InterTechnology Corporation
Proposed
Criteria and Recommendations for Selection of
PON Non-Residential Demonstration Sites
National Solar Demonstration Program

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.

ERDA Report No. COO-2688-76-11
ITC Report No. 081076
Contract No. E(11-1)2688

December 1976

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 Criteria and Recommendations for Selection of PON Non-Residential Demonstration Sites," was prepared as part of the requirements under contract E(11-1)2688. It is not intended to reflect an ERDA plan or position.

CRITERIA AND RECOMMENDATIONS FOR THE SELECTION OF DEMONSTRATION SITES

I. Introduction

To ensure that the Demonstration Program will be most effective in achieving the goals stated in P.L. 93-409, a rational basis for selecting demonstration projects must be developed and implemented. Such has been the objective of the Systems Level Plan and the Techno-Economic Cost/Benefit analysis.

The objective of the Techno-Economic Cost/Benefit analysis was to determine the number of federally funded demonstrations required to stimulate mass production of solar heating and cooling equipment to supply a self-perpetuating commercial market. Intimately involved was an analysis of the level of federal funding required and the cumulative and yearly energy savings which would likely result from each funding level. A parametric study of variations in levels of federal funding indicates that over a 5 year period, 667 small commercial demonstrations requiring federal support of 75 percent of system first costs and 90 percent of annual maintenance costs would yield the desired result. In no case was it found advantageous to conduct more than one demonstration on the same building type in the same region in a given year. A candidate demonstration became a funded demonstration only when the system life cycle cost, based on the privately contributed monies, became lower than conventional system life cycle costs.

Additional studies currently under way seek to determine the most effective manner in which a Federal building's solar heating and cooling program can or should interact with the National Demonstration Program for non-residential buildings. Preliminary results from this study indicate that the primary objective of a program for federal buildings should be to provide a market of sufficient size to support mass-production of solar heating and cooling systems.

The basic objective of the Systems Level Plan (Task 1) was to recommend various techniques for implementing the Demonstration Program so that all issues involved (technical, economic, and environmental/institutional) would be addressed in a rational manner. The plan was developed for a demonstration program containing 200 sites. The number of sites was specified by

ERDA prior to the completion of the techno-economic model; thus the reason for the difference in the numbers considered in the two tasks. ERDA recognized the diversity of potential approaches which could be taken in conducting a demonstration program. Consequently, two firms, InterTechnology Corporation and General Electric Company (ITC and GE), were contracted to independently develop program plans and cost/benefit analyses. It is expected that ERDA will use those studies to assist in developing the generalized final program.

This report has been prepared with the objective of providing ERDA with recommended procedures for implementing the strategies set forth in the Systems Level Plan which are considered essential to the success of the National Demonstration Program. In order to logically develop these recommendations, this report is divided into three sections:

- A. Overview of the Demonstration Program to date.
- B. Essential Overall Program Strategies.
- C. Candidate Screening and Selection Criteria.

II. Overview of Program to Date

In developing this overview, no consideration has been given to the four early NSF school experimental projects or to federal buildings which have been or may be implemented with solar systems. It was felt that the four NSF school projects were grossly uneconomical from a life-cycle cost point of view (indeed, they were not intended to be) nor employed solar collectors representative of currently marketed products. Federal buildings equipped with solar, while providing a production incentive, do not adequately address the many issues for which the commercial demonstration program is intended.

The demonstration projects which have been considered here include those selected from respondents to the first Program Opportunity Notice (PON DSE-75-2), General Electric design projects and InterTechnology Corporation design projects, which were developed during the ERDA sponsored program entitled "Solar Heating and Cooling, Commercial Buildings, National Solar Demonstration Program," and the NSF sponsored non-federal building projects, except for the four previously mentioned schools. A summary of these

projects by source and solar system function is illustrated in Table 1. The 32 projects selected from the PON respondents have been approved for funding by ERDA; the remaining eleven candidates selected and designed by InterTechnology Corporation and General Electric have been invited to submit proposals based on their designs.

The number of projects selected which involve cooling is surprising when the relative economics of these systems are compared with conventional reciprocating compressor systems. The emphasis on hot water and space heating plus hot water is, however, justified (53% of the total number of projects), as these systems compare more favorably with conventional systems from a life cycle cost point of view.

During the Phase 1 program, extensive use has been made of the concept of climatic regions (see Figure 1). These are regions of significantly different weather and insolation patterns. Thus building heating and cooling loads vary significantly from region to region as do expected performance of solar heating and cooling systems. Table 2 illustrates both the distribution of demonstrations and population in these regions.

The number and type of buildings are also important considerations for the Demonstration Program. Table 3 illustrates an approximate distribution of demonstrations according to building type and solar system function. The distribution is approximate because in several cases, the exact use of the building was not well defined and in others, the building served two or more purposes (e.g. office plus warehouse). The importance of a given building in a given region is provided by the total energy consumed for space heating (and cooling) by all buildings of that type in a given region. These relative importances are provided by Tables 4a and 4b. Thus, for example consideration must also be given to the type of system and/or components of the solar system. A highly simplified distribution of systems and components is presented in Table 5. As can be seen, a good start has been made in addressing a number of promising collector types and systems. This distribution is believed to be reasonably accurate, although

Table 1
NUMBER OF DEMONSTRATION PROJECTS

SOURCE	<u>SOLAR SYSTEM FUNCTION</u>					
	<u>Heating</u>	<u>Cooling with or w/o HW</u>	<u>H/C with or w/o HW</u>	<u>Heating and HW</u>	<u>Hot Water</u>	<u>Total</u>
PON	5	1	8	12	6	32
ITC	4		1		3	8
GE			1	2		3
ERDA/NSF		1	10			11
TOTAL	9	2	20	14	9	54

Table 2

DISTRIBUTION OF DEMONSTRATIONS
BY CLIMATIC REGION

<u>Regional Designator</u>	<u>Number of Demonstrations</u>	<u>Percent of 1975 U.S. Population (Continental)</u>
1. Eastern/Great Lakes	4	29.2
2. Mid Atlantic	13	13.6
3. Mid West/Down East	3	10.2
4. Far West	6	9.9
5. Southeast	5	8.6
6. Northern Plain	6	5.3
7. Central Humid	3	8.3
8. Southern Plain	3	5.0
9. Central Plain	2	4.6
10. Pacific Northwest	0	1.5
11. Southwest	3	1.9
12. Southern Florida	3	1.9
13. Outside Continental U.S.A.	3	-

Table 3

DEMONSTRATION PROJECTS
BY BUILDING TYPE AND FUNCTION

<u>Building Type</u>	<u>Heating</u>	<u>SOLAR SYSTEM FUNCTION</u>				<u>Total</u>
		<u>Cooling with or w/o</u>	<u>H/C with or w/o HW</u>	<u>Heating and HW</u>	<u>Hot Water</u>	
Office	4		5	4		13
Motel (Hotel)		1		1	3	5
Warehouse	2			1		3
Restaurant				1	1	2
Recreational			6	3		9
School (1-12)			5	1		6
Firehouse	1			1		2
Laboratory (Film)					1	1
Laundry					1	1
Fieldhouse				1		1
Hospital					1	1
Light Mfg.	1	1	1			3
Clinic/Office				1		1
Library	1					1
Central Plant			1		1	2
School (Voc, Univ)					1	1
Store			1			1
Auditorium/Classroom			1			1
Totals	9	2	20	14	9	54

REGION NUMBERS
(For descriptive names see Table 2)

SUM (BY BLDG)		12	11	8	5	4	7	9	2	6	3	1	10	
BUILDING TYPE	HOTEL	25.23	0.01	0.21	0.64	0.77	1.21	1.64	1.57	3.04	2.65	4.49	8.84	0.16
	LIBRARIES - MUSEUM	14.21	0.01	0.11	0.34	0.40	0.64	0.92	0.88	1.75	1.51	2.56	4.87	0.22
	SHOPPING- CENTER	33.91	0.00	0.16	0.59	0.36	0.67	2.42	2.28	4.64	4.06	6.90	11.38	0.44
	MOTEL & NURSING HOME	149.00	0.09	1.16	3.82	4.68	7.78	9.48	9.11	17.70	15.34	25.98	51.52	2.33
	WAREHOUSES	202.63	0.07	1.42	4.42	0.95	7.48	13.89	13.20	26.28	23.02	38.55	69.97	2.97
	OFFICE - BUILDING	297.10	0.13	2.32	7.19	8.27	13.61	19.38	18.46	36.39	31.49	53.45	101.90	4.51
	MEDICAL- INSTITUTION	83.39	0.06	0.71	2.18	2.69	4.40	5.30	5.04	9.90	8.48	14.48	28.84	1.32
	EDUCATIONAL	377.37	0.16	2.94	9.12	10.49	17.28	24.61	23.47	46.19	39.98	68.02	129.38	5.72
	RELIGIOUS & RECREATIONAL	210.41	0.14	1.88	7.44	7.26	11.79	13.15	12.53	24.42	20.96	35.70	71.77	3.37
	RETAIL- SUPERMARKET	21.42	0.00	0.13	0.44	0.42	0.74	1.37	1.31	3.73	2.26	3.82	6.89	0.30
SINGLE STORE & SERV. STAT.	550.87	0.47	4.57	13.81	17.34	28.12	33.15	31.72	74.66	53.18	90.75	193.10	10.01	
RESTAURANT	151.67	0.12	1.40	3.99	5.09	8.69	9.58	9.18	17.78	13.89	26.59	52.90	2.47	
SUM (BY REG) =		1.26	17.02	53.98	58.72	102.41	134.89	128.75	266.48	216.83	371.68	731.37	33.81	
TOTSUM=		2117.21												

Table 4a
ENERGY REQUIRED (MILLION BTU)
HEATING ONLY/ELEC AS CONVENTIONAL FUEL
SOLAR COST \$1/SQFT/YR, 35% HEATING LOAD

REGION NUMBERS
(For descriptive names see Table 2)

SUM (BY BLDG)		12	11	8	5	4	7	9	2	6	3	1	10	
BUILDING TYPE	HOTEL	46.97	1.18	0.85	2.42	3.94	2.94	3.67	2.42	6.44	3.13	5.63	13.96	0.39
	LIBRARIES - MUSEUM	28.31	0.75	0.48	1.48	2.50	1.68	2.27	1.38	3.92	1.81	3.28	8.46	0.28
	SHOPPING- CENTER	83.03	2.64	1.51	4.58	7.59	4.53	7.06	4.13	12.25	5.14	9.41	23.51	0.67
	MOTEL & NURSING HOME	303.30	8.88	5.75	16.72	26.84	21.22	23.97	15.62	41.93	18.89	34.72	85.63	3.12
	WAREHOUSES	339.04	33.05	5.77	15.59	5.23	17.46	25.88	18.17	46.00	25.70	44.51	98.20	3.47
	OFFICE - BUILDING	538.45	14.07	10.40	28.07	44.17	33.55	42.09	27.84	74.66	36.85	65.50	155.67	5.57
	MEDICAL- INSTITUTION	175.95	4.79	3.00	9.36	16.02	11.48	14.10	8.45	24.18	10.50	19.67	52.61	1.81
	EDUCATIONAL	629.23	13.90	10.37	30.05	48.00	36.55	48.43	32.85	85.34	45.30	80.49	191.15	6.81
	RELIGIOUS & RECREATIONAL	314.90	5.25	4.12	18.61	23.86	17.33	23.19	15.42	39.32	22.64	39.17	102.33	3.66
	RETAIL- SUPERMARKET	44.69	1.21	0.78	2.25	3.60	2.52	3.43	2.17	8.63	2.74	4.99	11.97	0.40
	SINGLE STORE & SERV. STAT.	936.21	22.05	16.92	45.49	71.91	58.57	67.21	46.28	145.49	61.36	108.90	280.19	11.85
	RESTAURANT	233.54	4.40	3.41	10.89	18.39	13.14	17.62	11.69	30.04	15.20	29.56	76.49	2.71
SUM (BY REG) =		112.18	63.37	185.50	272.06	220.97	278.92	186.44	518.20	249.28	445.82	1100.16	40.74	
TOTSUM =		3673.62												

Table 4b
ENERGY REQUIRED (MILLION MBTU)
HEATING & COOLING/ELEC AS CONV. FUEL
SOLAR COST \$1/SQFT/YR

Table 5

DEMONSTRATIONS BY COLLECTOR TYPE

Flat Plate	
Water	36
Air	6
Evacuated Tube	5
Fresnel Lens Concentrator	4
Parabolic Cylinder	1
Passive Heating	1
Stationary Reflector/Moving Absorber	2

Table 6

RELATIVE "VISIBILITY" OF DEMONSTRATIONS
ACCORDING TO LOCAL POPULATION*

Number of Demonstrations	Percent of Total Number	In Areas Having 1970 Populations [†] Less Than
6	11.7	10,000
13	25.5	50,000
17	33.3	100,000
25	49.0	500,000
29	56.9	1,000,000
46	90.2	5,000,000
49	96.1	10,000,000
51	100.0	50,000,000

These 51 demonstrations are in areas whose sum total population represents 36 percent of the total 1970 population.

* Note: Three demonstrations are outside the Continental U.S.

+ Note: Populations of large metropolitan areas are included if the demonstration is within such an area. The metropolitan areas are those defined by Rand-McNally.

clear details concerning the demonstration systems are either lacking or subject to change as final designs go out for bids.

Finally, consideration must also be given to the "availability" of demonstrations to the population. One may consider the local population around a demonstration as providing a measure of that demonstration's "visibility" or "availability" to the population. This measure is presented in Table 6 as the cumulative distribution of the number of demonstrations in local areas, each of which has a local population below a given level.

III. Essential Overall Program Strategies

As stated earlier, the objective of the Phase I program was to develop techniques for implementing a demonstration program which would address the many issues involved. The first step in that program was to identify those issues. It was observed that each issue 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 2. Each of these categories was then viewed as representing a strategic approach for the attainment of the program's goals. It is important that the Program Opportunity Notices address the concepts behind each strategy which are clarified below.

A. Technical Strategy

Detailed engineering performance of solar heating and cooling (SHAC) systems must be thoroughly understood in order to compute accurate life-cycle costs and to forecast the long-term impact solar heating and cooling will have on the United States' energy picture.

The measured system performance must then be correlated with engineering formulae so that system design procedures can be established. Once system performance is understood, estimation of future performance can be accomplished and relationships identifying optimum systems and subsystems can be identified. An understanding of these relationships is crucial if system design costs (currently a substantial portion of solar system first cost) are to be reduced substantially. To achieve this understanding, all parameters which describe the performance of each

FIGURE 2
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

subsystem of the complete solar heating and cooling system as well as building energy loads, and pertinent climatic variables must be documented.

Execution of this strategy requires that many systems of the same generic type be demonstrated in a variety of building types (representing a variety of energy load profiles) in virtually all climatic regions. These sites must be thoroughly monitored to gain reliable information concerning engineering performance.

Because no specific data regarding the current set of demonstrations is available, specific recommendations for the next set of demonstrations cannot be made. However, a procedure which can be followed in selecting the types of sites for this strategy is as follows:

1. Plot existing demonstrations (which are or will be monitored) of a specific generic type (e.g. flat plate water, space heating) on a map of the climatic regions.
2. Overlay the insolation maps presented in the Phase I Technical Report to identify those areas, systems, and buildings which have not addressed the technical strategy. A general procedure for accomplishing this is described in the Technical Report.
3. In forthcoming Program Opportunity Notices, stress that priority will be placed on choosing sites having the desired generic system in those areas identified in Step 2. This will provide potential respondents with guidance and those in the areas of importance with incentive to respond.

The sites which will be selected from the set of respondents must then be fitted with performance test and evaluation equipment.

B. Economic Strategy

Knowledge of the 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 (described below), and by observing economies of scale (des-

cribed below), a more reliable forecast can be made of the future of SHACOB technology economics relative to that held by conventional heating and cooling systems.

Several approaches must be adopted in order to fully address this strategy. First, accurate and detailed cost data must be obtained for all demonstrations, as installed. Rate structures for conventional energy costs must also be documented. This rule should apply across the board for all demonstrations, but particularly for those which are part of the technical strategy.

One of the major factors strongly influencing the cost of installed solar energy systems is labor cost. For solar energy systems to become clearly economic, labor installation costs simply must be reduced. At present, it is unclear precisely what factors are dominating these installation charges. Can the number of man-hours be reduced as laborers gain experience installing systems or is there something fundamentally wrong with the collector design? Are contractors choosing the best techniques and equipment for installing systems? We believe that the only real way to answer these and related questions is to have (preferably) the same crew install the same basic system a number of times. In the Phase I Technical Report, we have referred to this as an Installation Learning Study (ILS). Some of the ramifications of performing several of these 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.
2. The installation of six equivalent or identical systems will permit variations in system performance (if any) to be evaluated. Performance of several sets comprising different generic designs or operating regimes 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. Installation learning studies will provide a number of construction crews and builders with valuable hands-on experience.
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.

The precise mechanism which should be employed to conduct these studies presents a difficult question. The mechanism chosen must accomplish several things. First, the mechanism must ensure that the builder cannot inflate his installation charges. Second, it must allow the contractor to install several systems (preferably about six) in an appropriate sequence such that the same installation crew may be employed if the contractor deems this appropriate to reducing his labor costs. This means that lengthy negotiation from site to site cannot be tolerated. Third, the mechanism must provide incentive to the builder to reduce labor costs from installation to installation.

We suggest that a special Program Opportunity Notice be issued for this study. The selection of a contractor should be made competitively from the respondents employing the selection criteria developed in Section IV of this report. Because large systems are not required, the PON should state that preference will be given to small systems, as may be appropriate for chain restaurants, service stations, electronic stores, etc. Competition will help ensure against inflated costs. To provide an incentive to the contractor to reduce labor costs, a means might be provided to allow him to increase his profit per installation. This

ability to increase profits should be strictly a function of the contractor's initiative. The PON could request the contractor to specify an incentive mechanism for accomplishing this objective, or the suggested approach as follows might be employed. In addition to the normal fee of about 10%, the contractor might be given an opportunity to tap a "contingency fund" as the added profit. The fraction of the remaining "contingency fund" available to him at the end of the study might be one minus the ratio of the total man-hours required to complete "N" jobs to the product of number of man-hours for the first job and "N". If the "contingency fund" were equal to the normal job fee, the contractor would have an opportunity to increase his profits 22% for 6 jobs and a 90% labor reduction from job to job. It is essential for the future well-being of the solar industry that the level presented by such a reduction in labor costs become the norm. Through the "contingency fund concept," the contractor is not only protected financially, but can carry forward the knowledge and skill acquired in the previous job to increase his profits. The resultant should be continually decreasing labor costs as the contractor moves from job to job.

Another less important but potentially informative study, and which may require a separate PON, deals with the determination of any economy of scale associated with installed solar heating and cooling systems. Although materials costs can be easily documented, the effects of labor rates will be more difficult to interpret. If the same contractor were to install three different system sizes, his crew's learning curve would be superimposed upon the system size scaling factor. On the other hand, if different contractors install the three systems, the differing labor rates and methods of construction will influence the scaling factors. We believe it would be preferable to have the same installation crew install the three systems for this reason. The results of the installation learning study can be used to correct for possible learning curves superimposed on the economy of scale installations. This would not be possible for different crews. One contract to install three systems, provided detailed cost records are maintained, should yield the desired information.

C. Institutional/Societal/Environmental Strategies

It is desirable to identify those factors which add unnecessary costs to solar equipment, installation, or operation. 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 accomplish this, it will be necessary to document and publish in trade journals all problems encountered and the manner in which these were resolved. The responsibility of disseminating this information will reside with the contractor selected by ERDA to carry out these activities. Innovative ideas, provided they appear well thought-out, should be provided an opportunity for testing. Beyond these general comments, no specific recommendations can be made.

IV. Candidate Screening and Selection Criteria

To be most cost effective, the demonstration program needs to concentrate on small systems. Except for the need to perform economy of scale studies, there appears to be little justification for a few large systems over many small systems. Indeed, many smaller systems have the advantage of providing many designers, contractors, and installers with the required experience necessary to induce competition and carry the solar industry forward. We recommend that a size limitation of 5000 square feet of collector be a program "rule-of-thumb" since this limitation appears to offer the following advantages:

1. Ample flexibility to consider many system configurations on many building types.
2. Moderate costs to the taxpayer (about \$100 million for 667 demonstrations at an ERDA cost of \$30 per square foot of collector area installed).
3. Sufficient incentive to tool-up for mass production (3.3 million square feet required).

Systems actually chosen for the program may vary considerably from the suggested limitation depending upon proposed levels of cost share and issues addressed by the site. Thus the limitation suggested should not

be considered as absolute.

Refer to Figure 3 for an outline of the screening and selection criteria which will be discussed in this section.

The most important criteria to be applied when choosing candidate sites for demonstrations concerns anticipated economics of the proposed system. The Techno-Economic Cost/Benefit analysis performed by InterTechnology Corporation for ERDA indicates that in 1975 dollars, the solar heating and cooling systems should cost in the neighborhood of \$10-\$15 per installed square foot of collector in order for the system life-cycle cost to break even with current conventional electric heating and cooling systems. Thus, if current installed system costs are in the neighborhood of \$40-\$60 per square foot, then ERDA should expect building owners to require ERDA support in the neighborhood of 75% of the first cost. Two criteria for selection would then be to limit ERDA support to no more than 75 percent of the initial capital cost and a maximum of \$15/ft² installed system cost based on private funds. This is a rough figure and will depend primarily upon the region and actual fuel costs applicable to that site. Table 7 indicates more accurately the necessary system costs for each climatic region. These figures take into account regional average fuel costs and differences in performance of the solar heating and cooling system.

Economic considerations cannot, however, be the only criteria for choosing sites from a set of candidates. In terms of maximizing the program's impact, it would make little sense to select two or three schools (for example) in the same region exclusively on the basis that these sites were fortunate to have the lowest system costs for a group of candidates. We recommend that for the general demonstration program, no more than one building of a specific type in a given region be selected from a group of PON candidates. That is, eliminate duplicative sites within a given climatic region unless sufficient funding can justify it.

The strict economic criteria may also need to be relaxed somewhat to allow for demonstrations on many building types. For example, Table 3 indicates that no demonstrations have yet been performed on these building types:

- 1) supermarkets
- 2) service stations
- 3) shopping centers
- 4) churches

Figure 3

SITE SCREEN PROCEDURE

Given Set of Candidates	Weighting Factor (1-10)	Set Rejected
1. Eliminate Cand. Requiring more than about 5000 ft ²	6	Systems > 5000 ft ²
2. Screen on ERDA Cost Share	7	> 75% ERDA Funds
3. Screen on \$/ft ² (Private Money)	7	> Table 7
4. Separate into Regional Groupings		
5. Screen "Duplicate" Candidates within each Region	5	"Duplicate" Candidates
6. Screen Candidates which Duplicate Existing Demos or place Too Much Emphasis on One Building Type	5	Cand. "Duplicating" Demos
7. Group by Magnitude of Community Population		
8. Starting with Cand. in Larger Communities		
A. Select Most Cost Effective Sites in Each Region		
B. Proportion Number Selected According to Regional Populations	3	Less Cost Effective Cand. and/or Too Much Emphasis on One Demonstration Type
C. Ensure a Good Mix of New and Retrofit Installations		
9. Compute Required ERDA Funding		
10. If Equal to Amount Available, Stop		
11. If Less than Amount Available, Reconsider "Duplicate" Cand. and Cand. "Duplicating" Demos Groups		

Table 7

NECESSARY INSTALLED COSTS FOR
ECONOMIC SYSTEMS

Region	Approximate Installed System Cost+ (1975 \$/ft ²)*	Based on Useful Collector Output** (Btu/ft ² -yr)
Northern Plain	9.85	153,000
Mid West/Down East	10.68	114,000
Central Plain	-	-
Eastern/Great Lakes	12.31	88,500
Pacific Northwest	-	-
Mid Atlantic	11.59	98,900
Central Humid	-	-
Far West	10.11	122,000
Southern Plain	12.33	132,000
Southwest	15.72	193,000
Southeast	12.38	113,000
Southern Florida	-	-

* A "-" indicates that a market will not develop for 75% ERDA cost share.

** Values for typical cost-optimized heating system employing single-glaze, black-chrome collector.

+ These figures consider collector performance and climatic-region - averaged electrical energy costs.

Some of these building types present several interesting applications. Many churches are only used 2 or 3 days per week, some only once per week. This suggests that quite possibly a small collector system could "charge" the storage tank during the week to support the one or two uses. Large shopping centers offer the possibility of a central plant facility to supply individual stores. Because of the size of the system and the magnitude of the energy loads, particularly the cooling loads, a Rankine cycle system may be indicated. However, this type of demonstration will be very large and require substantial federal support. Therefore the selection of a shopping center must be made with care and considerable justification. Validation of the economy of size or scale may serve as such a justification. Service stations offer a very high visibility advantage. In addition, they are a high consumer of energy per square foot. Their large numbers and consistency in design offer high potential for mass production of economic "package systems."

The desired distribution of demonstrations will also modify the basic economic criteria previously discussed. This distribution to date is illustrated in Table 2, which has been previously described. Except for the Mid Atlantic region, the demonstrations appear to be acceptably distributed throughout the country. We feel, however, that the Mid Atlantic region should be de-emphasized during the selection of the next set of demonstrations. This de-emphasis should be reflected in the economic criteria screen since this region does not, in general, represent one of the more optimal areas for solar energy. The Eastern/Great Lakes climatic region, on the other hand, should be given moderate emphasis since the apparent and potential economics for solar energy are favorable in that area.

It should be noted that over 50% of the United States' population resides in the Eastern/Great Lakes, Mid Atlantic, and Mid West/Down East regions. Thus, locating about 50% of the demonstrations in the major population centers in these regions will achieve maximum impact on both visibility and economic

opportunities. That is, much of the country's economic activity takes place in these regions; hence the availability and opportunity of capital spending should be high in these regions.

We recommend that, when a choice between two candidate sites of approximately equal value must be made, the decision go to the site located in a state not yet represented by the demonstration program. To date, the following states do not have a demonstration site:

Arkansas	Mississippi	New York	Tennessee
Delaware	Montana	North Carolina	Utah
Idaho	Nebraska	Oklahoma	Vermont
Indiana	Nevada	Oregon	Wisconsin
Kansas	Maine	Rhode Island	Wyoming

Also related to the distribution of sites concerns the size of the community which receives a demonstration. While not the most important criteria, placing demonstrations within populous areas improves the "availability" of the site. By "availability" is simply meant that many potential buyers need to travel only a short distance to view and discuss a demonstrated system. In addition, a highly populated area generally implies more building construction activity than a rural, remote community. Thus, a builder/contractor who gains valuable solar installation experience in a populous region is simply more likely, from a statistical point of view, of being called upon to install another system, gaining additional experience. A rural builder/contractor whose volume is small, and who may be located in an area short of capital is not as likely to be called upon to install additional solar equipment. This factor is likely to have more impact than the physical visibility and availability of the site to potential users of solar energy.

So far, the mix of system types selected for demonstration appears to be good. We anticipate that solar assisted heat pump applications will become

more popular, particularly those systems in which solar can heat the space directly thus bypassing the heat pump altogether whenever the temperatures allow it. This heat pump configuration will permit maximum solar utilization. The parabolic cylinder concentrating collector is beginning to look promising particularly for supplying the high temperature energy needed to operate absorption chillers. While a mix of system and collector types should be addressed by the program, the primary factor here must be the economics. Emphasizing the importance of the economic criteria is essential to encourage engineers designing the systems to consider many alternatives. Except for possibly a few "research" projects the system types should not be dictated as this may stifle production of collector types identified by manufacturers as the best design.

The program should also encourage retrofit installations. One advantage retrofit installations offers over new installations is that they are not subject to general contractor's and in some cases, architect's fees. These fees can add substantially to the costs of solar systems on new buildings. We are unaware of any inherent costs associated with retrofit installations which would result in installed system costs being out of line with costs for new systems. Careful attention should be given to ensuring that the program contains a reasonable mix of new and retrofit installations.

Figure 3 can be used as a summary guide to the selection of sites which will serve as demonstrations from the set of PON candidates. Weighting factors have been associated with each criteria to the program. They are intended to serve more as judgmental tools to indicate the relative importance of each criteria than as absolute fact.