3								1	2	3	3	3	2	1										
ILS																									
EOS																									
PT	1										1	1	1	1	1										
I/E	4										1	1	1	1	1			2	2	2	2	2	1	1	1

QUARTERLY	0	0	0	6	8	1	6	4	0	4	6	2	3	0	0	0
YEARLY	6			19			12			3						

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: FORT WORTH										TABLE VII-3																MANAGEMENT																							
		Fiscal 1976 & 1977T										Fiscal 1977										Fiscal 1978										Fiscal 1979																	
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	13									4	4	4	4	4	2	2	3	4	4	2	2	1				1	1	2	2	3	3	3	2	3	2	1	1	1											
ILS																																																	
EOS																																																	
PT	4													1	1	1	1	1												1	1	1	1	1	1	1	1	1	2	1	1	1	1						
I/E

QUARTERLY	0	0	4	12	10	14	5	0	4	8	11	7	4	4	2	0
YEARLY	16				29				30				10			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: BISMARCK		TABLE VII-3												MANAGEMENT											
		Fiscal 1976 & 1977T						Fiscal 1977						Fiscal 1978						Fiscal 1979					
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	2										1	1	1	1	1										
ILS																									
EOS																									
PT	2										1	1	1	1	1										
I/E	4																						2	2	2

QUARTERLY	0	0	0	5	5	3	6	1	0	0	0	6	7	6	1	0
YEARLY	5			15			6			14						

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: CHARLESTON		TABLE VII-3																								MANAGEMENT													
		Fiscal 1976 & 1977T										Fiscal 1977										Fiscal 1978										Fiscal 1979							
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	4										1	1	1	1	3	2	2	2	3	1	1	1	1																
ILS	6																					1	2	3	4	5	5	4	3	2	1								
EOS																																							
PT	2										1	1	1	1	1																								
I/E	5

QUARTERLY	0	0	0	6	8	7	4	10	14	11	9	9	6	1	0	0
YEARLY	6				29				43				7			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: OMAHA		TABLE VII-3																								MANAGEMENT																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	5												2	3	3	3	3	1								1	1	1	1	1				1	1	1	1	1													
ILS																																																			
EOS	3																								1	2	3	3	3	2	1																				
PT	2													1	1	1	1	1																	1	1	1	1	1												
I/E

QUARTERLY	0	0	0	5	12	3	1	9	9	3	4	3	1	0	0	0
YEARLY	5				25				19				1			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MADISON

TABLE VII-3

MANAGEMENT

		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
	*																*	*	*	*	*																														
PS	6													2	3	4	4	5	3	2	1	1			1	1	1	1	1																						
ILS																																																			
	*																*	*	*	*	*																														
EOS	3																1	2	3	3	3	2	1																												
PT	2													1	1	1	1	1																																	
I/E	9																1	1	1	1	1				1	1	2	2	2	1	2	1	2	2	2	2	2	2	3	3	2	2	2	1	1	1	1

QUARTERLY	0	0	0	2	16	18	8	8	7	7	9	7	7	4	2	0
YEARLY	2				50				30				13			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: BOSTON		TABLE VII-3																								MANAGEMENT																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	* 6										3	3	3	3	3				*	*	*	*	*																										
																			1	1	1	2	3	2	2	2	1																						
ILS	* 6																		*	1	2	3	4	5	5	4	3	2	1																				
EOS	3																																																
PT	3																																																
I/E	22																																																
																																			</

QUARTERLY	0	0	3	11	6	1	10	22	26	20	16	17	19	22	24	0
YEARLY	14				39				79				65			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MIAMI		TABLE VII-3																								MANAGEMENT																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS																																																	
ILS																																																	
EOS																																																	
PT	1																												1	1	1	1	1																
I/E	2																	1	1	1	1	1												1	1	1	1	1

QUARTERLY	0	0	0	0	0	2	3	0	0	0	0	0	2	6	2	0
YEARLY	0					5					0					10

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: LOS ANGELES

TABLE VII-3

MANAGEMENT

		Fiscal 1976 & 1977T										Fiscal 1977										Fiscal 1978										Fiscal 1979									
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S				
PS	*10											1	2	2	2	2	1		1	1	2	2	2	1	3	3	3	3	3	1	1	2	2	2	2	*3	*2	*1	*1	*1	
	*																																								
ILS	6																																								
EOS																																									
PT	4											1	1	1	1	1												1	1	1	2	3	2	2	2	1					
I/E	2																											1	2	2	2	2	1

QUARTERLY	0	0	0	8	7	2	6	7	14	16	14	11	14	6	0	0
YEARLY	8				22				55				20			

(a) Purpose of demonstration

PS - Parametric Study

PT - Promising Technology

(b) Number of demonstrations

ILS - Installation Learning Study

I/E - Institutional, Environmental, Societal

*One demo counted twice because of dual purpose.

EOS - Economy of Scale

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: SEATTLE		TABLE VII-3																								MANAGEMENT																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	1												1	1	1	1	1																																
ILS																																																	
EOS																																																	
PT	1												1	1	1	1	1																																
I/E	1												1	1	1	1	1

QUARTERLY	0	0	0	3	9	3	0	0	0	0	0	0	0	0	0	0
YEARLY	3				12				0				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

QUARTERLY	0	0	3	9	4	7	15	23	22	6	10	10	6	14	11	0
YEARLY	12				49				48				31			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

 - I/E only

FIGURE VII-2: SITE MANAGEMENT

Milestone	Fiscal 1976					Fiscal 1977				Fiscal 1978				Fiscal 1979			
	1st	2nd	3rd	4th	TQ	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Sign Site Management Contract				▽													
2. Staff Area Office				▽													
3. Monitor Site Installation																	
4. Monitor Site Reporting																	
5. Monthly Reports					▽▽▽.....												
6. Annual Reports									▽				▽				
7. Final Site Reports					as required												

FIGURE VII-3: TEST AND EVALUATION MANAGEMENT AND OPERATION

Milestone	Fiscal 1976					Fiscal 1977				Fiscal 1978				Fiscal 1979			
	1st	2nd	3rd	4th	TQ	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Sign T&E Contract				▽													
2. Hardware Design				▽													
a. Prototype				▽													
b. Environmental test				▽													
c. Design Review & First Article				▽													
3. Production Run									▽								
4. Installation																	▽
5. Software Design				▽													
a. Checkout & Debug				▽													▽
b. Operation																	
6. Data Collection																	▽
a. Technical																	▽
b. Non-technical																	▽
7. Data Evaluation																	▽
8. Forecasts																	▽
9. System Effectiveness Reports																	▽
10. Annual Reports					▽				▽				▽				▽

REGION: NASHVILLE		TABLE VII-4																								UTE INSTALLATIONS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	3													1	1	1																																	
ILS																																																	
EOS																																																	
PT	1																								1																								
I/E	4																								1

QUARTERLY	0	0	0	0	2	1	0	2	0	0	2	0	1	0	0	0
YEARLY	0				5				2				1			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: FORT WORTH														TABLE VII-4														UTE INSTALLATIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
PS	13													4					2			1	1								1		1		1	1		1

QUARTERLY	0	0	0	0	4	3	2	0	0	1	2	2	1	1	1	0
YEARLY	0				9				5				3			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: BISMARCK														TABLE VII-4														UTE INSTALLATIONS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	2													1											1																										
ILS																																																			
EOS																																																			
PT	2													1										1																											
I/E	4

QUARTERLY	0	0	0	0	2	0	1	1	0	0	0	0	2	1	1	0
YEARLY	0				4				0				4			

(a) Purpose of demonstration
 (b) Number of demonstrations
 *One demo counted twice because of dual purpose.

PS - Parametric Study
 ILS - Installation Learning Study
 EOS - Economy of Scale

PT - Promising Technology
 I/E - Institutional, Environmental, Societal
 ■ - PS plus ILS plus EOS plus PT
 ▨ - I/E only

REGION: CHARLESTON														TABLE VII-4														UTE INSTALLATIONS																											
Fiscal 1976 & 1977T														Fiscal 1977														Fiscal 1978														Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S																		
PS	4													1			2																																						
ILS	6																									1	1	1	1	1	1																								
EOS																																																							
PT	2													1																					1																				
I/E	5																																	1	1		1

QUARTERLY	0	0	0	0	2	2	0	1	3	3	1	2	2	1	0	0
YEARLY	0				5				9				3			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: OMAHA		TABLE VII-4																								UTE INSTALLATIONS																										
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979														
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S			
PS	5														2	1												1								1																
ILS																																																				
EOS	3																											1	1	1																						
PT	2																																						1													
I/E

QUARTERLY	0	0	0	0	2	2	0	0	3	1	1	0	1	0	0	0
YEARLY	0				4				5				1			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

- PS plus ILS plus EOS plus PT

☑ - I/E only

REGION: MADISON		TABLE VII-4																								UTE INSTALLATIONS																											
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979															
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S				
PS	* 6																2	1	1	*	1					1																											
ILS																																																					
EOS	* 3																			*	1	1	1																														
PT	2																1																		1																		
I/E	9																	1									1	1					1	1			1	1	1			1

QUARTERLY	0	0	0	0	0	6	2	1	2	1	2	1	2	1	1	0
YEARLY	0				9				6				4			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: PHOENIX		TABLE VII-4												UTE INSTALLATIONS																							
		Fiscal 1976 & 1977T						Fiscal 1977						Fiscal 1978						Fiscal 1979																	
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	9																*	*																			
																	2	2																			
ILS	6																*	*	*	*	*	*															
																	1	1	1	1	1	1															
EOS																																					
PT	4																																				
LMS *	18																*	*	*	*	*	*	*														
																	3	5	3	1	2	2	2

QUARTERLY	0	0	0	0	3	10	5	2	2	0	2	1	2	0	0	0
YEARLY	0				20				5				2			

(a) Purpose of demonstration
 (b) Number of demonstrations
 *10 Double counted with heating
 only PS or ILS demos.

PS - Parametric Study
 ILS - Installation Learning Study
 EOS - Economy of Scale

PT - Promising Technology
 LMS- Local Market Stimulation
 ■ - PS plus ILS plus EOS plus PT plus LMS
 ▨ - LMS only

REGION: BOSTON										TABLE VII-4										UTE INSTALLATIONS																														
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S													
	*																						*																											
PS	6													3										1			1	1																						
	*																						*																											
ILS	6																							1	1	1	1	1	1																					
EOS	3																																																	
PT	3																1																																	
I/E	22

QUARTERLY	0	0	0	0	4	0	0	3	5	5	3	4	2	5	8	0
YEARLY	0				7				17				15			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MIAMI		TABLE VII-4																								UTE INSTALLATIONS																								
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	
PS																																																		
ILS																																																		
EOS																																																		
PT	1																																																	
I/E	2

QUARTERLY	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
YEARLY	0				1				0				2			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: LOS ANGELES														TABLE VII-4														UTE INSTALLATIONS																						
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S													
PS	* 10													1	1							1		1			2	1					1	1		*	1													
ILS	* 6																																			*	1													
EOS																																																		
PT	4													1																				1																
I/E	2

QUARTERLY	0	0	0	0	3	0	1	1	2	3	3	2	3	3	0	0
YEARLY	0				5				10				6			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: SEATTLE		TABLE VII-4																																				UTE INSTALLATIONS													
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	1														1																																				
ILS																																																			
EOS																																																			
PT	1														1																																				
I/E	1															1

QUARTERLY	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
YEARLY	0				3				0				0			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: WASHINGTON, D.C.														TABLE VII-4														UTE INSTALLATIONS																					
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979											
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S												
PS	8													2						1					1										1				2										
ILS																																																	
EOS	3																																																
PT	2																																			1				1									
I/E	15													1									1	2		1		3	1	1						1			1	1

QUARTERLY	0	0	0	0	3	0	2	4	6	2	1	3	1	1	5	0
YEARLY	0				9				12				7			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: NASHVILLE														TABLE VII-5														UTE OPERATIONS																							
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	3																1	2	3	3	3	3	3	3	3	3	3	3	3	2	1																				
ILS																																																			
EOS																																																			
PT	1																								1	1	1	1	1	1	1	1	1	1	1	1	1														
I/E	4																								1	1	1	1	1	1	1	1	1	1	1	1	3	3	2	2	2	2	3	3	3	3	3	3	1	1	1

QUARTERLY	0	0	0	0	1	8	9	11	14	7	6	10	6	9	9	3
YEARLY	0				29				37				27			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: FORT WORTH		TABLE VII-5																								UTE OPERATIONS																								
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S													
PS	13														4	4	4	4	4	6	6	7	8	8	8	8	4	4	4	4	5	3	4	3	3	4	4	4	5	5	5	5	4	4	3	3	2	1	1	
ILS																																																		
EOS																																																		
PT	4																			1	1	1	1	1	1	1	1	1	1	1	1							1	1	1	1	1	2	2	2	2	3	3	3	2
I/E

QUARTERLY	0	0	0	0	8	12	22	27	19	16	10	12	17	19	17	12
YEARLY	0				69				57				65			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: BISMARCK										TABLE VII-5																UTE OPERATIONS																												
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979																
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S																	
PS	2																1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1																			
ILS																																																						
EOS																																																						
PT	2																1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1																			
I/E	4																																												2	2	2	2	3	4	4	4	4	4

QUARTERLY	0	0	0	0	1	6	6	11	11	6	6	1	2	6	11	12
YEARLY	0				24				24				31			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

QUARTERLY	0	0	0	0	2	6	12	14	16	21	22	26	27	23	17	11
YEARLY	0				34				85				78

- I/E only

REGION: OMAHA		TABLE VII-5																								UTE OPERATIONS																															
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979																			
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S								
PS	5																2	3	3	3	3	3	3	3	3	3	4	4	2	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1												
ILS																																																									
EOS	3																											1	2	3	3	3	3	3	3	3	3	3	3	3	2	1															
PT	2																1	1	1	1	1	1	1	1	1	1	1	1	1	1																											
I/E

QUARTERLY	0	0	0	0	0	9	12	12	15	14	12	15	14	7	6	3
YEARLY	0					33			56				30			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: MADISON		TABLE VII-5												UTE OPERATIONS											
		Fiscal 1976 & 1977T						Fiscal 1977						Fiscal 1978						Fiscal 1979					
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
PS	*																								
	6																								
ILS																									
EOS	*																								
	3																								
PT	2																								
	2																								
I/E	9

QUARTERLY	0	0	0	0	0	6	19	26	29	29	18	18	18	18	18	13
YEARLY	0					51			94				67			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: PHOENIX		TABLE VII-5																								UTE OPERATIONS																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	9																*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ILS	6																*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EOS																																																			
PT	4																																																		
LMS*	18

QUARTERLY	0	0	0	0	0	22	42	56	60	44	26	18	16	15	13	7
YEARLY	0					120				148				51		

(a) Purpose of demonstration

(b) Number of demonstrations

* 10 Double counted with heating only PS or ILS demos.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

LMS - Local Market Stimulation

■ - PS plus ILS plus EOS plus PT plus LMS

▨ - LMS only

REGION: BOSTON		TABLE VII-5																								UTE OPERATIONS																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
	*																								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
PS	6													3	3	3	3	3	3	3	3	3	3	3	4	4	4	2	3	3	3	3	3	3	3	3	3	2	2	2	1										
ILS	*																								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
	6																								1	2	3	4	5	6	6	6	6	6	6	6	6	5	4	3	2	1									
EOS	3																																																		
PT	3																	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
I/E	22

QUARTERLY	0	0	0	0	6	12	12	15	18	29	45	49	47	47	36	53
YEARLY	0				45				141				183			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

QUARTERLY	0	0	0	0	0	0	0	3	3	3	3	0	0	0	4	6
YEARLY	0				3				9				10

- I/E only

QUARTERLY	0	0	0	0	2	9	9	13	13	14	23	30	33	34	31	20
YEARLY	0				33				80				118			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E- Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

 - I/E only

REGION: SEATTLE		TABLE VII-5																								UTE OPERATIONS																									
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979													
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		
PS	1																1	1	1	1	1	1	1	1	1	1	1	1	1																						
ILS																																																			
EOS																																																			
PT	1																1	1	1	1	1	1	1	1	1	1	1	1	1																						
I/E	1																1	1	1	1	1	1	1	1	1	1	1	1	1

QUARTERLY	0	0	0	0	0	6	9	9	9	3	0	0	0	0	0	0
YEARLY	0					24					12					0

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

REGION: WASHINGTON, D.C.														TABLE VII-5														UTE OPERATIONS																						
		Fiscal 1976 & 1977T												Fiscal 1977												Fiscal 1978												Fiscal 1979												
(a)	(b)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S													
PS	8														2	2	2	2	2	2	3	3	3	3	4	4	4	2	2	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	3	3	2	
ILS																																																		
EOS	3																												1	1	2	2	3	3	3	3	3	3	3	3	3	2	2	1	1					
PT	2																																																	
I/E	15														1	1	1	1	1	1	1	1	2	4	4	5	4	7	8	9	9	9	9	9	9	8	6	7	6	6	4	3	3	3	3	4	5	5	5	4

QUARTERLY	0	0	0	0	6	9	11	20	24	39	42	37	34	20	20	27
YEARLY	0				46				142				101			

(a) Purpose of demonstration

(b) Number of demonstrations

*One demo counted twice because of dual purpose.

PS - Parametric Study

ILS - Installation Learning Study

EOS - Economy of Scale

PT - Promising Technology

I/E - Institutional, Environmental, Societal

■ - PS plus ILS plus EOS plus PT

▨ - I/E only

FIGURE VII-4: INFORMATION DISSEMINATION MANAGEMENT

Milestone	Fiscal 1976				TQ	Fiscal 1977				Fiscal 1978				Fiscal 1979			
	1st	2nd	3rd	4th		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Sign Information Dissemination Contract			▽														
2. Staff Offices			— ▽														
3. Release Monthly Newsletters				▽▽▽▽.....													
4. Publish Trade Journal Articles				▽		and as appropriate											
5. SHAC Training Programs						▽		▽		▽		▽		▽		▽	
6. Prepare Documentaries						as appropriate											

VIII. Phase II Deliverable Items

A. Introduction

The deliverable items presented in this section are intended to include the following:

1. All items directly related to individual demonstrations which are necessary for efficient program management and which provide inputs in support of the program goals;
2. Items which must be developed or assembled in support of execution of the T&E plan;
3. Program organizational requirements, action items, and reporting requirements for proper information utilization and dissemination; and
4. The overall plan products.

Most of the items are to be delivered by contractors to ERDA Program Management. However, several items within the information dissemination plan must be carried out by ERDA.

B. Deliverable Items for Demonstration Sites

1. Final Design Phase (commences at issuance of contract)
 - a. Monthly Progress Reports
 1. Progress to date
 2. Problems encountered, "Trouble Report"
 3. Acceptance test results
 4. System design changes
 5. Data shortages

b. Final Design Report

1. Detailed engineering design drawings
2. List of components, specifications, manufacturers, costs
3. Design calculations indicating assumptions employed, anticipated system performance, and costs.

2. Construction Phase

a. Monthly Progress Reports

1. Deviations from design specifications, components, etc.
2. Delivery schedule (items and lead times)
3. Identification of long lead time items and alternative suppliers
4. Description of construction anomalies, deviations from building codes; description of any exceptions obtained or corrective action.
5. Labor/management and trade jurisdictional disputes
6. Inspection report and summary of any deviations from specifications and drawings
7. Items received during month
8. Material, equipment, and labor costs (reported separately, by item or labor type)
9. Conformance to construction schedule

b. Final Construction Report

1. As-built drawings
2. Recommendations for future design modifications and/or construction procedures
3. Resolution of any problems identified in monthly reports but not resolved in those reports.
4. List of work performed by trades (related to trade jurisdictions)

3. System Testing and Shakedown Phase

a. Monthly Progress Reports, if required

1. Identify the nature and extent of all problems encountered and proposed or workable solutions
2. Identify all modifications made to system

b. Final Report

1. Validate system operational capability, reliability, and availability through application of the Acceptance Test Plan
 2. Itemized total project costs: Professional, labor, parts, equipment
4. Installation, operation and maintenance instruction manual for the as-installed system.

5. System Operation Phase

a. Monthly Summary Reports

1. Energy consumption by fuel type and end use
2. Typical building use pattern for that month
3. Description of unusual occurrences:

System failures

Weather, storms

Vandalism, etc.

Unexpected operating modes

4. System down time and reasons
5. Weather data, including insolation on a daily basis
6. Description of environmental or societal impacts observed
7. Percent of monthly energy load supplied by system

b. Daily Operations Site Log

c. Annual Site Analysis Report

1. Maintenance costs (labor and parts, identified)
2. Cost and amount of fuel saved
3. Best estimate of life cycle cost (Net Present Value, employing year of contract award as base year)
4. Observed social impact
5. Observed environmental impact
6. Performance of equipment: efficiency (or COP), reliability, durability, observed deterioration of equipment
7. All costs incurred by solar or related equipment, itemized
8. Explanations of all unexpected operational modes
9. Recommended changes in equipment design, materials, or construction procedures based on proposed solutions to any identified problems.

C. Testing and Evaluation Plan Requirements

1. Computation and Data Acquisition Facility
2. Site and Data Acquisition Center Telephone Lines
3. Software

To scan data for errors and faulty data

To convert data to usable form

To manipulate and analyze data for system performance, calculation of efficiencies, energy savings, etc.

4. Monthly Summary Site T&E Progress Reports

Test and data collection, equipment calibration

Operating problems with description of the nature of the problem and solutions employed

Assesment of actual performance with design specifications

Installation problems and solutions employed

5. Monthly Summary Progress Reports for overall T&E Program

Adequacy of all software to accomplish mission

Data link problems

Nature of data received, if faulty with assessment of problem's cause and suggested solutions

Recommendations for overall systems improvement

Summary of any unusual or unexpected solar/HVAC system operations as revealed through the T&E.

6. Environmental and Societal Baselines (See Environmental and Societal Evaluation Plan for details)

D. Final Site Report

1. Life Cycle Cost Analysis and Comparisons

2. Monthly SHAC System Costs Summary

Capital costs for all equipment, design and construction labor, etc.

Operating Costs - Maintenance labor, replacement parts, cost of equipment operation (pumps electrical energy consumed, for example)

Costs and amounts of energy saved

3. Performance and Operation Deviations from Design Specs

4. Hourly Insolation and Climatic Data Tables

5. Reliability, Maintainability, and Availability of System

6. Durability and Deterioration of System Components

7. Social Impact Analysis

8. Environmental Impact Analysis

9. Projected Energy and Cost Savings for Life of System.

E. Information Utilization and Dissemination Requirements

(Refer to the section containing the information utilization and dissemination plan for specific recommendations concerning the following items.)

1. National Solar Energy Information Centers
2. Regional Committees
3. Solar Energy Information Data Bank
4. Trade and Technical Journal Reports

Architectural

Solar engineering

HVAC engineering

Construction

Code administration

Labor, trade where appropriate

5. News Releases
6. Educational Films
7. Training Courses, Seminars
8. General Information Literature
9. Supportive Technical Reports
10. Manual and Handbook Updates
11. Monthly Newsletters

Architectural/Engineering/Code Administration

Construction/labor

Financial/legal

NOTE: Several of these items are currently being developed under guidance and support from ERDA (items 1, 3) while others are currently being provided (item 5) or are in the planning stage (items 6, 7). They are included here to indicate their importance in the successful execution of the dissemination plan.

F. National Demonstration Program Final Report

1. Economic and Life Cycle Cost Analyses
2. Projected energy and cost savings
3. Engineering Performance Evaluation
4. Societal and Environmental Impact Analysis
5. Evaluation of Technology Cycles

6. Owner Responses
7. Contractor Responses
8. Proposed Incentives
9. Remaining Barriers
10. Recommended Additional Research
11. Industry and Marketing Responses
12. Establishment of Learning Curves for Design and Construction
13. Establishment of Economies of Scale Relations
14. Analysis of Subsystem and Labor Costs

G. SHACOB Guideline/Design Manual

1. Design Methodologies for a variety of system configurations
2. Performance criteria
3. Economic comparison methods and cost analysis
4. Identification of pitfalls
5. Methods for avoiding adverse environmental impacts
6. System safety considerations
7. References
8. Data tables

IX. Resources Required

A. System Installation

Installed solar system costs for the demonstrations were estimated by assuming the cost of the solar system will be \$30/ft² for new installations, \$40/ft² for retrofit installations. System sizing was based upon the assumption that the collector area would be one-half the average building size for each type of building considered. A tabulation of average building size employed is shown in Table IX-1. Regional cost variations were not considered. Cost sharing was not factored into the installation cost figures. Cost reductions as a result of learning and cost increases due to inflation were assumed to cancel each other thereby yielding the fixed costs/ft² of the system.

Present uncertainties associated with the variables which affect total installed solar system costs make this simplistic approach in determining the dollar requirements to support the plan reasonable. The dollar amounts shown in Table IX-2 indicate the funding by regions. These figures represent the year funding is required, not necessarily the year the funds will be used.

As pointed out in previous sections, the legal constraints of overall program scheduling account for the large commitment in fiscal year 1977.

TABLE IX-1

AVERAGE BUILDING SIZE FOR VARIOUS BUILDING CATEGORIES

<u>Building Type</u>	<u>Average Size (ft²)</u>	<u>Collector Area Assumed</u>
1. Restaurants	1,400	700
2. Stores, Service stations	4,200	2,100
3. Supermarkets	12,500	6,250
4. Churches	16,300	8,150
5. Offices	16,000	8,000
6. Schools	25,600	12,800
7. Hospitals	60,000	25,000
8. Shopping Centers	63,075	31,500
9. Motels	20,500	10,250
10. Warehouses	13,000	6,500
11. Libraries, Museums	25,000	8,333
12. Hotels	50,000	N.A.

TABLE IX-2
ESTIMATED INSTALLED SYSTEM COSTS BY REGION AND FISCAL YEAR

<u>Region</u>	<u>Fiscal Year</u>				<u>Total</u>
	<u>1976+77TQ</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	
Boston	1,069	6,896	2,996	3,158	14,119
Washington	1,848	5,237	491	1,703	9,279
Madison	1,480	5,478	2,275	-	9,233
Los Angeles	901	4,177	2,294	-	7,372
Charleston	730	783	481	-	1,994
Bismarck	649	896	240	1,580	3,365
Nashville	425	1,003	333	-	1,761
Fort Worth	1,589	2,255	425	-	4,269
Omaha	752	1,595	-	-	2,347
Seattle	1,785	-	-	-	1,785
Phoenix	3,860	1,744	1,413	-	7,017
Miami	-	512	634	-	1,146
Total	15,088	30,576	11,582	6,441	63,687

B. Management and Test and Evaluation Hardware

Management costs as well as test and evaluation hardware costs by fiscal year to support the management level as outlined in Section VI are shown in Table IX-3.

TABLE IX-3
MANAGEMENT COST
\$, Thousands

<u>Management Task</u>	<u>FY1976-77TQ</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>Total</u>
Program Management	609	632	655	687	2,583
Construction & Operation	274	869	849	531	2,523
Uniform Test & Evaluation	392	854	533	818	2,897
Information Dissemination	52	366	215	469	1,102
UTE Site Hardware	<u>1,700</u>	<u>1,700</u>	<u>350</u>	<u>350</u>	<u>4,100</u>
Total Management	3,027	4,421	2,902	2,855	13,205
Total Management Less Hardware	1,327	2,721	2,552	2,505	9,105

C. Total Resources Required

Total resources to accomplish the tasks indicated in this plan are shown in Table IX-4.

TABLE IX-4

TOTAL PLAN COST

\$, Thousands

	<u>FY1976-77TQ</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>Total</u>
Management	3,027	4,421	2,902	2,855	13,205
Demonstration	<u>15,088</u>	<u>30,576</u>	<u>11,582</u>	<u>6,441</u>	<u>63,687</u>
Grand Total	18,115	34,997	24,484	9,296	76,892