IEA

SOLAR R&D

INTERNATIONAL ENERGY AGENCY

solar heating and
cooling programme

task II
coordination of R&D on solar heating and cooling components and systems

survey on commercialization and operating experience of solar heating and cooling systems

Subtask C

august 1984

SURVEY ON COMMERCIALIZATION OF AND OPERATING EXPERIENCE WITH SOLAR HEATING AND COOLING SYSTEMS AND COMPONENTS

T. Noguchi
Solar Research Laboratory, GIRI Nagoya
AIST MITI Japan

August 1984

This report is part of the work within the IEA Solar Heating and Cooling Programme,
Task II: Co-ordination of Research and Development on Solar Heating and Cooling Components and Systems,
Subtask C: Survey on Commercialization of and Operating Experience with Solar Heating and Cooling Systems and Components

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Additional copies can be ordered from: T. Noguchi
Solar Research Laboratory
GIRI, Nagoya
1 Hirate-cho, Kita-ku, Nagoya
462 Japan

ABSTRACT

This document provides information on commercialization of and operating experiences with solar heating and cooling systems and components in the Task II participating countries. The compilation is based on the reports submitted during 1983 and 1984 by the Participants. The countries which contributed reports are Austria, Belgium, Greece, Japan, the Netherlands, Norway, Sweden and the United States. The contact persons for each country participating in the Task II are listed in Appendix 2.

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1. PREFACE

International Energy Agency

In order to strengthen cooperation in the vital area of energy policy, an agreement on an International Energy Programme was formulated among a number of industrialized countries in November, 1974. The International Energy Agency (IEA) was established as an autonomous body within the Organization for Economic Cooperation and Development (OECD) to administer that agreement. Twenty countries are currently members of the IEA with the Commission of the European Communities participating under a special arrangement.

As one element of the International Energy Programme the participants undertake cooperative activities in energy research, development, and demonstration. A number of new and improved energy technologies which have the potential of making significant contributions to our energy needs were identified for collaborative efforts. The IEA committee for energy, research and development (CRD), assisted by a small Secretariat, coordinated the energy research development, and demonstration programme.

Solar Heating and Cooling Programme

In July, 1975 Solar Heating and Cooling was selected as one of the sixteen technology fields for multilateral cooperation. The objective was to undertake cooperative research, development demonstrations and exchanges of information in order to advance the activities of all participants in the field of solar heating and cooling systems. Several tasks were developed in key areas of solar heating and cooling. A formal implementing agreement was prepared, covering the contributions, obligations and rights of the participants, as well as the scope of each task. The agreement has been signed by the seventeen countries and the Commission of the European Communities. The overall programme is managed by an Executive Committee, while the management of each task is the responsibility of an Operating Agent who acts on behalf of the other participants. The tasks of the IEA Solar Heating and Cooling Programme and their respective Operating Agents (lead organization responsible for the task) are:

I Investigation of the Performance of Solar Heating and Cooling systems - Technical University of Denmark

II Coordination of Research and Development on Solar Heating and Cooling Components - Agency of Industrial Science and Technology, Japan

III Performance Testing of Solar Collectors - Kernforschungsanlage Jülich, Federal Republic of Germany

IV Development of an Insolation Handbook and Instrumentation Package - United States Department of Energy.

V Use of Existing Meteorological Information for Solar Energy Applications - Swedish Meteorological and Hydrological Institute.

VI Performance of Solar Heating, Cooling and Hot Water Systems Using Evacuated Collectors - United States Department of Energy.

VII Central Solar Heating with Seasonal Storage - Swedish Council for Building Research.

VIII Passive and Hybrid Solar Low Energy Buildings - United States Department of Energy.

IX Solar Radiation and Pyranometer Studies - Canadian Atomospheric Environment Service.

Collaboration in additional areas may be considered as projects are completed or fruitful topics for cooperation are identified.

TASK II - COORDINATION OF RESEARCH AND DEVELOPMENT ON SOLAR HEATING AND COOLING COMPONENTS AND SYSTEMS

The objective of this Task is to increase the effectiveness of the national R&D programmes related to the development of solar heating, cooling and hot water supply systems and components for buildings, including the application in industrial process heat. By the sharing of information and expertise it is hoped that duplication of effort can be avoided and development of solar heating & cooling components and systems accelerated.

The subtasks included in this project are:

A. Summary of Solar Energy R&D Projects

B. Survey and Review of Existing R, D&D Plans

C. Survey on Commercialization of and Operating Experience with Solar Heating and Cooling Systems and Components

D. Organization of Workshops

The Participants in this Task are Austria, Belgium, Denmark, Greece, Italy, Japan, the Netherlands, Norway, Sweden and the U.S.A.

2. INTRODUCTION

The objective of IEA Task II, Coordination of R&D on Solar Heating and Cooling Components and Systems, is to increase the effectiveness of the national R&D programmes related to the development of solar heating, cooling and hot water supply systems and components for buildings, including the application in industrial process heat.

Subtask C, Survey and Commercialization of and Operating Experiences with Solar Heating and Cooling Systems and Components, was initiated when Task II activities were extended in 1981 (phase II). This subtask examines information on many aspects of commercialization including the size and state of solar energy industries, technical problems for installation and maintenance, training and education for installers, and possibilities for cost reduction. The Participants have exchanged information on commercialization and operating experience of solar heating and cooling systems through the Expert Meetings held in October, 1982 in Madrid and in October, 1983 in Freiburg, as well as the Workshop on Status and Trends in National Solar Heating and Cooling Programmes and Activities held in October, 1983 in Freiburg. In addition, an earlier survey (January, 1983) was compiled as a working document.

The Participants prepared their input based on the reporting format (see Appendix 1) prepared by the Operating Agent, who compiled and summarized material for this survey. This document reflects the status of solar heating and cooling commercialization in the Participants' countries as of the end of 1983. Eight out of Task II's eleven Participating Countries contributed to this report. Denmark, Italy and Spain did not submit survey on Commercialization and Operating Experience of Solar Heating and Cooling Systems.

Since the initiation of national solar heating and cooling programmes in many participating countries ten years ago, steady RD&D activities have been undertaken by the respective governments and the solar energy industries. However, some recent developments which might impede the growth of the solar energy industry and propagation of solar heating, cooling and

DHW systems have appeared. These developments include world economic recession, an easing of strained oil relation, overproduction of oil, and the results of energy conservation measures taken during the early crisis. In some participating countries government policy, funding, and the organizational-structure of solar heating and cooling R&D have changed, while other Participants' governments have been steadily supporting their R&D programmes and industry. The attitudes of both the public and private sectors are quite important for the further growth of solar energy industry and the pursuits of solar energy development for the long term.

This report contains nine chapters:

1) Solar manufacturers
2) Collector manufacturing data
3) Solar system installations
4) Government incentives
5) Standards and certification
6) Operating experiences
7) Warranties
8) Education and training
9) Information dissemination

3. SUMMARY OF SOLAR HEATING AND COOLING R&D AND D PROGRAMMES IN PARTICIPATING COUNTRIES

This chapter presents brief summaries of RD&D Programmes for solar heating and cooling systems and components in the participating countries. A review of these programme summaries will give the reader a picture of the relationship between RD&D programmes and commercialization in the various countries.

Details of each country's RD&D Programme are presented in another Task II, Subtask A Technical Report entitled "Summary of Solar Energy R&D Projects", August 1984.

Many factors such as socio-economics, topographic characteristics and climatic conditions are responsible for the wide variations in emphasis and status of RD&D and commercialization activities in the participating countries.

This chapter is cited from the "Brief Summary on the National Solar Heating and Cooling Programmes" of the Chapter 4 of the Subtask A Technical Report, Task II.

3.1 SOLAR ENERGY R,D AND D PROGRAMMES IN AUSTRIA

METEOROLOGICAL CONDITIONS AND POTENTIAL FOR SOLAR ENERGY UTILIZATION

In Austria the insolation values vary as follows: March to May up to 450 kwh/m^2, June to August 520 kwh/m^2, September to November 250 kwh/m^2 and December to February up to 160 kwh/m^2. The annual global radiation sum is of the order to 1,000 to 1,400 kwh/m^2.

The daily sum of insolation on cloudless days in the summer period may be as high as 8 kwh/m^{2}d.

The daily variations of insolation on cloudless days are highly dependent on the seasonal cycle. In summer, the maximum attains some 0.9 kw/m^2, in spring some 0.6 kw/m^2 and in winter some 0.25 kw/m^2.

During the period from May to September, an average of 45 percent of total insolation is diffuse radiation, from October to April about 65 percent.

The unfavorable ratio of maximum (June) and minimum (December) irradiation in Austria is obvious. Ratios of 8 : 1 are possible. In the case of space heating, energy demand is thus highest when supply is lowest.

Due to the meteorological conditions solar systems in Austria are used mainly for domestic hot water heating and for swimming pool heating during the summer period.

MARKET PENETRATION

The use of solar systems has been increasing in Austria since 1975. Until the end of 1983 about 134,000 m^2 of collector area were installed, about 65 % of which are used for swimming pool heating and 35 % for domestic hot water heating.

At present state of technology, the direct utilization of solar energy for space heating is not yet economical in Austria. Otherwise heat pump systems are increasingly used for space heating with air, water or soil as sources of heat.

RESEARCH, DEVELOPMENT AND DEMONSTRATION IN THE FIELD OF SOLAR HEATING SYSTEMS

Research and development works in connection with components and systems for utilization of solar energy were concentrated in Austria in past years on the following subjects:

> The development and testing of economical and efficient collectors and solar systems for swimming pool and domestic water heating; the objective is to reach a life time of more than ten years.
>
> The development and testing of heating systems with direct (collectors) or indirect (heat pumps) utilization of solar energy, special consideration being given to ecological and economic aspects.

In order to add to scientific findings specific data and experience with operating systems, the "Austrian Measurement Network for the Utilization of Solar Energy" was established in 1976. On behalf of the Austrian Federal

Ministry for Science and Research about 50 test stations with solar and/or heat pump systems were installed by the end of 1983. The Austrian Solar and Space Agency (ASSA) co-ordinates these test stations, evaluates the results and provides all those interested with the information required.

The experiments undertaken have contributed not only to the improvement of serial production of components and systems, but also to the establishment of standards and guidelines to be followed in the design, construction and operation of solar and heat pump systems.

ENERGY POLICY AND RESEARCH

A. THE INSTITUTIONAL SYSTEM

Austria is a Federal State. The Federal Government (BUND) and the Federal Provinces(Länder), within their respective fields of competence, are each responsible for energy matters including research and development.

At the federal level, Federal Ministries are responsible for energy matters, including research and development, with respect to their specific area of activity.

Matters of energy policy are handled by the Federal Ministry for Trade, Commerce and Industry.

The responsibility for the co-ordination of energy research and development at the federal level rests with the Federal Ministry for Science and Research.

B. GOALS AND PRINCIPLES OF ENERGY POLICY

To secure Austria's energy supply and to minimize negative impacts on the economy and on the environment, the energy policy and research in Austria are aimed at:

- Optimizing the exploration for and the use of domestic resources of energy, in particular by further exploitation of hydropower, and new sources of energy or those rarely used up to now, such as biomass, solar and geothermal energy,

- Substituting hydrocarbons as far as possible,

- Reducing energy consumption through more efficient energy use,

- Securing the necessary energy imports by diversifying supplier countries and energy sources.

The energy policy of the Federal Government emphasizes the exploration for oil, natural gas and coal deposits, and in particular the expansion of both large- and small-scale hydropower. The power plant expansion programme provides for the continuous expansion of hydropower. Besides the construction of large- and medium-size plants, particular attention is given to the expansion of small hydropower plants. As such small plants have considerable potential for future energy supply, a number of measures have been taken for their promotion, such as tax reduction, loans and interest allowances.

C. GOALS AND PRINCIPLES OF ENERGY RESEARCH

The objective of the Austrian Concept of Energy Research is to ensure that work sponsored from public funds is in conformity with the goals of Austria's energy policy and takes into consideration concerns of the economic and research policy, including environmental factors. Austria's Concept of Energy Research was first established in 1974 and is being updated periodically.

D. SPECIAL MEASURES FOR THE PROMOTION OF SOLAR TECHNOLOGIES

If their application meets specific energy policy requirements, solar systems qualify for tax advantages as energy saving investments.

Standards for solar collectors are already available in Austria. Guidelines and recommendations for planning, design and operation of solar systems have been elaborated by the Austrian Solar and Space Agency (ASSA) based on the results gained with existing facilities.

Reliability, cost-effectiveness, serial production of parts and components, and better information on technologies are preconditions of using new and renewable sources of energy. Appropriate documentation, teaching and demonstration materials have been elaborated in Austria, in order to provide information to all interested and to promote the use of solar systems.

The introduction of new technologies requires good training of technical manpower. For this purpose, seminars are held in regular intervals, dealing with the planning design and operation of solar systems. Between 1977 and 1983 more than 250 seminars were held in Austria on this subjects.

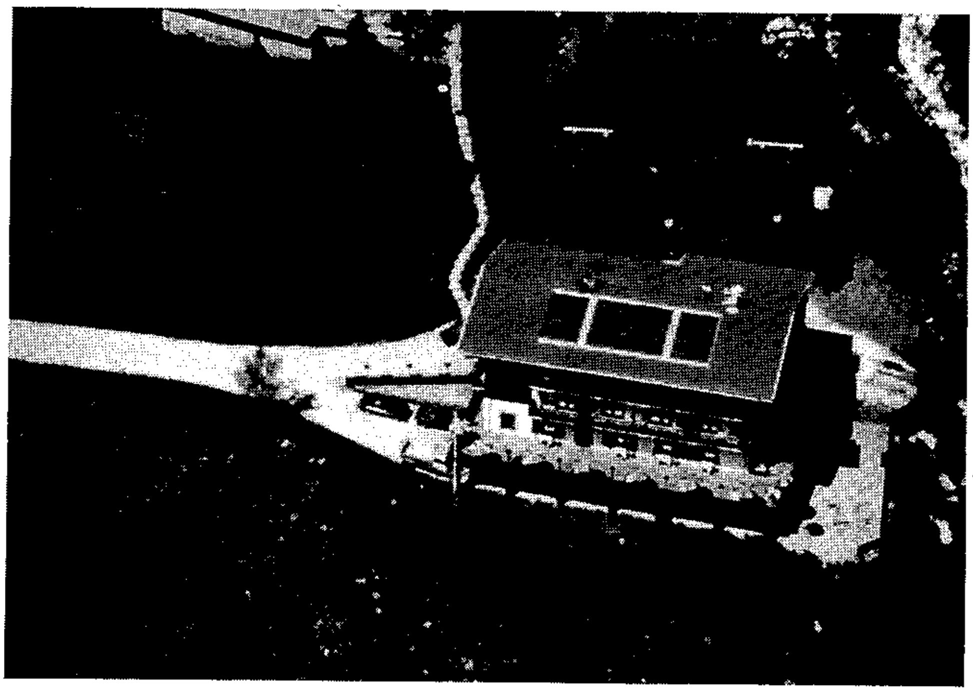
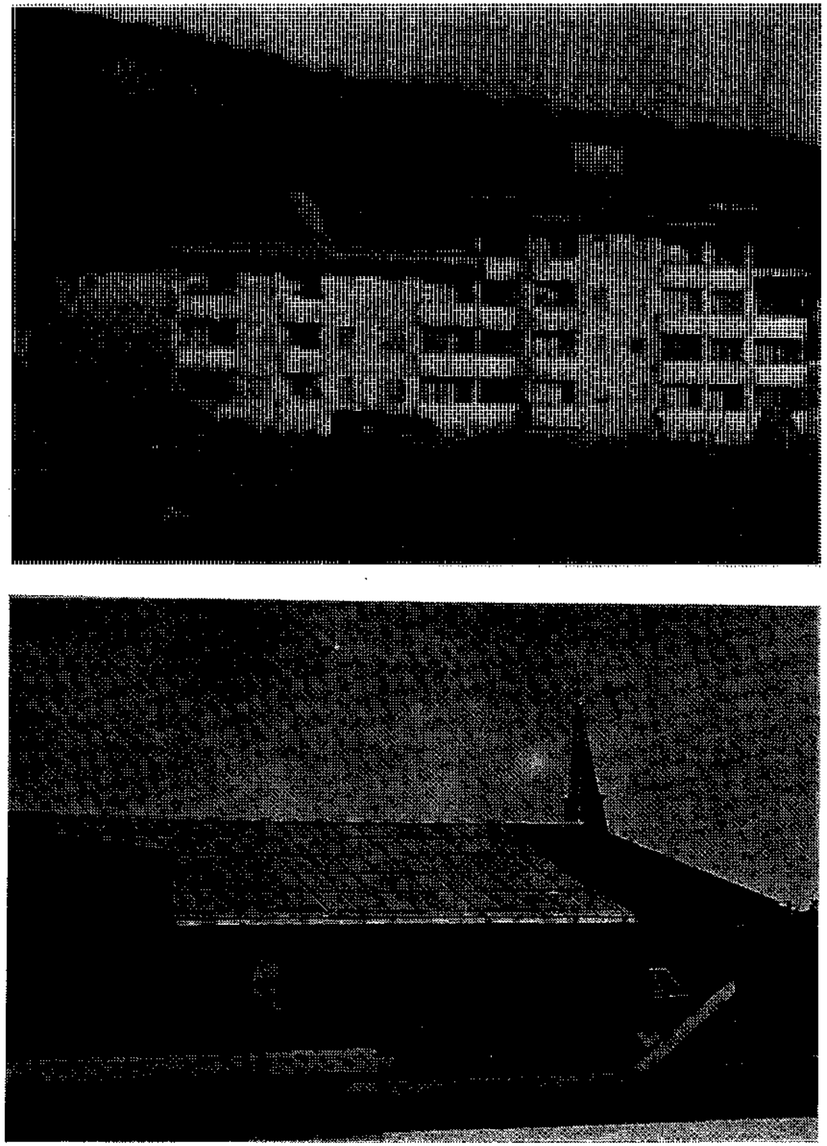
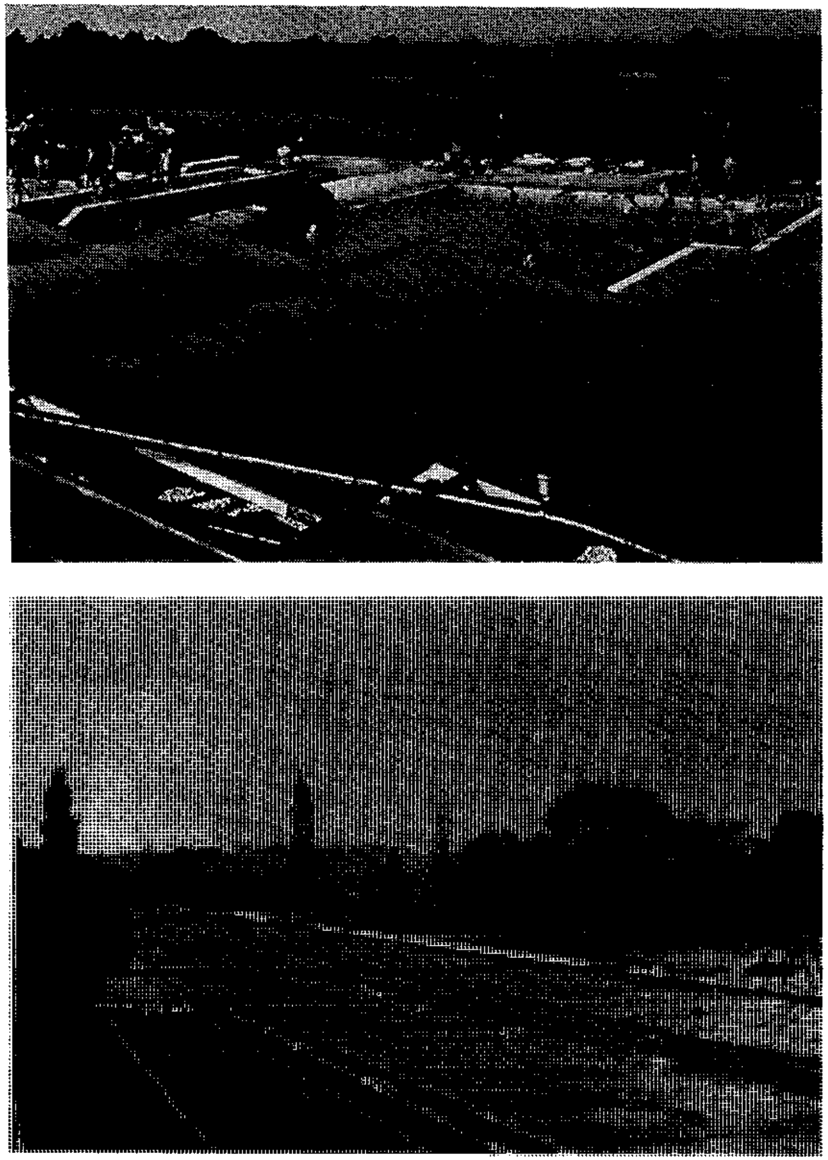


Fig. 1. Integration of solar collectors in buildings: example of a hotel.



a) Domestic Water Heating



b) Swimmimg Pool Heating

Fig. 2. Examples of Solar Heating Systems

3.2 SOLAR HEATING AND COOLING R&D IN BELGIUM

Most of the R&D projects concerning solar heating and cooling are treated within the National R&D Energy Program.

This program is managed by the Sciences Policy Office of Belgium. The Projects are executed by university laboratories, research centers and industries.

The last two years research in the field of active solar heating for domestic purposes is less intensive. Experience with existing commercial installaions has shown that most of them are technically good but that pay off time is too high to permit large scale commercialization.

This is mainly due to the high systems cost and the rather low solar energy potential in Belgium (around 950 KWh/m² year). Supplementary efforts have been initiated for the development of passive solar heating, which can make a substantial contribution to energy conservation in Belgium.

The other research efforts are concentrated on solar drying of agricultural products, air conditionning and cooling and desalination.

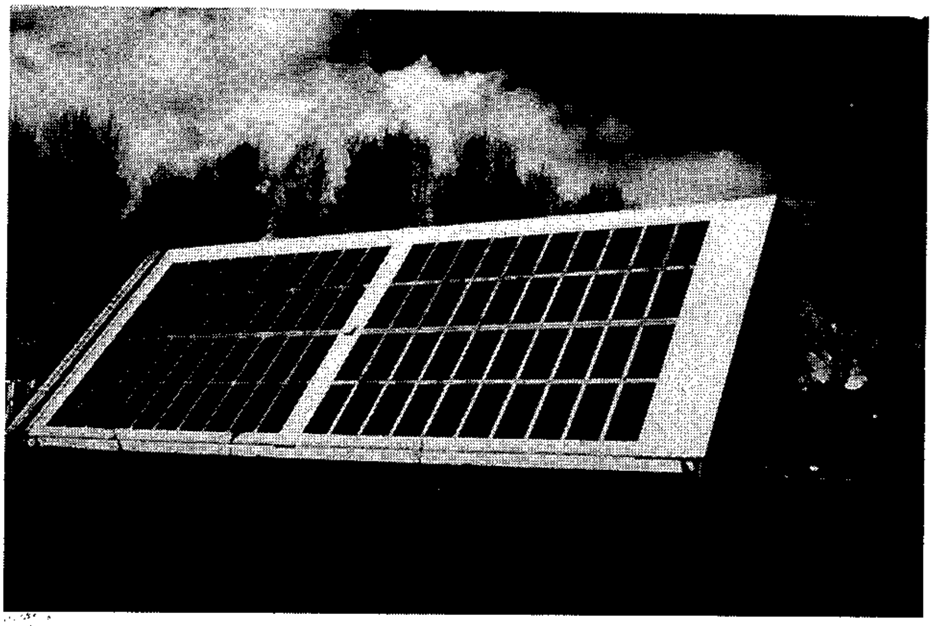


Photo 1. Pilot Test Facility - Katholieke Universiteit Leuven

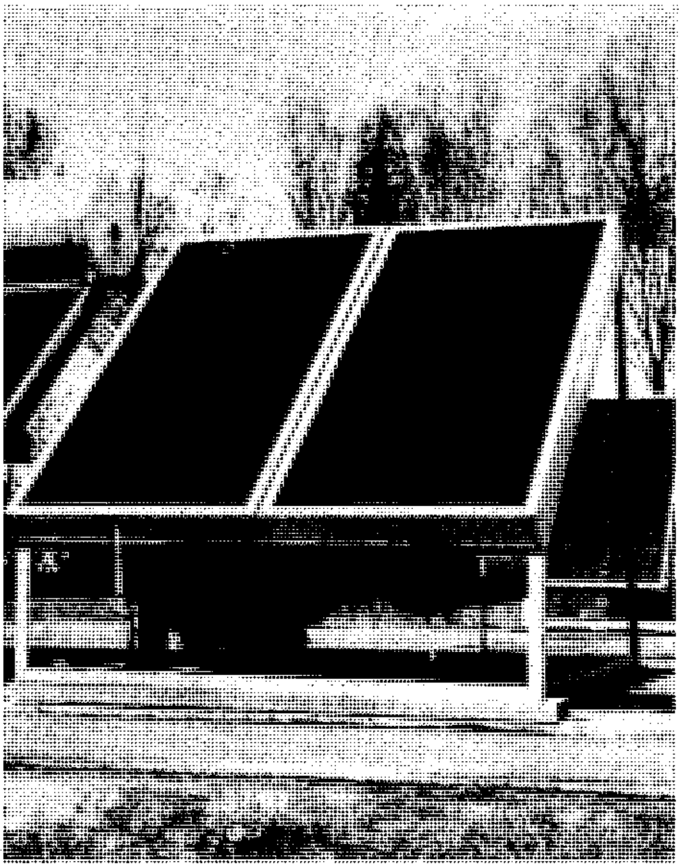


Photo 2. Nobels Peelman High Efficiency Aircollector.

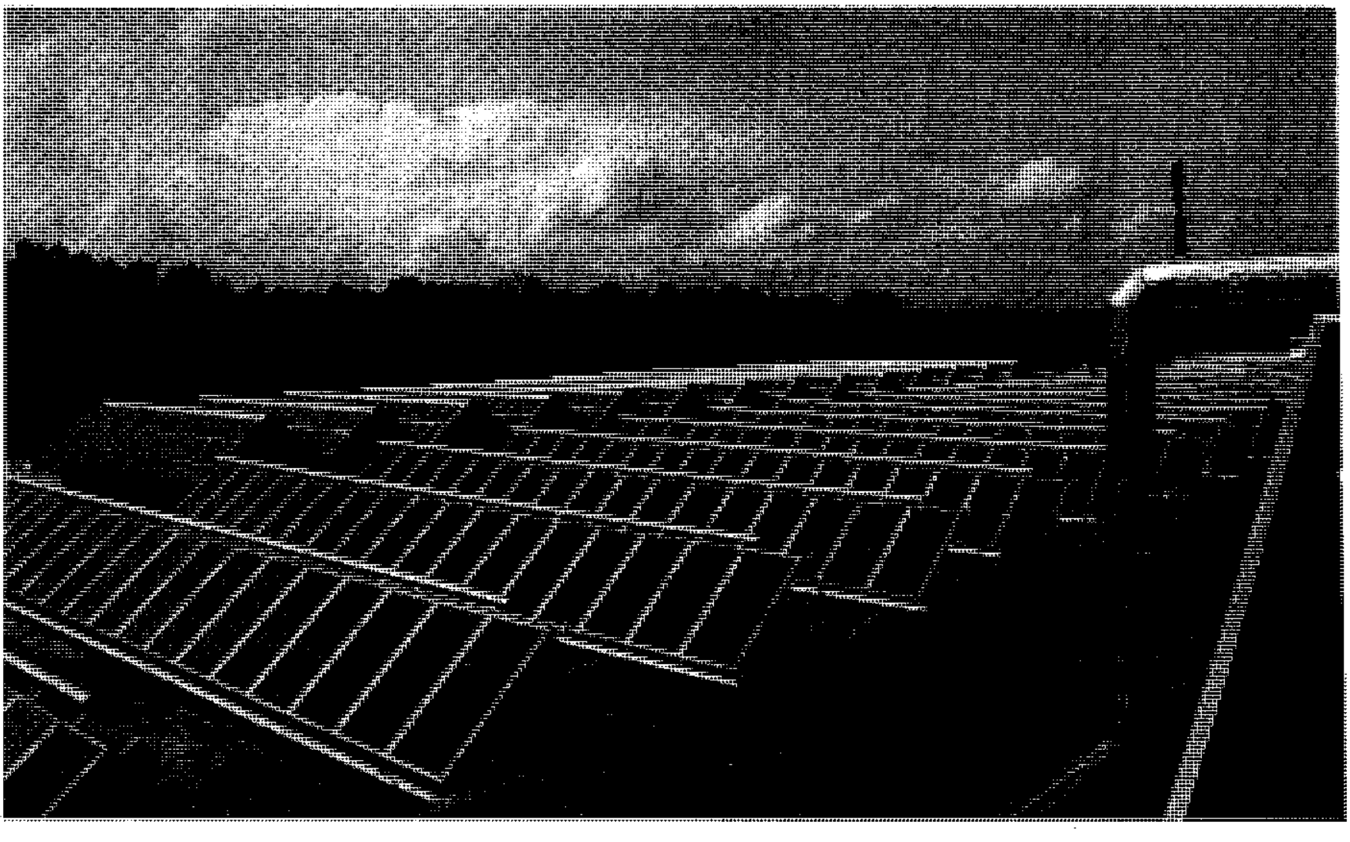


Photo 3. Solar Heating of the Chevetogne sport complex (2.132 m²) - I.D.E.

3.3 R&D PROJECTS IN DENMARK

Research Laboratories

All but one of the projects are carried out by either the Thermal Insulation Laboratory at the Technical University of Denmark or at the Technological Institute in Denmark.

Passive Systems

Part of the work is focused on the development of new components, solar walls, hybrid solar walls, thermo-siphon solar water heaters. By the participation in Task VIII of the International Energy Agency Solar Heating and Cooling Programme a broad range of problem areas of passive and hybrid solar low energy buildings, i.e. from system simulation to the monitoring of demonstration projects is pursued.

Active Systems

Active solar heating systems for domestic hot water and heating is still the dominating area of solar research in Denmark. The main emphasis is put on obtaining reliable, cost-effective systems, development of new or improved components and systems development.

Seasonal Storage

The two projects on seasonal storage both deal with aspects of uninsolated large scale warm water stores.

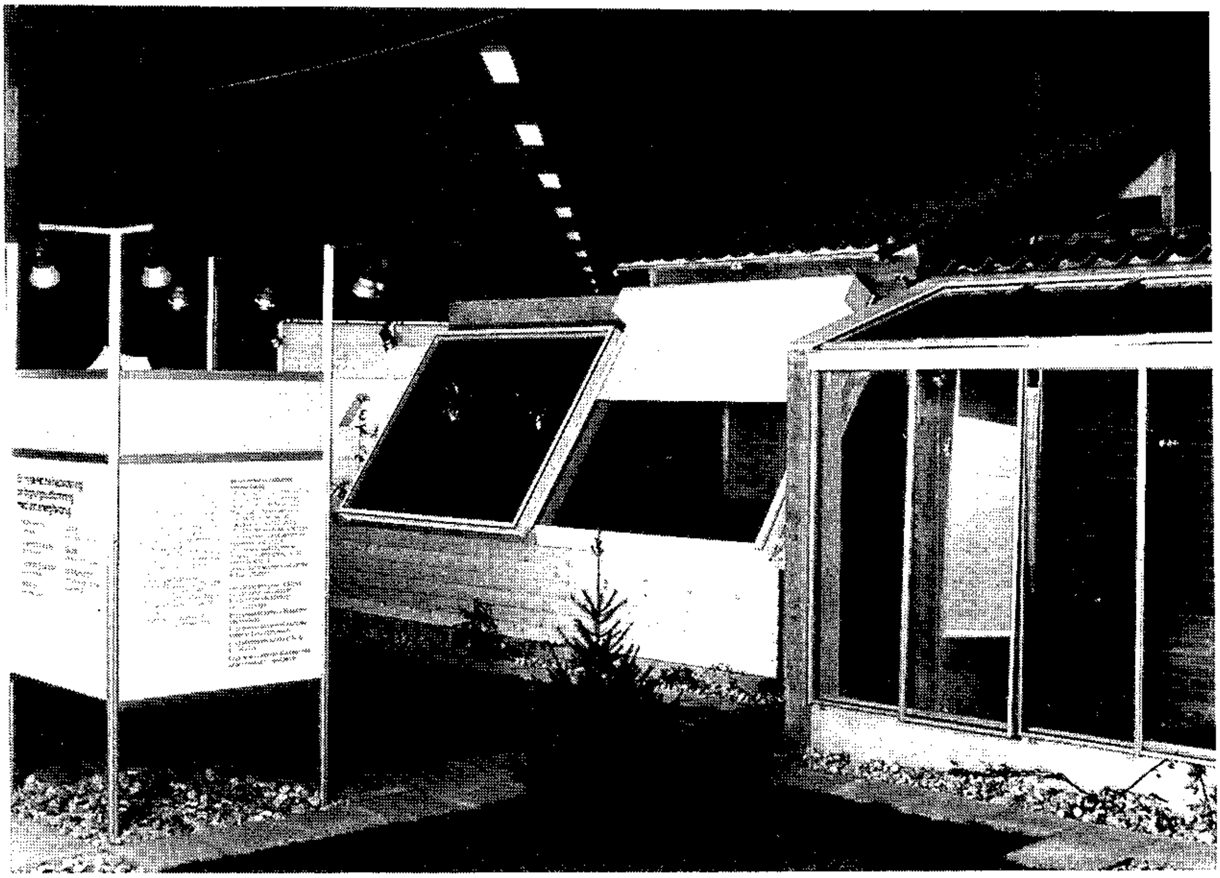
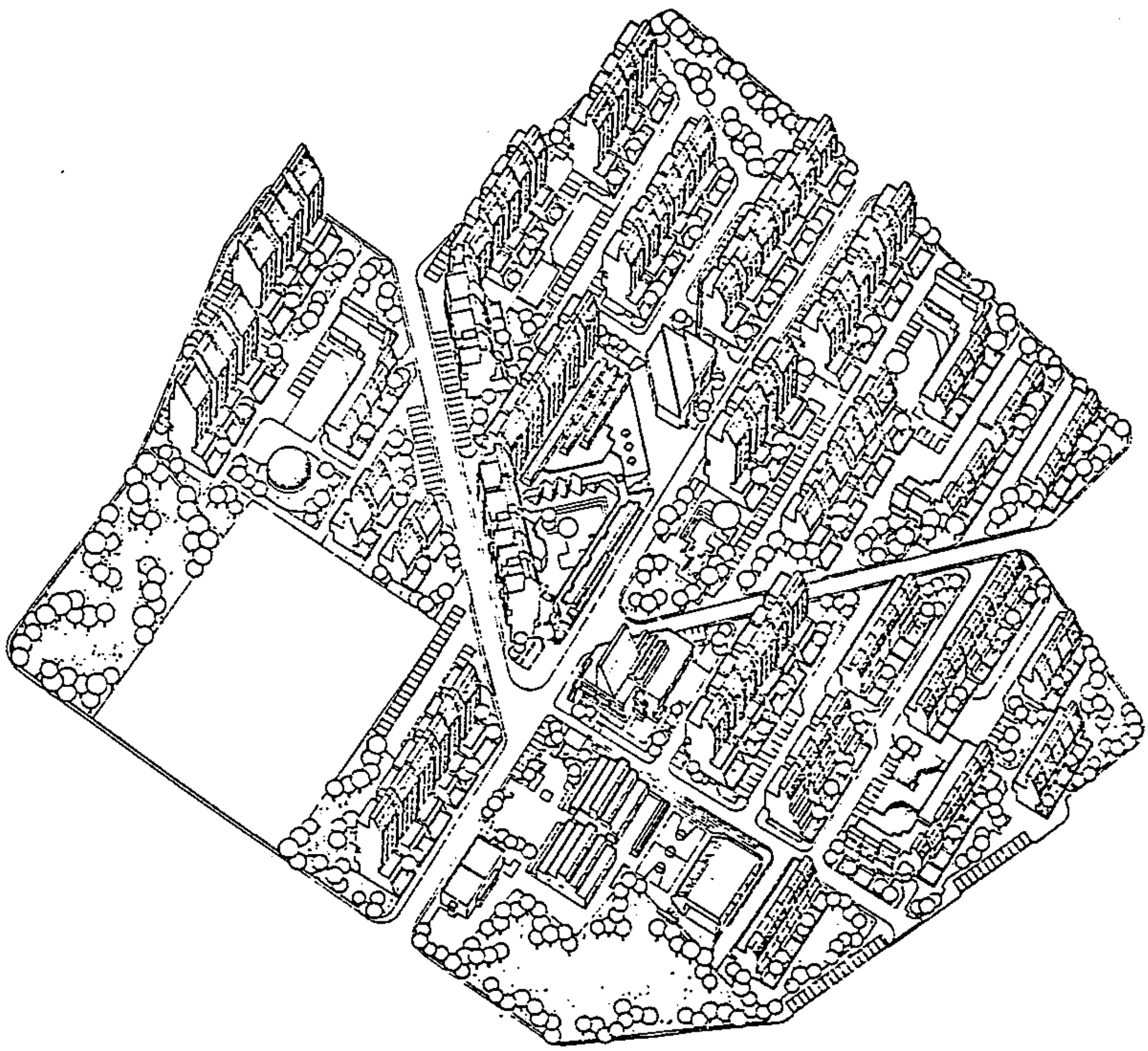


Photo 1. View of the south facade of the Danish Task VIII Solar Low Energy House.

3.4 SURVEY OF SYSTEMS AND COMPONENTS R&D FOR SOLAR HEATING, COOLING AND INDUSTRIAL PROCESS HEAT SYSTEMS IN GREECE

According to the five-year national programme, the solar energy research and development has an important role to play.



Solar Village in Lykovrissi

47 buildings with total number of 500 flats have already designed for passive heating.

Marathon passive solar house

South and east faces

3.5 SUMMARY OF JAPANESE SOLAR HEATING AND COOLING RD&D PROGRAMS

ORGANIZATION

The Sunshine Project Promotion Headquarters, AIST, MITI is responsible for R&D on active solar heating and cooling systems as well as on solar industrial process heat systems. The passive solar systems and components R&D is subsidized by the Housing Industry Division on MITI.

Active SHC System

The first generation R&D on active solar heating and cooling systems have terminated by 1980 (as 7 year program since 1974). Basic studies on materials and components as well as testing procedures both on component and systems are still being pursued after 1980, while commercialization efforts are vigorously concentrated by the industry.

R&D and D works on solar industrial process heat and long term heat storage have been the main topics in the second step projects (1980 - 1985) in the active solar heating and cooling program. The cascading temperature SIPH system is studied by a textile dyeing model, and the other SIPH system project is on the agricultural warehouse model. The long term heat storage projects are subdivided into underground heat storage program and also chemical reaction heat storage program by metal hydrides.

PASSIVE AND HYBRID SYSTEMS

R&D Projects on passive and hybrid systems as well as materials and components have been inaugurated since 1980 as for the five year program in which eleven private sectors are being funded. System analysis and components research are the main topics in these projects. Another 6 year program on passive system is also funded by the Ministry of Education to 7 - 19 universities since 1980 for system analysis studies.

FUNDING

FY(M yen)

	1983	1984
Active solar	1,270	706
Passive solar	385	242
Total	1,655	948

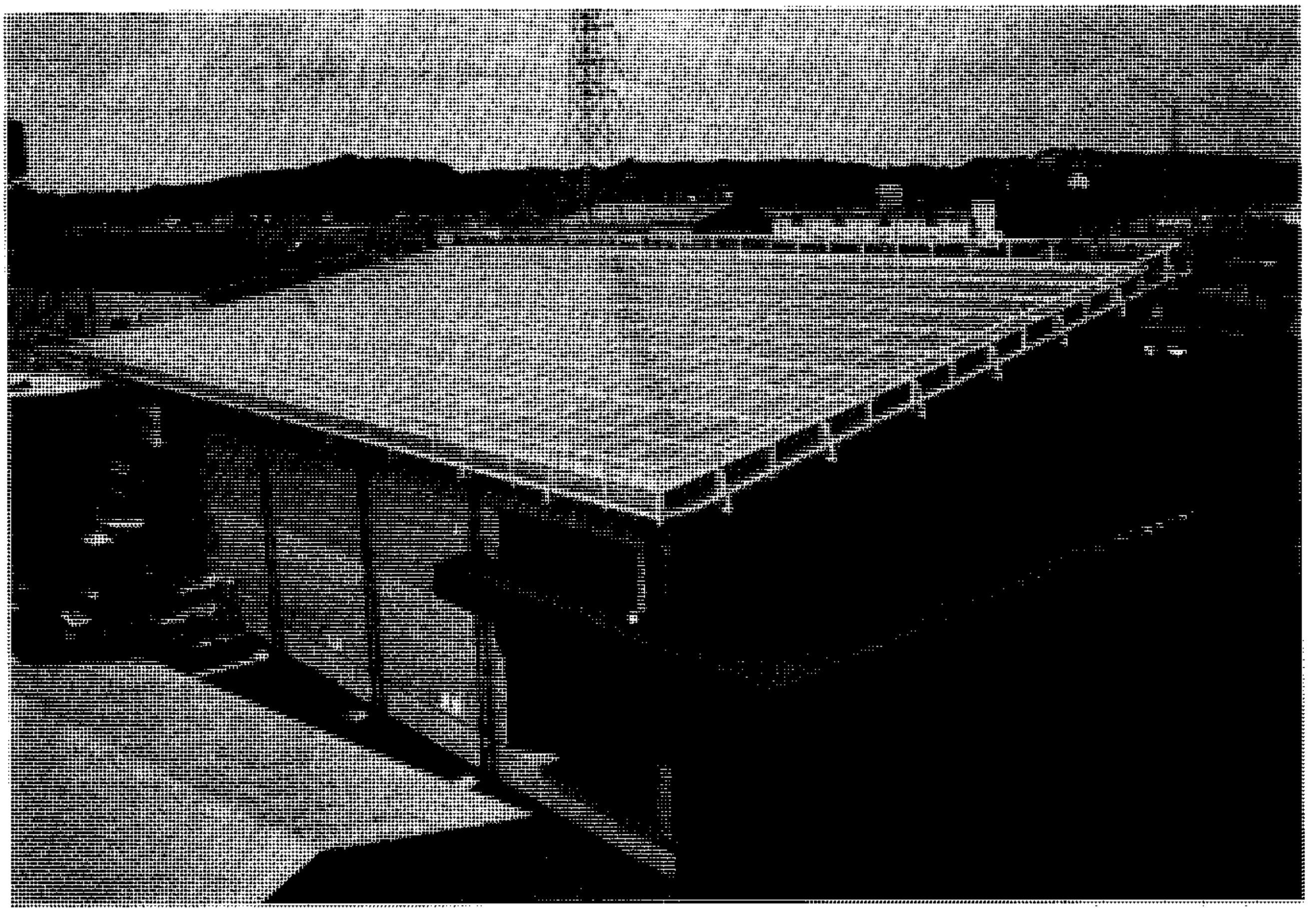


Photo 1. Agricultural Warehouse (SIPH) in Miyazaki.
Solar collector of 682 m² and Water storage tank of 75 m³ with absorption chiller 32,000 Kcal/h.

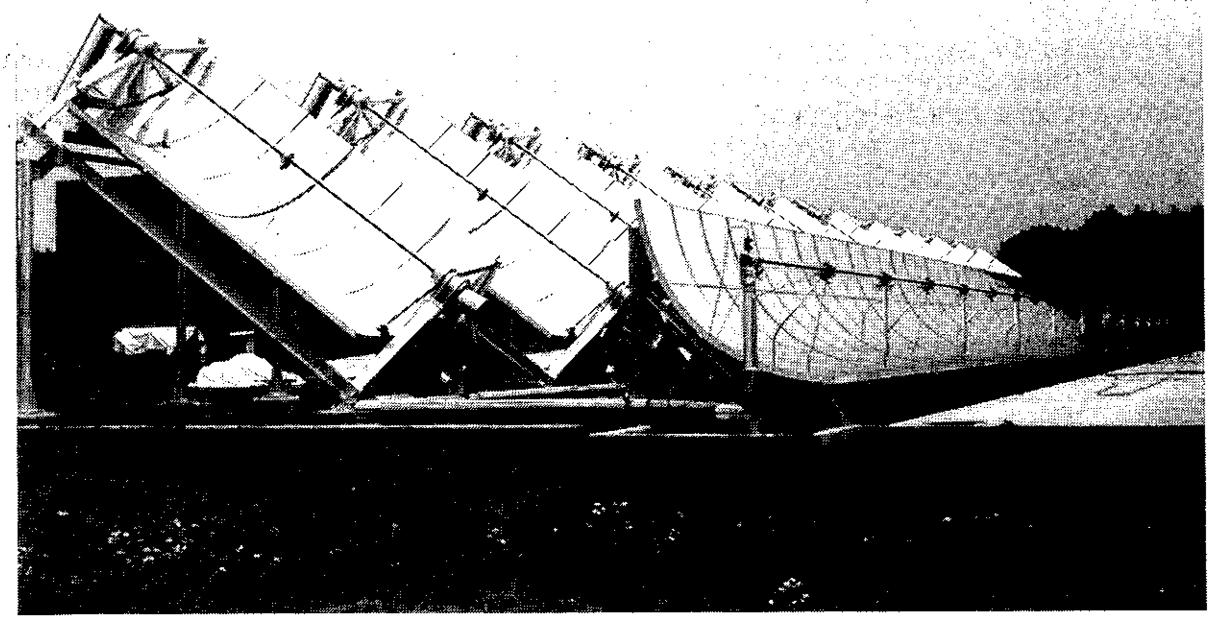


Photo 2. SIPH and power generation system at Tsukuba.
(45 KW thermal + 15 KW electric)

3.6 THE NETHERLANDS NATIONAL RESEARCH PROGRAMME ON SOLAR ENERGY

The forty-four Solar Projects are operated under the umbrella of a national research programme on solar energy. This coordinated programme is dedicated to the research, development and field testing of solar energy conversion systems. The main goal is the introduction of solar systems that proved to be the most successful in phase I of the programme. This means mainly thermal conversion of solar energy for low temperature applications.

Swimming pool heating by solar energy, a mature technique now, is no longer supported. Also no support is given to cooling and climate control due to the specific climatological conditions. Solar boilers have been demonstrated sufficiently, although the market response is slow.

A central focus in the programme is space heating. Simplified systems, passive installations and seasonal storage are the main topics. A very important activity is the transfer of knowledge and information.

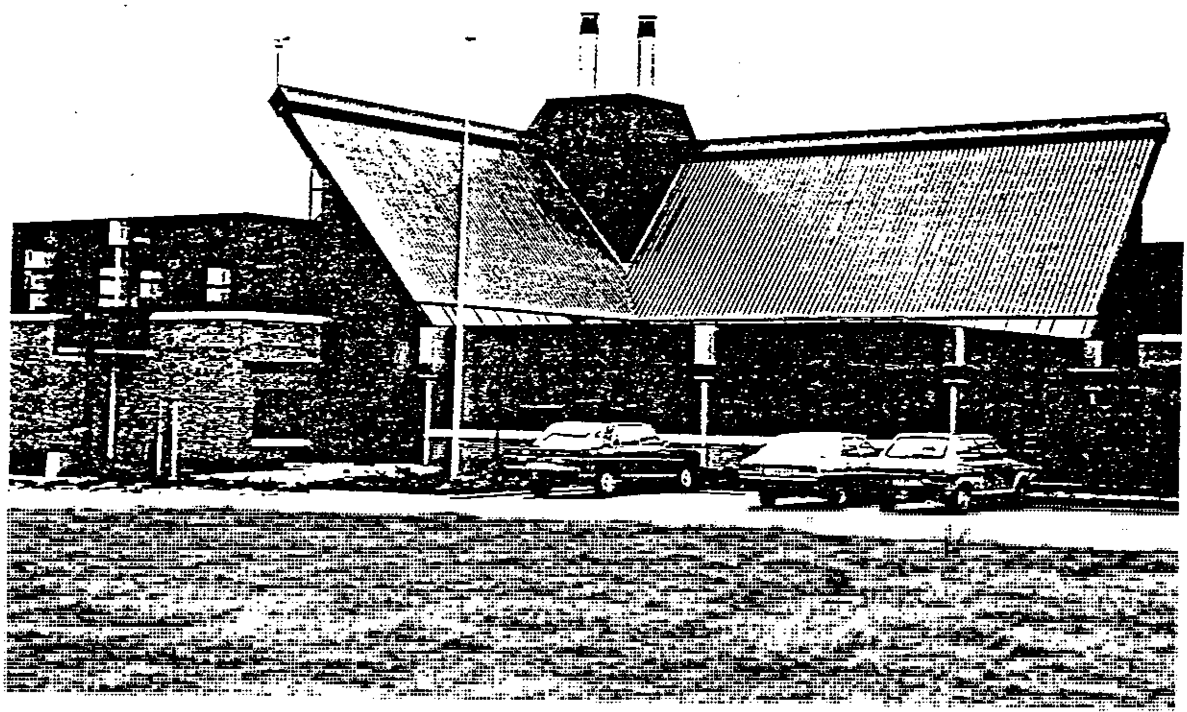


Photo 1. Architect's Office Building, Shagen

Photo 2. Domestic Hot Water System Demonstration in Alkmaar

3.7 STATUS AND TRENDS IN THE NORWEGIAN SOLAR ENERGY R&D PROGRAMME

Solar energy is not expected to take a substantial part of the total national energy demand in Norway in this century. Norway has a very favourable energy situation and almost 60% of the domestic energy consumption is renewable hydro electricity. The oil production in 1983 was 10 times the oil consumption.

Since 1975, 15 mill.NOK (2 mill.US$) have been funded to 30 solar energy projects. The governmental fundings have been decreased from 1980 to 84, corresponding to appr. 8 man-years in 1980 and 3-4 in 84. In addition to the R&D fundings there is a budget for experimental buildings. The amount for solar energy from this budget is appr. 0.5 mill.NOK in 1984.

Solar radiation

About 20 - 30% of the R&D fundings has been used in projects to get a better understanding of the amount and distribution of solar radiation. The global radiation per year differs between 1,000 KWh/m² in the south-east part to 600 KWh/m² in the northern part. The global radiation during the heating season is at about the same level in both the northern and the southern part. This is due to the fact that the heating season is almost 300 days in the north of Norway compared to about 200 days in the south.

A "Radiation Handbook" for Norway will be completed in 1984. The handbook will be updated with new radiation datas from measureing stations in the coming years.

Passive solar projects

Norway participates the IEA passive solar project and the national programme is therefore almost identical with the Task VIII programme. All the Norwegian passive solar activities are canalized through this project. At least two experimental buildings will be built in connection with this work.

The Norwegian passive project is a cooperation between different research institutions and we have made a reference group with representatives from industries, energy suppliers, consulting engineers and architects.

Active solar systems

There is almost none R&D projects in Norway dealing with commercial solar water heating systems, neither for DHW or space heating. The Norwegian research programme in active solar systems deals mostly with building integrated systems. Most of the systems are air-heating systems. The only present R&D system with a water-collector is a project with a tricklet solar collector. The system using this collector is integrated in walls and roofs and the cost is expected to about appr. 350 NOK/m² (50US$/m²).

The air-heating solar systems are both for DHW and space heating. The most promising one is a 150 m² air-collector system on a Squash-center producing hot water for showers etc. The total installation cost for the system is about 500 NOK/m². The system will be measured in 1983/84.

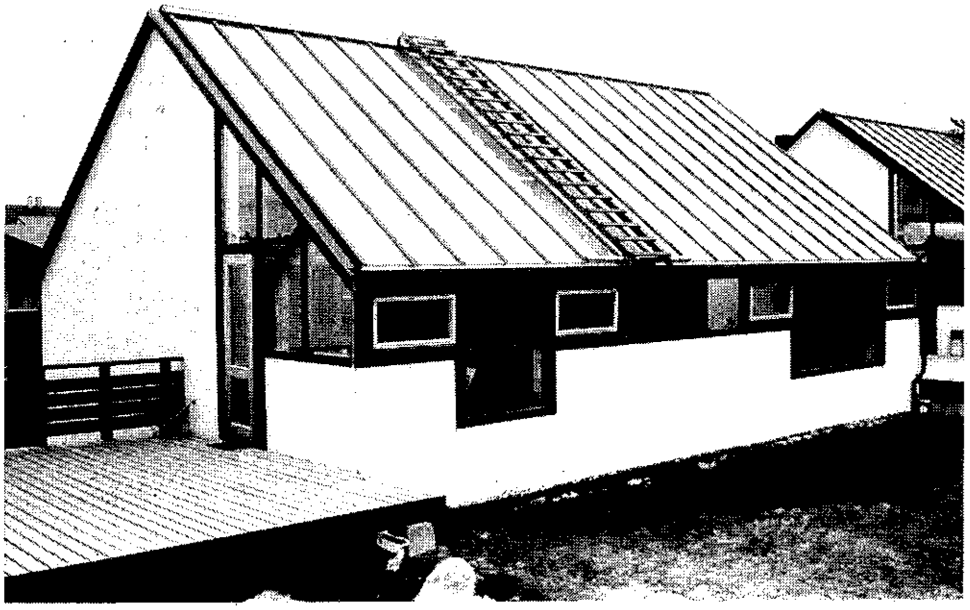


Photo 1.

Photo 2.

Photo 1 & 2.

Double-shell one family house from a solar energy project at SINTEF in Trondheim.

A project at the Technical University in Trondheim plans to use the indoor solar simulator to do thermal small scale experiments with buildings and solar systems. The scope is to get theoretical models which can be used in practical small scale experiments.

By 1984 an evaluation report of the Norwegian active solar houses will be worked out, and this will be the basis for the future R&D projects.

Commercial

The commercial activity is for the moment almost zero, but a lot of architects has been interested to build big semi-climatic glaszones in larger buildings. It is expected that those types of buildings can be well suited for solar energy systems at reasonable costs.

3.8 THE SWEDISH SOLAR HEATING PROGRAMME

Background

The solar programme for space heating is managed by the Swedish Council for Building Research. The main goal of the Swedish energy policy is to reduce the oil dependence. This has so far been achieved by energy conservation, nuclear energy introduction, use of other fuels and heat pumps. As a result of a referendum and parliament dicision nuclear power is to be gradually phased out until the year 2010. Therefore, Sweden interest is now directed towards R&D on domestic energy sources.

The Solar Programme

Solar insolation amounts to about 1000 kwh/m^2 year on a horizontal surface, i.e. about the same as in central Europe. However the distribution of this energy throughout the year is less favourable than in many other countries. Irradiation on a horizontal surface in Stockholm is about 15 times less in December than in June, and in the far north the insolation is zero during some winter months. Further limitations on solar energy are imposed by the proportion of diffuse radiation, which amounts to about 50 % of global radiation, and the number of days with alternating sun and cloud cover.

A target-oriented solar energy programme, known as the Solar 85 programme, was established at the end of the 1970s. Apart from R&D the programme contained a market goal of solar contribution by 1990 in the range of 1-3 TWh. The R&D part of this work is administered by the council.

Objectives for the solar heating programme:

- component development: Increased performance and reduced costs, better durability
- solar heated domestic hot water: Development of low cost systems for multifamily housing units and monitoring of systems in detached houses
- solar collectors in combination with district heating and block centrals: Establishment of full scale systems and monitoring of systems already in operation

The first stage of the programme was directed towards the development and evaluation of a variety of system concepts. During the second stage, from 1982 and onwards, a few interesting system types developed towards better cost efficiency. The programme is now in its third stage which also includes evaluation of the programme and the technology.

The market

Several small industries developed during 1974 - 1980. Most of them concentrated on domestic hot water systems. Production reached its peak in 1980, more than 20,000 m^2 of collectors sold. After that sales decreased rapidly. In all some 60,000 m^2 of collectors have been installed during the last ten years. (See Fig. 1). Favourable subsidies have been offered to buyers of solar equipment. This year, 1984, 50 % of the approved installation cost is subsidized. The low price of electricity has been the major obstacle for solar introduction.

A number of evaluation groups freestanding from the council have been following different parts of the programme. Apart from the evaluation they have contributed with input data for the solar 85 model (see Fig. 2), the market model used for the prediction of solar storage and heat pump contribution to the Swedish solar energy system.

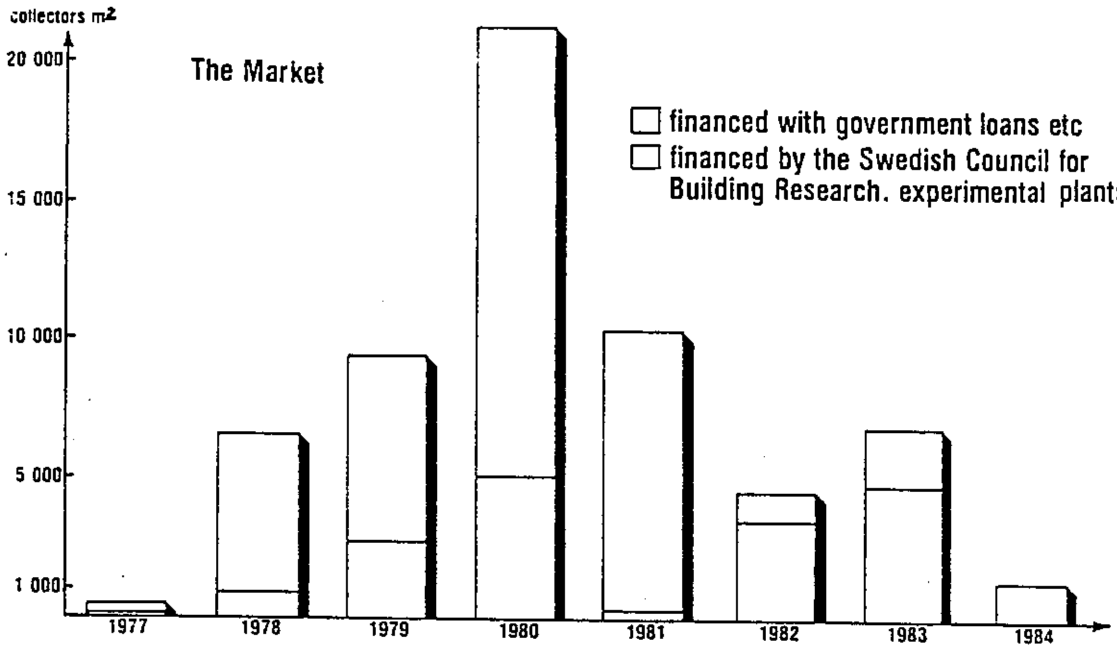


fig 1 The Market

- The market reached its peak shortly after the second oil crisis and the referendum on nuclear energy.
- From 1982 and on many house-owners have changed from oil to electricity.
- Systems financed by the Council are mainly for seasonal storage, district heating and domestic hot water in multifamily houses.

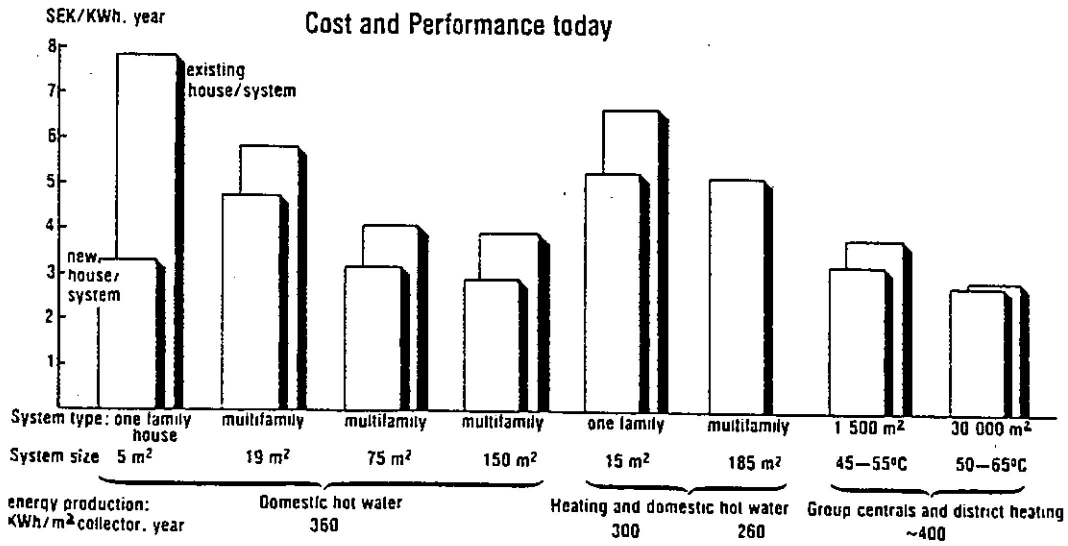


fig 2 Cost/performance for installed systems. (Investment cost per yearly produced KWh.).

- These data are input to the solar 85 model.
- The data represent the best systems today.
- A significant decrease in cost and increase in performance has been experienced the last few years.
- Further improvements are expected, especially for large solar fields.

3.9 SUMMARY OF U.S. SOLAR HEATING AND COOLING RD&D PROGRAM

ORGANIZATION

Solar heating and cooling is the responsibility of the U.S. Department of Energy's Office of Solar Heat Technologies which comes under the Assistant Secretary for Conservation and Renewable Energy. The Program is divided between the Active Heating and Cooling and the Passive and Hybrid Systems Division.

PROGRAM GOALS

The goal of the U.S. Solar Heating and Cooling Program is to provide industry with a technology base that will enable it to develop components and systems that efficiently and cost-effectively convert solar energy into usable thermal energy. This is accomplished by (1) supporting long range and high risk R&D having high benefit potential and by (2) transferring research results to industry.

Specific goals of the Active Solar Program are:

- To improve cost/performance ratios by a factor of two to four over that of today's state-of-the-art active solar systems
- To achieve improvements in component and system reliability and durability to assure 20-year service life of active solar systems.

Specific goals of the Passive Solar Program are:

- To facilitate development of solar cooling technologies that, when integrated with daylighting strategies, are capable of reducing the amount of electricity used in nonresidential buildings by 60 percent.
- To developed advanced technologies that improve performance of passive and hybrid solar heating systems by at least a factor of two over current technology, while mitigating off-season adverse effects.

PROGRAM EMPHASIS

To achieve the above goals, the following areas of program emphasis have been established:

Active Solar

1. Advanced Research and Analysis
   - Collector Materials & Components
   - Thermal Storage
   - Absorption Cooling
   - Rankine Cooling
   - Desiccant Cooling
2. Systems Research and Analysis
   - Systems Testing and Analysis
   - Performance monitoring
   - System Effectiveness Research
   - Test Procedures and Performance Criteria

Passive Solar

1. Systems R&D
   - Passive Heating and Cooling Performance Analysis
     - Non-residential buildings
     - Residential buildings
     - Daylighting systems
     - Cooling
   - Performance Testing and Evaluation
     - Performance monitoring
     - Simulation Code Validation
     - Design Tools
   - Heat Transfer Research
2. Advanced Materials and Components
   - Solar Load Control
     - Aperture Materials and Components
     - Daylighting enhancement
   - Thermal Storage Materials
     - Phase change materials
     - Masonry
     - Desiccants
   - Thermal Transport Subsystems
     - Thermal diodes

FUNDING

	(In millions $U.S.) FY83	FY84
Active Solar	6.7	8.4
Passive Solar	5.0	8.5

4. SOLAR MANUFACTURERS

Reflecting the growth of the solar energy industry in the participating countries, the number of manufacturers of solar heating and cooling systems and components has steadily increased since the 1970's. The reported figures of solar manufacturers in participating countries are summarized in Table 4.1. There is no drastic change in figures for most of the Participants and almost no change in Canada, Japan, Netherlands, and the U.S. However, a remarkable decrease of 50% to 90% in solar manufacturers has been observed in Denmark, Federal Republic of Germany, Sweden and Switzerland.* The causes for these decreases are many but may be partly attributed to reluctance to invest in solar systems because of their high cost, uncertainty about performance and reliability, and discontent as a result of over-inflated expectations of the 1970's. Concentrated efforts by the manufacturers to improve system efficiency, durability and reliability of the solar heating and cooling systems as well as adequate financial support by government might overcome this difficult situation.

* Workshop on Status and Trends in National Solar Heating and Cooling Programmes and Activities, Freiburg, October 18, 1983.

Table 4.1. Solar Manufacturers (1982)

	Number of Component Manufacturers	Number of Packaged System Manufacturers
AUSTRIA	80 (120)	4 (6)
BELGIUM	8 (7)	5 (5)
DENMARK	12	12
GREECE	20*	20*
ITALY	----	----
JAPAN	66 [1/] (75)	38 (30)
NETHERLANDS	5-10 (5-10)	5-15 (5-10)
NORWAY	< 5 (5)	< 5 (5)
SPAIN	(105)	
SWEDEN	3 (40)	4 (3)
USA	450 [2/] (450)	60 [3/] (60)

* 150 small (3-5 workers)

Figures in parentheses indicate data in 1981.

Note:

1/ Manufacturers of solar collectors and solar water heaters were summed up by the Solar System Development Association.

2/ Based on number of trademarks listed in the Solar Engineering Master Catalog and Buyer Guide, 1981 - 1982.

3/ Estimate based on requests for system certification data from the Solar Rating and Certification Corporation plus other known packaged system manufacturers.

5. COLLECTOR MANUFACTURING DATA

This paragraph provides data on square meters of solar collectors sold, by collector types, such as low temperature collectors (below 60°C), medium temperature air and liquid collectors (60 - 80°C), evacuated tubular collector, concentrating collectors, etc. in 1982 or latest year possible. The data were summarized in Table 5.1 which presents collector area in m². One might notice that the U.S. and Japan have manufactured more than one million square meters of solar collectors. A decrease of manufactured collector area in 1982 is observed in most countries compared with data from 1981. Japan's manufacturing activity seems to be almost constant except for a decrease to 1,187,639 m² in 1983. This might be related to a decrease of solar collector manufacturers. Data on Denmark and Spain are cited from Task II, January, 1983 Working Document on Survey on Commercialization and Operating Experience of Solar Heating and Cooling Systems.

Collector manufacturing data in 1982 is shown by % of total square meters of all collectors manufactured in Table 5.2. The type of manufactured solar collectors vary among the participating countries. Austria, Denmark, Greece, Japan and Spain have concentrated on rather low temperature collectors while Belgium, Netherlands, Norway, Sweden and the U.S. are manufacturing more medium temperature collectors. Emphasis on air collectors is seen in Norway and Sweden. Evacuated tubular collectors are manufactured in Belgium, Japan, Netherlands and the U.S. Concentrating collectors are produced only in Japan, Spain, Sweden and the U.S.

In addition to these domestically produced solar collectors, information on imported solar collectors is presented in Table 5.3. Although international trade activity in solar heating and cooling equipment is not prevalent at this moment and statistics on imported collectors are not widely available, an increase of export and import activities is expected in the future.

Table 5.1. Collector Manufacturing Data in 1982 (m^2)

	Low Temperature Collector (below 60°C)		Medium Temperature Collector (60 ~ 80°C)		Evacuated Tube	Concentrating	Other	Total (m^2)
	Metallic	Non-Metallic	Air	Liquid				
AUSTRIA	8,300 (13,400)	10,400 (10,530)	---	---	---	---	---	18,700 (23,930)
BELGIUM	---	200 (1,400)	470 (700)	4,000 (5,200)	500	---	---	5,110 (7,300)
DENMARK	3,000	2,000						5,000
GREECE	100,000*	---	---	---	---	---	---	100,000
ITALY	---	---	---	---	---	---	---	---
JAPAN	885,717 1/ (952,394)		321,596 (580)	(262,933)	64,011 (43,345)	--- (1,820)	---	1,271,324 (1,261,072)
NETHERLANDS	---	(1,000)	(500)	(5,000)	(1,000)	---	---	(7,500)
NORWAY	(100)	---	(200)	---	---	---	---	(300)
SPAIN	(35,000)	---	---	---	---	(2,000)	---	(37,000)
SWEDEN	2,400*	--- (4,000)	---	4,200* (7,200)	--- (400)	--- (90)	---	6,600* (11,690)
USA 2/	75,000 (124,000)	619,600 (672,000)	104,900 (41,000)	869,500 (976,000)	7,800 (16,000)	51,300 (25,000)	1,500 (1,000)	1,729,600 (1,855,500)

* : 1983   ( ) : figure in parenthesis indicate the data in 1981

Note: 1/ Based on the statistical data by the Better Living Promotion Association 1982

2/ Source, Energy Information Administration, U.S. Department of Energy: Solar Collector Manufacturing Activity, July 1982, DOE/EIA-0174 (82)

Table 5.2. Collector Manufacturing Data in 1982
(% of total square meters of all collectors manufactured)

	Low Temperature Collector (below 60°C)		Medium Temperature Collector (60 - 80°C)		Evacuated Tube	Concentrating	Others
	Metallic	Non-Metallic	Air	Liquid			
AUSTRIA	44.4	55.6	---	---	---	---	---
BELGIUM	---	5	10	85	---	---	---
DENMARK	(60)	(40)	---	---	---	---	---
GREECE	92.5*	---	---	---	---	---	---
ITALY	---	---	---	---	---	---	---
JAPAN	69.7		25.3		5.0	---	---
NETHERLANDS	---	(14)	(6)	(67)	(13)	---	---
NORWAY	(30)	---	(70)	---	---	---	---
SPAIN	(95)	---	---	---	---	(5)	---
SWEDEN	36*	---	64*	---	---	---	---
USA	4.3	35.8	6.1	50.3	0.5	3.0	0.1

* data in 1983
( ) data in 1981

Table 5.3. Imported Solar Collectors Data in 1982 (m^2)

	Low Temperature Collector		Medium and High Temperature Collector		Total
	Metallic	Non-Metallic	Liquid	Evacuated	
AUSTRIA	200	600	---	50	850
BELGIUM	---	---	170	---	---
GREECE	8,000*	---	---	---	8,000*
JAPAN	**	259*	---	---	**
NORWAY	(100)	---	---	---	(100)
USA	---	---	---	---	38,800***

* data in 1983.

** from Australia and Italy, quantity unknown.

*** Includes only those collectors imported by collector manufactures that responded to DOE survey.

( ) data in 1981.

6. SOLAR SYSTEM INSTALLATIONS

With the significant growth of solar heating and cooling components production, especially that of solar collectors, the number of solar systems installations rapidly increased in the participating countries. The purpose of the survey on these installations is to highlight the recent trends of the solar energy industry. This chapter presents the completed surveys which contain information on the type, number, average size and cost of installed solar systems.

Data is presented for cumulative number of installations through 1982 and for the number of installations for the year 1983. Statistics on total area of collectors (in m^2) used in these installations are also provided. In addition, average size of installation, average system cost and average installation cost are indicated. Detailed data on installations were reported by Japan and the U.S. Most of the other participants did not have access to such systematic statistics and provided their best estimates.

Briefly, in the swimming pool installations, Austria, Greece and the U.S. reported that they employed rather inexpensive solar heating systems at less than 100 $\$/m^2$. This may have been achieved by using unglazed solar collector systems especially designed for heating large volumes of water with relatively low temperatures. The Japanese indoor swimming pool systems are rather expensive because of the use of medium temperature collectors.

Regarding DHW systems, the average size of most of the single family residential systems is less than 10 m^2/system, while the collector area for multi-family and commercial buildings varies depending on the building design.

Japan, Netherlands, Norway, Sweden and the U.S. reported their space heating installations. Only Japan and the U.S. reported their solar cooling systems. Japan, Sweden and the U.S. reported a wide variety of industrial process heat applications. Greece, Norway, Sweden and the U.S. have increased the number of passive system installations. With passive systems still in the RD&D stages, installations might increase dramatically each year.

The figures provided on total system costs indicate that the installation represents a very high proportion of the costs of the system. If solar system sales are to become more wide-spread, the ratio of installation costs to equipment costs per m^2 of collector must be reduced.

It should be noted that the data for Denmark and Spain are based on figures given for the 1981 survey, and the data given for the U.S. are for 1982.

6.1 SOLAR SYSTEM INSTALLATIONS [AUSTRIA]

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1982 Total Number	TOTAL INSTALLED: Through 1982 Total Area m²	TOTAL INSTALLED: 1983 Total Number	TOTAL INSTALLED: 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION (1983) ($ US): System Cost/m²	AVERAGE COST PER INSTALLATION (1983) ($ US): Installation Cost/m²	AVERAGE COST PER INSTALLATION (1983) ($ US): Total
a. SWIMMING POOL								
Residential	50	1,400	50	1,400	20 - 40	70	55	3,750
Public	30	9,000	40	12,000	200 - 600	65	45	44,000
b. DHW (Includes thermosyphon)								
Single-Family Residence	560	4,500	300	2,400	6 - 10	400	100	4,000
Multi-Family Residence	70	2,000	40	1,200	20 - 40	350	50	12,000
Commercial Building	20	1,800	15	1,500	80 - 120	350	50	40,000
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	-	-	-	-	-	-	-	-
Multi-Family Residence	-	-	-	-	-	-	-	-
Commercial Building	-	-	-	-	-	-	-	-

* m² of collectors. (1 AS = 0.05 $US) (Jan. 84)

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1982: Total Number	TOTAL INSTALLED: Through 1982: Total Area m²	TOTAL INSTALLED: 1983: Total Number	TOTAL INSTALLED: 1983: Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) (US $): System Cost/m²	AVERAGE COST PER INSTALLATION(1983) (US $): Installation Cost/m²	AVERAGE COST PER INSTALLATION(1983) (US $): Total
d. SPACE COOLING								
Single-Family Residence	-	-	-	-	-	-	-	-
Multi-Family Residence	-	-	-	-	-	-	-	-
Commercial Building	-	-	-	-	-	-	-	-
e. INDUSTRIAL PROCESS HEAT								
	-	-	-	-	-	-	-	-
f. PASSIVE								
New	-	-	-	-	-	-	-	-
Retrofit	-	-	-	-	-	-	-	-

6.2 SOLAR SYSTEM INSTALLATIONS [BELGIUM]

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	Through 1982 Total Area m²	1983 Total Number	1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION (1983) ($ US) System Cost/m²	Installation Cost/m²	Total BF/m²
a. SWIMMING POOL								
Residential	-	200	na	na	na	na	na	
Public	-	-	na	-	-	-	-	298
b. DHW (Includes thermosyphon)								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								291
c. SPACE HEATING (With or without DHW)								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								

* m² of collectors. (1 BF = 0.0182 $US) na: not available

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	TOTAL INSTALLED Through 1982 Total Area m²	TOTAL INSTALLED 1983 Total Number	TOTAL INSTALLED 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION (1983) (US $) System Cost/m²	AVERAGE COST PER INSTALLATION (1983) (US $) Installation Cost/m²	AVERAGE COST PER INSTALLATION (1983) (US $) Total
d. SPACE COOLING	na (probably very limited)							
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
e. INDUSTRIAL PROCESS HEAT	na							
f. PASSIVE								
New								
Retrofit								

Source: HELIOBEL

6.3 SOLAR SYSTEM INSTALLATIONS [DENMARK] (1981)

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1980 Total Number	Through 1980 Total Area m^2	1981 Total Number	1981 Total Area m^2	AVERAGE SIZE* PER INSTALLATION (1981)	AVERAGE COST PER INSTALLATION (1981) (US $): System Cost/$m^2$	Installation Cost/m^2	Total
a. SWIMMING POOL								
Residential	250	-	25	-	20	83	125	4,152
Public	5	-	3	-	300	83	90	51,900
b. DHW (Includes thermosyphon)								
Single-Family Residence	1,200	-	500	-	8	195	130	2,595
Multi-Family Residence	30	-	20	-	50	187	125	15,570
Commercial Building	20	-	20	-	20	208	104	6,228
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	800	-	400	-	20	260	156	8,304
Multi-Family Residence	70	-	20	-	60	260	173	25,950
Commercial Building	30	-	15	-	60	260	173	25,950

* m^2 of collectors.

(1 D.Crs. = 0.1038 $US)

TYPE OF SYSTEM	TOTAL INSTALLED Through 1980 Total Number	Total Area m²	1981 Total Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION 1981	AVERAGE COST PER INSTALLATION (1981) (US $) System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence	0		0					
Multi-Family Residence	0		0					
Commercial Building	0		0					
e. INDUSTRIAL PROCESS HEAT								
	0		0					
f. PASSIVE								
New								
Retrofit								

6.4 SOLAR SYSTEM INSTALLATIONS [GREECE]

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	TOTAL INSTALLED Through 1982 Total Area m²	TOTAL INSTALLED 1983 Total Number	TOTAL INSTALLED 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION (1983) ($ US) System Cost/m²	AVERAGE COST PER INSTALLATION (1983) ($ US) Installation Cost/m²	AVERAGE COST PER INSTALLATION (1983) ($ US) Total
a. SWIMMING POOL								
Residential								
Public			3	4,000	1,333	60	40	133,300
b. DHW (Includes thermosyphon)								
Single-Family Residence	38,000	95,000	40,000	100,000	2.5	220	25	612
Multi-Family Residence	2,000	5,000	4,000	6,000	2.5	220	30	625
Commercial Building	20	3,000	15	2,000	133	290	80	22,610
c. SPACE HEATING (With or without DHW)								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								

* m² of collectors.

(1 DRCH = 0.01 $US)

	TOTAL INSTALLED					AVERAGE COST PER INSTALLATION (1983) (US $)		
	Through 1982		1983		AVERAGE SIZE* PER INSTALLATION 1983			
TYPE OF SYSTEM	Total Number	Total Area m²	Total Number	Total Area m²		System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
e. INDUSTRIAL PROCESS HEAT								
f. PASSIVE								
New			4	755	180	-	-	-
Retrofit								

6.5 SOLAR SYSTEM INSTALLATIONS [JAPAN]

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	TOTAL INSTALLED Through 1982 Total Area m²	TOTAL INSTALLED 1983 Total Number	TOTAL INSTALLED 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST[1/] PER INSTALLATION (1983) ($ US) System Cost/m²	AVERAGE COST[1/] PER INSTALLATION (1983) ($ US) Installation Cost/m²	AVERAGE COST[1/] PER INSTALLATION (1983) ($ US) Total
a. SWIMMING POOL								
Residential	0	0	0	0		0	0	0
Public	51	na	8	1,857	232	290 - 550	200 - 340	160,080
b. DHW not (Includes thermosyphon)[2/]								
Single-Family Residence	108,685	na	63,094	296,405	5	320 - 930	120 - 370	4,350
Multi-Family Residence	178	na	122	11,905	98	350 - 840	190 - 470	90,650
Commercial Building	3,430	na	686	68,184	99	280 - 590	110 - 540	75,240
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	704	na	71	1,025	14	320 - 750	110 - 280	10,220
Multi-Family Residence	5	na	2	196	98	350 - 470	260 - 280	66,640
Commercial Building	170	na	10	861	86	350 - 780	170 - 610	82,130

* m² of collectors. (1 Yen = 0.00417 $US)

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1982 Total Number	TOTAL INSTALLED: Through 1982 Total Area m²	TOTAL INSTALLED: 1983 Total Number	TOTAL INSTALLED: 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) (US $): System Cost/m²	AVERAGE COST PER INSTALLATION(1983) (US $): Installation Cost/m²	AVERAGE COST PER INSTALLATION(1983) (US $): Total
d. SPACE COOLING								
Single-Family Residence	70	na	0	0	40	380 - 440	130 - 200	23,000
Multi-Family Residence	6	na	1	84	84	790 - 910	540 - 560	117,600
Commercial Building	278	na	33	9,475	287	390 - 1,160	270- 490	331,485
e. INDUSTRIAL PROCESS HEAT								
	185	na	54	3,006	56	220 - 1,080	190- 790	63,840
f. PASSIVE na								
New								
Retrofit								

1/ includes cost of auxiliary heat source. All data are based on survey by the Solar System Development Association as of the end of 1983, on the solar heating and cooling systems subjected to low interest bank loans

2/ 3.77 millions thermosyphon type solar water heaters of 2 - 6 m^2 have been installed through 1982. In 1983 382,700 units (average size 3 m^2 with 200 liters water tank) have been installed with average system cost of 250 $ US/m2 and installation cost of 250 $/$m^2$ and accordingly $ 1,500 in total.

6.6 SOLAR SYSTEM INSTALLATIONS [NETHERLANDS]

TYPE OF SYSTEM	TOTAL INSTALLED [1/] Through 1982 Total Number	Through 1982 Total Area m²	1983 Total Number	1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION (1983) ($ US) System Cost/m²	Installation Cost/m²	Total
a. SWIMMING POOL								
Residential	-	-	na	na	na	-	-	-
Public	5	600	6	700	-	-	-	-
b. DHW (Includes thermosyphon)								
Single-Family Residence	-	-						
Multi-Family Residence	-	-	725	5,000	-	-	-	-
Commercial Building	-	-						
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	-	-						
Multi-Family Residence	-	-		9,000				
Commercial Building	-	-						

* m² of collectors. (1 = $US)

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	Total Area m²	1983 Total Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) (US $) System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence			-					
Multi-Family Residence			-					
Commercial Building			-					
e. INDUSTRIAL PROCESS HEAT								
			-					
f. PASSIVE								
New			-					
Retrofit			-					

1/ Within Solar Programme

SOLAR SYSTEM INSTALLATIONS [NORWAY]

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1982 Total Number	TOTAL INSTALLED: Through 1982 Total Area/m²	TOTAL INSTALLED: 1983 Total Number	TOTAL INSTALLED: 1983 Total Area/m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) ($ US): System Cost/m²	AVERAGE COST PER INSTALLATION(1983) ($ US): Installation Cost/m²	AVERAGE COST PER INSTALLATION(1983) ($ US): Total
a. SWIMMING POOL								
Residential	10	200	< 5					
Public	5	100	< 5					
b. DHW (Includes thermosyphon)								
Single-Family Residence	15	90	< 10	60	6	180	100	1680
Multi-Family Residence								
Commercial Building	5	200	< 10		10-150	25**	40**	9750**
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	15	400	< 5		15-60	25	100	7500
Multi-Family Residence	5		< 5					
Commercial Building	5		< 5					

* m² of collectors. ** the most promising installation. (1 NOK = 0.125 $US)

	TOTAL INSTALLED					AVERAGE COST PER INSTALLATION(1983) (US $)		
	Through 1982		1983					
TYPE OF SYSTEM	Total Number	Total Area m²	Total Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence	0			0				
Multi-Family Residence	0			0				
Commercial Building	0			0				
e. INDUSTRIAL PROCESS HEAT								
	0			0				
f. PASSIVE								
New	10			2				
Retrofit								

6.8 SOLAR SYSTEM INSTALLATIONS [SPAIN] (1981)

	TOTAL INSTALLED					AVERAGE COST PER INSTALLATION (1981) (US $)		
	Through 1980		1981		AVERAGE SIZE* PER INSTALLATION (1981)			
TYPE OF SYSTEM	Total Number	Total Area m²	Total Number	Total Area m²		System Cost/m²	Installation Cost/m²	Total
a. SWIMMING POOL								
Residential				700	20	164	70	4,677
Public				-	-			
b. DHW (Includes thermosyphon)								
Single-Family Residence				8,000	4	178	76	1,016
Multi-Family Residence				20,000	70	150	64	14,968
Commercial Building				-	-			
c. SPACE HEATING (With or without DHW)								
Single-Family Residence				6,300	30	140	60	6,014
Multi-Family Residence				-	-			
Commercial Building				-	-			

* m² of collectors.

(1 PTS = 0.006688 $US)

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1980 Total Number	TOTAL INSTALLED: Through 1980 Total Area m²	TOTAL INSTALLED: 1981 Total Number	TOTAL INSTALLED: 1981 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1981	AVERAGE COST PER INSTALLATION (1981) (US $): System Cost/m²	AVERAGE COST PER INSTALLATION (1981) (US $): Installation Cost/m²	AVERAGE COST PER INSTALLATION (1981) (US $): Total
d. SPACE COOLING								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
e. INDUSTRIAL PROCESS HEAT				2,000	1,000	187	80	267,280
f. PASSIVE								
New								
Retrofit								

6.9 SOLAR SYSTEM INSTALLATIONS [SWEDEN]

TYPE OF SYSTEM	TOTAL INSTALLED: Through 1982 Total Number	TOTAL INSTALLED: Through 1982 Total Area m²	TOTAL INSTALLED: 1983 Total Number	TOTAL INSTALLED: 1983 Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) ($ US): System Cost/m²	AVERAGE COST PER INSTALLATION(1983) ($ US): Installation Cost/m²	AVERAGE COST PER INSTALLATION(1983) ($ US): Total
a. SWIMMING POOL								
Residential	750-1,000	10-15,000			15	125		1,875
Public	5	1,500	1	300	300	250		75,000
b. DHW (Includes thermosyphon)								
Single-Family Residence	4,950	39,630	217	1,735	8	250		2,000
Multi-Family Residence	21	1,680	1	365	80	187		15,000
Commercial Building								
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	30	600	na	na	20	250		5,000
Multi-Family Residence	1	4	na	na				
Commercial Building	-	-	-	-				
***	10	7,409	2	4,216		212.5		895,900

* m²of collectors.

(1 SEK = 0.1196 $US)

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	Total Area m²	1983 Total Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST PER INSTALLATION(1983) (US $) System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
e. INDUSTRIAL PROCESS HEAT								
	2	500			250	-	-	-
f. PASSIVE								
New	200	4,000						
Retrofit	(building area)							

*** Block Central, District Heating

6.10 SOLAR SYSTEM INSTALLATIONS [USA]

TYPE OF SYSTEM	TOTAL INSTALLED 1981 Through ~~1982~~ Total[4/] Number	Total Area m²	1982# ~~1983~~ Total[5/] Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION [6/] 1982	AVERAGE COST PER INSTALLATION (1982) ($ US) System Cost/m²	Installation [8/] Cost/m²	Total
a. SWIMMING POOL								
Residential	95,000	3,325,000	17,900	627,400	SF 35 MF 76	43 - 215	21 - 110	SF 3,455 MF 7,522
Public	na	na	350	20,000	CM 113	na	na	15,019
b. DHW (Includes thermosyphon)								
Single-Family Residence	238,000	1,428,000	109,500	657,000	6	390 - 646	86 - 161	3,235
Multi-Family Residence	9,100	236,600	1,100	28,000	26	na	na	8,171
Commercial Building	3,400	163,200	150	7,200	48	344 - 420	86 - 140	13,218
c. SPACE HEATING (With or without DHW)								
Single-Family Residence	50,000	1,200,000	8,500	204,000	24 [7/]	370 - 485	na	9,520
Multi-Family Residence	1,400	46,200	250	8,700	33	na	na	13,064
Commercial Building	1,600	91,200	100	6,500	57	na	na	19,344

* m² of collectors. (1 = $US) #1983 data not available

TYPE OF SYSTEM	TOTAL INSTALLED Through 1981 (~~1982~~) Total Number	Total Area m²	1982 (~~1983~~) Total Number	Total Area m²	AVERAGE SIZE* PER INSTALLATION 1982	AVERAGE COST PER INSTALLATION (1982) (US $) System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence	300	6,300	300	6,052	21	na	na	10,241
Multi-Family Residence	5 - 10	1,255-2,450	5 - 20	1,225-4,990	245	na	na	169,000
Commercial Building	5 - 10	1,750-3,500	5 - 20	1,750-7,160	358	na	na	243,764
e. INDUSTRIAL PROCESS HEAT								
	Under	40	5 - 10	27,400	460 - 4,600	500 - 700	Installed	
f. PASSIVE								
New	70,000		28,000 9/			na	na	Approx. 3,000 &higher
Retrofit	na		na			na	na	depends with design

SF: Single Family MF: Multi-Family CM: Commercial

4/ Total systems installed through 1981 is an estimate based on the 1980 and 1981 Active Solar Installation Surveys (ASIS) prepared for the Energy Information Administration, U.S. Department of Energy. A revised total was developed using a variety of correction factors.

The number of passive systems is based on a straight application of an estimated percent of passive construction applied to the total number of new starts, as reported by the National Association of Home Builders Research Corporation. (See footnote 9)

5/ Estimates based on Solar Collector Manufacturing Activity, DOE/IEA-0174 (82) and 1981 Active Solar Installation Survey, DOE/EIA, DOE/EIA-0174 (82).

6/ The average size per installation for space heating is an average for systems with and without demestic water heating, from the 1981 Active Solar Installation report.

7/ The average size per installation for space heating is an average for systems with and without domestic water heating, from the 1981 Active Solar Installation report.

8/ System and installation cost estimates come from several sources: interviews with Solar Energy Industries Association members and staff; review of product catalogs; information developed by Mueller Associates, Inc., for the Gas Research Institute; and data from the Tennessee Valley Authority solar water heater programme. No definitive data exists, and costs are presented in possible ranges.

9/ The number of passive systems installed in 1982 is based on an estimate of 2 percent of new housing starts. Passive solar houses are those with a significant percent of energy needs being met by the system, and do not include "sun tempered' houses or houses with small sun spaces. No reliable source exists for this data.

7. GOVERNMENT INCENTIVES

One of the most critical aspects of the early stages of commercialization of an energy technology is government incentives. This was emphasized at the Workshop on Trends and Status of National Solar Heating and Cooling Programmes and Activities held in Freiburg in October, 1983. Participants agree that the government incentives are quite indispensable in promoting the propagation of solar heating and cooling systems and the growth of the solar energy industry.

AUSTRIA

Income tax reduction for owners of solar and heat pump systems.

BELGIUM

The government allows profit making industries to write off 135% of the investments for energy conservation.

DENMARK (1981)

For all installations of renewable energy, there is given subsidy to the owner at 30% basis. For projects with an attractive economy of energy (often large collector plants) there is a possibility of extra subsidies up to 35% of the rest, i.e. 54.5% of the total.

GREECE

Tax credits 30,000 DRCH (300 US$) deductable from the taxable income.

70% of value of solar heating system (including installation expenses) payable in three years (6 month installment) with interest rate 17%. For commercial systems there are grants up to 30% of the value of system including installation. The loan in this case is up to 40%.

JAPAN

Low interest bank loans (1980 -):

The frame of low interest bank loans in 1983 was 2.4 billion yen.

For residential: interest of 5.5%, 5 years repayment within the limit of 2 millions yen.

For commercial bldg.: interest of 6.5%, 10 years repayment within the limit of 100 millions yen.

Energy conservation loan to small scale industries:

Interest of 7.8%, 10 years repayment within the limit of 300 M yen.

Agricultural loan for livestock yard heating:

No interest, 5 years repayment within the limit of 14,600 yen/m^2.

Loans to fishermen for solar water heaters:

No interest, 2 years repayment within the limit of 100,000 yen.

Subsidies to the local governments (50%):

Solar heating, cooling and DHW systems for school, hospital, public hall, city offices. The frame of subsidies per year is 3.6 billions yen in 1983.

Local governments incentives:

Most of the local governments have their own incentive measures of wide varieties such as low interest loans to individuals and small scale industries respectively for energy conservation purposes. Brief description on them appears in the following

Tax reduction (1981 -):

Tax reduction for commercial bldgs.: 7% of total solar cost is exempted from income tax or 30% of total solar cost is added to the depreciation cost of the first year.

Tax reduction on property tax (25%) for three years.

Energy conservation loan for public bath business by local governments:

21 prefectural government and 6 cities have been giving five loans from 20 - 3 M yen and 22 subsidy programs of 4.5 - 0.4 M yen on the basis of 75 - 25% to public bath business for energy conservation.

LOCAL GOVERNMENT INCENTIVES FOR SOLAR SYSTEM INSTALLATION

A. Energy Conservation Loan for Small Scale Industries

Prefecture	Upper Limit (M yen)	Interest (%)	Repayment (years)	Started since	Remarks
HOKKAIDO	40	7.4	10	1981	Frame 2 B yen
YAMAGATA	30	6.9	7	1982	Energy saving > 10%
FUKUSHIMA	40	7.0	10	1980	
TOCHIGI	10	6.0	5	1980	
Tochigi City	10	6.3	8	1980	
GUNMA	50	5.8	10	1980	Energy saving > 10%
Isezaki City	5	6.7	7	1981	
SAITAMA	20	6.4	6	1979	
CHIBA	30	6.5	7	1980	
TOKYO	30	8.7	11	1981	Energy saving > 5%
KANAGAWA					
Yokohama City	30	7.0	5	1982	
NIIGATA	15	----	5	1981	
TOYAMA	20	6.9	5	1982	Energy saving > 10%
ISHIKAWA	20	5.9	7	1982	Energy saving > 10%
YAMANASHI	20	6.7	7	1980	Energy saving > 10%
SHIZUOKA	30	5.8	7	1979	
AICHI	70	6.2	7	1983	
Nagoya City	20	6.2	7	1983	
GIFU	20	6.7	7	1980	Frame 1.5 B yen
MIE	20	6.8	7	1982	
SHIGA	20	6.7	10	1981	
KYOTO	30	5.0	7	1981	
OSAKA	80	6.8	7	1982	
HYOGO	30	6.7	7	1981	
NARA	20	7.0	7	1980	
TOTTORI	20	6.0	7	1983	
SHIMANE	30	6.1	10	1979	
OKAYAMA	25	6.4	8	1980	
HIROSHIMA	20	6.6	7	1980	
Hiroshima City	20	6.5	5	1980	Frame 38 M yen
YAMAGUCHI	30	6.7	7	1980	
TOKUSHIMA	30	6.5	10	1983	Frame 12 M yen
KAGAWA	20	6.3	7	1981	
KOCHI	2.5	6.2	10	1983	Frame 200 M yen
FUKUOKA					
Fukuoka City	10	6.0	5	1981	
Kitakyushu City	30	6.0	10	1981	
SAGA	30	6.0	7	1983	
NAGASAKI	30	7.2	7	1983	
OITA	35	6.8	7	1981	
KUMAMOTO					
Yatsushiro City	5	6.5	6	1981	
MIYAZAKI	1.5	7.3	7	1981	

LOCAL GOVERNMENT INCENTIVES FOR SOLAR SYSTEM INSTALLATION

B. Energy Conservation Loan for Individuals

Prefecture	Upper Limit (Thousand Yen)	Interest (%)	Repayment (years)	Started Since	Remarks
HOKKAIDO					
Kitami City	1,000	6.5	12	1982	Frame 20 M yen
Asahikawa City	1,000	6.0	10	1983	Frame 105 M yen
IBARAGI					
Shimozuma City	300	7.2	3	1981	
TOCHIGI					
Tochigi City	300	5.0	3	1980	
Kamimikawa Town	30	---	---	1981	
GUNMA					
Takasaki City	500	5.7	12	1980	Frame 95 M yen
Tatebayashi City	20	---	---	1981	
Fujioka City	15	---	---	1982	
SAITAMA					
Yono City	50	---	---	1980	
CHIBA					
Chiba City	30	---	---	1981	
Nagareyama City	30	---	---	1982	
Kimitsu City	15	---	---	1981	
TOKYO					
Kokubunji City	15	---	---	1981	
Higashikurume City	25	2.0	2	1981	
Mitaka City	300	8.0	3	1980	
Musashino City	500	8.0	3	1981	
Musashimurayama City	300	6.1	3	1980	
Higashimurayama City	15	---	---	1980	
Itabashi-ku	2,000	5.75	5	1980	
Bunkyo-ku	300	7.0	2	1981	
Chofu City	25	---	---	1981	Frame 0.5 M yen
KANAGAWA					
Yokohama City	1,000	5.5	5	1980	
YAMANASHI					
Fujiyoshida City	200	9.0	2	1980	
AICHI					
Koda City	20	---	---	1981	
Obu City	200	5.5	1	1980	
Kasugai City	300	5.5	3	1981	
Handa City	300	5.7	3	1981	
HYOGO					
Itami City	500	7.3	5	1981	
YAMAGUCHI	300	6.8	20	1980	
FUKUOKA					
Kitakyushu City	1,000	2.5	5	1981	
Kurume City	2,000	2.5	5	1980	
NAGASAKI					
Omura City	2,000	2.0	5	1980	
Oshima Town	2,000	2.0	5	1980	
OITA					
Oita City	200	4.8	2	1980	
Saiki City	200	5.0	2	1980	
Mie Town	100	3.0	2	1980	
Hida City	200	4.8	2	1980	

NETHERLANDS

Tax credits (WIR) for non-private sectors.

NORWAY

No loans or tax credits, but small fundings for special prototypes.

SPAIN (1981)

The Spanish government subsidizes the solar flat plate collectors installed with 6,500.0 Pts. square meter per collector.

SWEDEN

Single family houses: grant up to 50% of solar cost.

Multi-family houses : grant up to 50% of solar cost and 6% interest-subsidy.

USA

Federal and State Governments provide incentives for purchasers of renewable energy systems. The Federal Government offers a residential income tax credit equal to forty percent of system cost to a maximum of $4,000 on $10,000 of expenditure. The credit applies to active and non-structural components of passive systems.

A fifteen percent business energy investment tax credit exists for purchasers of renewable energy equipment, who are also eligible for the standard ten percent investment tax credit for certain applications (excluding heating and cooling) for a combined credit of twenty-five percent. Solar equipment is also eligible for accelerated depreciation.

The Federal Government is inaugurating a Conservation and Solar Development Bank to finance consumer purchases of solar energy systems (excluding active solar), a program which will be run on a state level.

States have a wide range incentives from income tax incentives to exclusion of solar equipment from sales and property taxes. The table attached provides a summary of these incentives.

STATE TAX BREAKS FOR RESIDENTIAL SOLAR SYSTEMS

State	Property Tax Exemption	Income Tax Incentive	Sales Tax Exemption
Alabama	no	up to $1000 credit	no
Alaska	no	up to $200 credit	not applicable
Arizona	exemption	up to $1000 credit	exemption
Arkansas	no	100% deduction	no
California	no	up to $3000 credit per application	no
Colorado	exemption	up to $3000 credit	no
Connecticut	local option	not applicable	exemption
Delaware	no	$200 credit for DHW systems	not applicable
Florida	exemption	not applicable	exemption
Georgia	local option	no	refund
Hawaii	exemption	10% credit	no
Idaho	no	100% deduction	no
Illinois	exemption	no	
Indiana	exemption	up to $3000 credit	no
Iowa	exemption	no	no
Kansas	exemption; refund based on efficiency of system		
Kentucky	no	no	no
Louisiana	exemption	no	no
Maine	exemption	up to $100 credit	refund
Maryland	exemption statewide plus credit at local option	no	no
Massachusetts	exemption	up to $1000 credit	exemption
Michigan	exemption	up to $1700 credit	exemption
Minnesota	exemption	up to $2000 credit	no
Mississippi	no	no	exemption for colleges, junior colleges and universities
Missouri	no	no	no
Montana	exemption	up to $125 credit	not applicable
Nebraska	yes	up to $3000 credit	refund
Nevada	limited exemption	not applicable	no
New Hampshire	local option	not applicable	not applicable
New Jersey	exemption	no	exemption
New Mexico	no	up to $4000 credit	no
New York	exemption	up to $2750 credit	no
North Carolina	exemption	up to $1000 credit	no
North Dakota	exemption	5% credit for two years	no
Ohio	exemption	up to $1000 credit	exemption
Oklahoma	no	up to $2800 credit	no
Oregon	exemption	up to $1000 credit	not applicable
Pennsylvania	no	no	no
Rhode Island	exemption	up to $1000 credit	refund
South Carolina	no	up to $1000 deduction	no
South Dakota	exemption	not applicable	no
Tennessee	exemption	not applicable	no
Texas	exemption	not applicable	exemption
Utah	no	up to $1000 credit	no
Vermont	local option	up to $1000 credit	no
Virginia	local option	starts 1983	no
Washington	exemption	not applicable	no
West Virginia	no	no	no
Wisconsin	exemption	no*	no
Wyoming	no	not applicable	no

*Wisconsin offers a direct rebate for part of solar expenditures; the rebate is unrelated to taxes. Data from Conservation and Renewable Energy Inquiry and Referral Service (800) 523-2929.

8. STANDARDS AND CERTIFICATION

Both standards and certification play significant roles in the late RD&D and commercialization stages of recent technologies. With the evolution of the technology, the growth of solar energy industries, and increasing numbers of installations, more and more countries are dealing with the need to develop standards and certification programmes. Standardization will require the time consuming efforts and cooperation among manufacturers, installers, scientists, researchers, and governmental agencies.

The statements by the Participants on standards and certification programmes are as follows:

AUSTRIA

ÖNORM M 7710 - M 7716

BELGIUM

An agreement procedure for solar collectors and systems is in preparation.

DENMARK

To obtain the 30% subsidy it is conditional that the manufacturer or agent has a system approval of his plant issued by the Danish Solar Energy Testing Laboratory.

GREECE

ELOT 388-1 and 388-2 for flat plate collector. For flat plate collectors, there are two test stations: The University of Thrace Test Facility and GAEF/Demokritos Test Facilities.

JAPAN

Solar Water Heaters: JIS A 4111 (1979)

Solar Flat Plate Collectors and Theraml Storage Tanks: Japanese Industrial Standards will be issued in 1984. No national system performance standards exists. Procedures on them are in preparation.

Certification Programmes: Solar heating and cooling components and systems by the Solar System Development Association since 1980.

The Certification Programme for Better Solar Heating and Cooling Components was inaugurated in February, 1984. This programme relates to certification on solar collectors and storage tanks of active systems at this moment. The certification is issued by Minister of the Ministry of International Trade and Industry, through the Better Solar System Component Certification Standards Committee and Solar System Development Association as the Designated Investigation Organization and Japan Metals and Machinery Inspection Institute as the Designated Test Organization.

The testing procedures for solar collectors cover exposure test, thermal shock/cold fill, static pressure test, mechanical strengths and thermal performance tests, compound heat cycle test, leak resistance test followed with the disassembly inspection. Instantaneous performance test is performed by a solar simulator of 72 KW and the test results are translated into standard day performance of ΔT with six stages from 5° - 80°C and insolation as 3,000, 4,000 and 5,000 Kcal/m^2day. Those for water storage tanks cover heat loss measurement, performance test of heat exchanger, static pressure test and effective discharge rate determination.

In addition to the appropriate investigation results, following requirements must be met in this certification programmes. For a flat plate type solar collector tested, collector rating number at $\Delta T = 10°C$ and 5,000 Kcal/m^2day should exceed 2,000 Kcal/m^2 of gross area of collector unit. For the heat loss measurement of a water storage tank, heat loss coefficient $KA < 0.003$ times $V + 5$ where V is the capacity of tank (ℓ), and the heat exchange rate Q indicates values of more than 95 % of applicant's data. Effective discharge rate η_T is more than 80 %.

Those solar heating and cooling components which satisfy the above requirements bear the label the sample of which is shown below.

NETHERLANDS

Certification programme TNO-SNEP-C.E.E.

NORWAY

None

SPAIN (1981)

Standard INTA 610010 "Quasi-steady state test of flat solar collector" (published in 1979). Nowadays the standard INTA 610010 has been accepted as a Spanish official standards.

SWEDEN

The following items for solar collectors are tested: thermal efficiency as a function of temperature difference (collector mean temperature and outdoor temperature), stagnation and shock-cooling tests as well as wind load, snow load, rain proof and pressure test to 2 MPa.

USA

No national performance standard exists. The Solar Energy Industries Association and the Inter-State Solar Coordinating Council established an industry-supported solar collector certification program, which will also certify domestic water heating systems. The Solar Rating and Certification Corporation pressure tests, cold fill and cold spray test, performs a stagnation test and instantaneous performance test and then disassembly inspects collectors. Test results are translated into standard day performance estimates for six delta T and three insolation conditions. The air conditioning and Refrigeration Institute has a similar program. (The SRCC Summary is attached as a separate sheet.)

The Department of Housing and Urban Development has an Intermediate Minimum Property Standard for solar energy systems that apply to government sponsored or purchased systems. Several local juridictional code agencies have incorporated solar energy into their building codes.

The U.S. institutional infrastructure for standards has begun to incorporate solar heating and cooling.

THE SOLAR RATING & CERTIFICATION CORPORATION

The Solar Rating & Certification Corporation (SRCC) is a non-profit organization whose primary purpose is the development and implementation of certification programs and national rating standards for solar equipment. The corporation is co-sponsored by the Interstate Solar Coordination Council (ISCC) and the Solar Energy Industries Association(SEIA). SRCC is governed by a Board of Directors comprised of solar experts from both the public and private sectors. The public sector representatives are appointed by the ISCC and their industry sector counterparts are appointed by SEIA. The Solar Rating & Certification Corporation is unique in that not only is it the only national certification program established solely for solar energy products, but it is also the only certification organization whose programs are the direct result of the combined efforts of state organizations involved in the administration of standards and an industry association. Since its incorporation in 1980, SRCC has grown into the largest national certifying entity for solar equipment in the country. SRCC is supported financially solely through program participant fees.

For the past year, SRCC has been successfully administering a certification, rating, and labelling program for solar collectors and has recently begun the administration of a certification, rating, and labelling program for domestic solar water heating systems. More than 100 of the estimated 250 solar equipment manufacturers and participating in the SRCC collector cettification program, representing over 450 collector models rated and certified by SRCC. According to market statistics, this level of manufacturer participation and collector model certification represents over 85% of the medium temperature market production and an almost equal percentage representation of the unglazed collector market production. Since the approval of the systems standards document and program guidelines in March 1982, and the systems certification program implementation procedures in July and November of 1982, more than 30 manufacturers of passive and active systems have applied for SRCC systems certification and rating.

SRCC'S COLLECTOR CERTIFICATION AND RATING PROGRAM

The SRCC Solar Collector Certification Program provides a means for evaluating the maintainability and structural integrity of solar collectors and a thermal performance rating characteristic of all-day energy output of a solar collector under prescribed rating conditions. The scope of the program includes liquid, air, innovative, and site-dependent collectors as used for swimming pool heating, space heating, cooling, and water heating. The program is administered according to SRCC Document OG-100, "Operating Guidelines for Certifying Solar Collectors", and its companion documents, SRCC Standard 100-81, "Test Methods and Minimum Standards for Certifying Solar Collectors", and SRCC Document RM-1, "Methodology for Determining the Thermal Performance Rating for Solar Collectors". SRCC's collector certification program meets the test methods and standards prescribed by the ISCC documants as well as the ISCC operating guidelines and is, therefore, accepted by the ISCC as being equivalent.

The basic element of SRCC's collector certification program is the performance testing. The ratings are based on tests conducted at independent laboratories accredited by the SRCC. The test methods upon which certification is based and the SRCC ratings calculated are ASHRAE Standard 93-77 and ASHRAE Standard 96-80. The rating numbers derived by SRCC are valid only for the fluid and flow rate used to generate the ASHRAE test data. The SRCC collector test sequence is as follows:

Receiving Inspection
Static Pressure Test
Thirty-Day Exposure Test
Thermal Shock/Water Spray Test
Thermal Shock/Cold Fill Test
Static Pressure Test
Collector Time Constant Determination Test
Post-Exposure Thermal Performance Test
Incident Angle Modifier Test
Disassembly and Final Inspection

Before a collector model is isuued a certified rating, the SRCC requires that an individual collector be selected at random from the manufacturer's inventory. The unit then undergoes a specific set of required performance and conditioning test. Once the unit has successfully completed the battery of tests, the results are sent to SRCC for evaluation. Once the evaluation of the test data has been completed, the performance ratings are calculated and certification is awarded.

Collector models must also meet the SRCC requirements for durability in design and construction in order to qualify for certification. Upon receiving SRCC certification and rating, the manufacturer must permanently affix an approved SRCC Certification and Rating Label to each production unit of the certified collector model. The label must bear the SRCC logo and the unit's thermal performance rating. A sample label is contained below:

SOLAR RATING & CERTIFICATION CORPORATION

SOLAR CERTIFICATION SRCC ISCC & SEIA ™

SOLAR COLLECTOR STANDARD 100-81

COLLECTOR RATING NUMBERS Thousands of BTUs per Day per Panel			
Category ΔT (°F)	2,000 BTU/ft²	1,500 BTU/ft²	1,000 BTU/ft²
A (-9)			
B (+9)			
C (+36)			
D (+90)			
E (+144)			

Manufacturer ____________________
Address ____________________
Model No. ____________ Serial No. ____________
Fluid ____________ Gross Area ____________

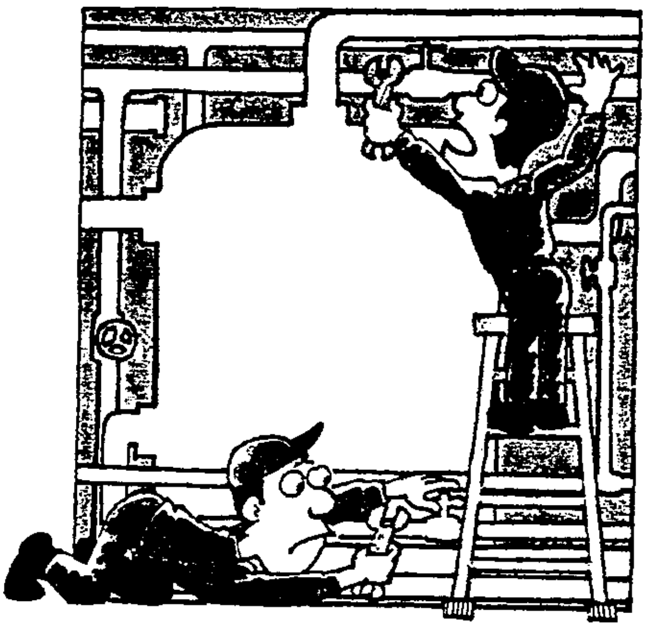
9. OPERATING EXPERIENCE

It is rather difficult to summarize the operating experiences with solar heating and cooling systems. Relevant topics may include system failure, freeze protection, boiling protection, maintenance, corrosions and degradation of solar components, poor system efficiency and so forth, most of which relates to the reliability and durability of solar heating and cooling systems. Various IEA reports and workshops have addressed some of these topics. "Failure Modes of Solar Collectors", a Task III technical report, was published in August 1981 by P. V. Pedersen of the Thermal Insulation Laboratory, Technical University of Denmark. A Workshop on the Design and Performance of Large Solar Thermal Collector Arrays was held in San Diego in June, 1984 under cosponsorship of IEA, Task VI and Task VII, and the IEA Small Solar Power Systems Project.

Detailed information on solar heating and cooling systems and components, especially on system performance, is of great interest to solar researchers, installers and manufacturers. This chapter does not present detailed data, but it does prosent general information on important operating experience topics.

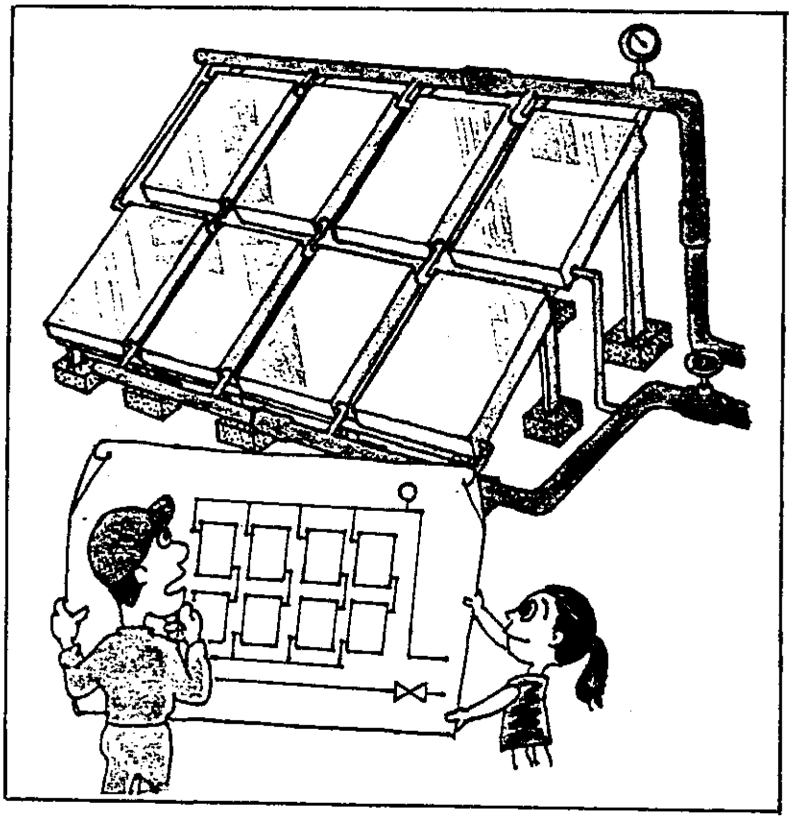
The installation of solar heating and cooling systems requires careful attention to the following aspects:

a) In the design of piping and layout, enough service space for maintenance of pipings, collector mounts, storage tank, etc. must be secured.



When no sufficient service space is secured....

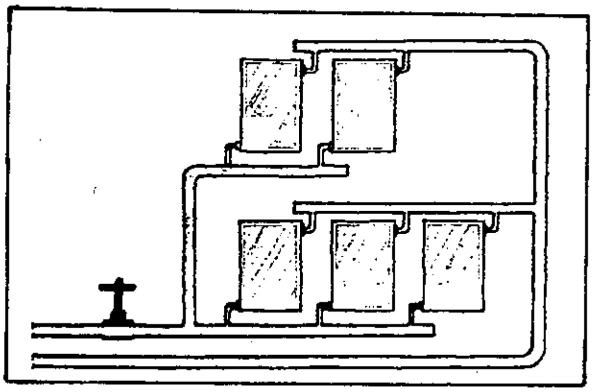
b) Confirmation of pipings as designed and the flow rate of collector arrays, especially flow rate check in the maintenance service.



Something wrong with pipings ?

c) Prevention of heat losses through pipe lines and around the collectors, i.e., enough insulation and caulking as well as lagging to prevent permeation of rain water, to improve system efficiency.

d) Collector mounts must have enough strength against weight of the collector, wind, snow, and environmental threats, if any, to satisfy the local building codes. Specifically, attention must be paid to the strength of the collector mounts and roof structure in the case of retrofit systems.

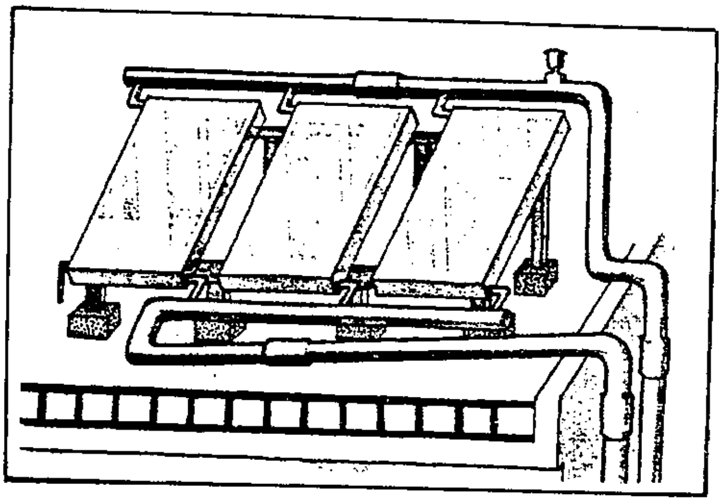


Failure example of flow control.

e) For installation of storage tank, similar attention to collector mounting should be given.

f) Storage tanks must be insulated, especially tank bottoms and manhole covers to prevent heat losses.

g) For freeze protection, there are four possible procedures: 1) drain out, 2) drain down to the storage tank, 3) use of anti-freeze solution and 4) forced circulation. In the case of drain out and drain down systems, the gradient and bending of pipings must be checked, so that no remaining water exists in the pipe. In the drain down system, the outdoor piping with remaining water must be heated to prevent freezing during cold winter nights.



Inadequate gradient of manifold.

h) The position of temperature sensors in both the collector and storage tank must be carefully checked for malfunctioning of the control system, which might cause a decrease of system efficiency.

There might be other indication on a key problem further, and the statements by the Participants are as follows:

AUSTRIA

Collector systems have to meet the requirements of ÖNORM M 7710 and ÖNORM M 7702. The application is limited to the period April to May. (about 80% of the energy output)

BELGIUM

The following problems are indicated as:

air evacuation (water collector),
corrosion of some collectors using aluminum absorbers,
degradation of absorber surfaces,
condensation on the innerside of the cover glass,
bad regulation systems ... very few problems with freeze protection.

DENMARK (1981)

GREECE

Freeze protection is made mainly with anti-freeze solution (double circuit systems).

Corrosion protection is made by glass-lined or hot galvanized with anode protection (magnesium), boiling protection is made by safety valves.

JAPAN

Japan is the very long islands stretching from north to south with varied climatic conditions. Freeze protection techniques such as forced circulation, anti-freeze solution, drain down system and drain back to tank are well established as the guidelines for installers and designers.

Guidelines on solution for troubles in maintenance of solar heating, cooling and DHW systems have been distributed to the members of Solar System Development Association, affiliated organization of manufacturers, to disseminate them.

NETHERLANDS

Literature available through BEOP-ECN.

NORWAY

Most of the water systems have a glycol freeze protection, 5 years experience with some, no special problems, especially the air systems have had a good reliability.

SPAIN (1981)

The price of the installation disturbs its commercialization. It is difficult to mount solar installations in multi-family buildings. Low quality solar components nowadays.

SWEDEN

Freezing occured in the 1st generation systems. (See Technical Report Task III, IEA)

USA

The U.S. is highly diverse climatically. Freeze protection for solar energy systems is provided by: non-freezing transfer fluids, namely water/glycol mixtures or silicon oil; draindown; drainback; or recirculation. Water/glycol closed loop systems have predominated in northern climates.

Data on integrity and maintenance is still being gathered and evaluated for current--post-demonstration program--technology. Numerous examples of systems exist that have successfully dealt with corrosion, boiling, stagnation, and degradation.

10. WARRANTIES

Solar energy industries are not mature enough to give sufficient warranties at present. The availability of adequate warranties on solar heating and cooling systems and components has significant meaning both for manufacturers and consumers, and for the steady growth of the solar energy industry. The participants reports' indicate that current warranties vary from 1 to 5 years.

AUSTRIA

5 years lifetime warranty.

5 years maintenance contract.

BELGIUM

Information not available.

DENMARK

There is a conventional one year warranty on solar energy products and solar energy installations.

GREECE

Typical warranties are for four to five years.

JAPAN

So far warranty is concerned, it is based on the civil law regarding articles on buying and selling as well as contract in general.

Solar heating, cooling and DHW systems are guaranteed for 2 years and system components for 2 year.

NETHERLANDS

Depending on vendor.

NORWAY

Same as for HVAC installation, 1 year.

SPAIN (1981)

Three years.

SWEDEN

Same as for HVAC installations: 1 year.

USA

For solar collectors a five year limited warranty covering material and workmanship is typical. Some manufacturers will warrant collectors for ten years on a limited basis. Other components in a system are usually the standard one year or less warranty for such equipment. Limited warranty coverage amounts to replacement given specified conditions, while installation, labor, handling and local delivery may or may not be included. Such five year warranties are usually reduced to one year for non-residential applications.

Some manufacturers will cover material defects and workmanship for one year, and corrosion and erosion and degredation of components for five years. Phase change storage modules may have up to ten years replacement warranty for materials and workmanship.

11. EDUCATION AND TRAINING

Solar heating and cooling education is very important for fostering and stimulating the students who aspire to become solar energy researchers, engineers, dealers, etc.

Education and training for installers and plumbers as well as their supervisors is an urgent necessity. Manufacturers and affiliated associations in the participating countries are making vigorous efforts on education and training in recent years.

AUSTRIA

The introduction of new technologies requires good training of the technical man-power. For this purpose, seminars are held in regular intervals, dealing with the planning, design and operation of solar and heat pump systems. Between 1977 and 1982 more than 200 seminars were held in Austria on this subject.

Responsible: Austrian Solar and Space Agency, ASSA

BELGIUM

Postgraduate courses on energy at several universities.

Special courses on solar energy installations.

DENMARK (1981)

The Technical University of Denmark gives university-courses primarily in designing solar energy systems.

The Technological Institute gives courses and manuals for professional designers and installers.

GREECE

Summer School of the University of Patras 1983 on "Energy and Environment", Seminar by trade association.

JAPAN

Institute of Building Energy Conservation (IBEC) gives the training course for the leaders of solar systems installers regularly.

Japan Association of Refrigeration and Air Conditioning Contractors (JARAC) gives education and training courses for solar installers.

Manufacturers of solar systems and components as well as Solar System Development Association are playing the key role on training of designers and installers.

NETHERLANDS

"Holland Solar" is organized by national solar organization.

NORWAY

Solar energy technology is a smaller part of the course for students in HVAC-engineering and architecture at the Technical University in Trondheim and the Institute of Architecture in Oslo.

SPAIN (1981)

Development of an intense general information campaigning, short courses and publications.

SWEDEN

Almost no activity during 1983.

USA

The U.S. Department of Labor sponsored a Jobs Corps solar installer training program at two sites.

Over 700 colleges, universities, technical schools, and other post-secondary education institutions offer courses on solar energy. Graduate and undergraduate degrees in solar-related fields are offered in 150 schools.

Trade associations have home study courses in design and installation. The national solar trade association sponsors an installer short course at its annual meetings and offers a project experience handbook for manufacturers. Numerous trade and professional associations publish handbooks, training for the industry, however, is provided directly by manufacturers of systems and components.

12. INFORMATION AND DISSEMINATION

Information dissemination for designers, builders and end-users is usually one of the important functions of governmental bodies and affiliated associations. Some of the Participants have established information centers to disseminate useful information on solar heating and cooling to the general public and end-users. Others have some functioning infrastructures within their countries. Academic societies such as International Solar Energy Society and the national Sections have also been providing lateral information dissemination support.

AUSTRIA

ASSA is responsible for information dissemination.

BELGIUM

Information on solar energy can be obtained from the Science Policy Office.

Information on rational use of energy in general is available from the Energy Conservation Service (Ministry of Economic Affairs).

DENMARK

The Ministry of Energy has supported a Solar Energy Information Center situated at the Technological Institute.

The Danish Section of International Solar Energy Society organizes meetings and conferences and gives informations in technical magazines. This Section has 100 members.

GREECE

JAPAN

Agency of Industrial Science and Technology, MITI has been distributing the documents on solar energy R&D achievements through the Japan Industrial Technology Association.

Energy Policy Offices of 8 Regional Bureaus of International Trade and Industries acts as information centers both for industries and end-users.

Solar System Development Association also acts as an information center.

Three Exhibition Center have been opened all the year round since 1980.

Annual Exhibition has been held in spring and fall every year since 1980.

Publications and their distributions.

Publicity by TV, press etc.

Consultation to end-users.

NETHERLANDS

Literatures available through BEOP-ECN.

NORWAY

Information from R&D Projects in technical magazines and papers.

Congresses and seminars arranged by the Norwegian Solar Energy Society in cooperation with the Norwegian Research Council.

SPAIN (1981)

General Catalogue of Manufacturers and Fitters of Solar Energy (3rd edition).

Mean Dates of Irradiation in Spain.

SWEDEN

Information is available through:

The Swedish Building Center
The Swedish Institute of Building Documentation
ISES-Scandinavian Section.

USA

The Federal Government provides solar energy information for a variety of users through normal information dissemination programs and procedures.

A free feneral public service is offered by the Conservation and Renewable Energy Inquiry and Referral Service. Toll free telephone requests and written requests for basic information are answered with referrals or prepared material. Several states offer similar information services for the general public.

Appendix 1 Reporting Format of Subtask C

INTERNATIONAL ENERGY AGENCY

Task II, Subtask C

SURVEY ON COMMERCIALIZATION AND OPERATING EXPERIENCE OF SOLAR HEATING AND COOLING SYSTEMS

Country: ____________________

1. SOLAR MANUFACTURERS

Number of Components (Collectors, Controls, etc.) Manufacturers ____________________

Number of Packaged System Manufacturers ____________________

2. COLLECTOR MANUFACTURING DATA

Please provide data on square meters of collectors sold by collector type, for 1981 or latest year available.

Data is for year 19____.

Collector Type	Domestically Produced m^2	% of Total m^2 of all collector manufactured	Imported m^2
A. Low Temperature (generally below 60°C)			
Metallic	________	________	________
Non-metallic	________	________	________
B. Medium Temperature (generally 60 - 80°C)			
Air	________	________	________
Liquid	________	________	________
C. Evacuated Tube	________	________	________
D. Concentrating	________	________	________
E. Other: ________	________	________	________

Note: If exact data is not available, give best estimate.

3. SOLAR SYSTEM INSTALLATIONS

TYPE OF SYSTEM	TOTAL INSTALLED Through 1982 Total Number	Total Area/m²	1983 Total Number	Total Area/m²	AVERAGE SIZE* PER INSTALLATION 1983	AVERAGE COST** PER INSTALLATION (1983) System Cost/m²	Installation Cost/m²	Total
a. SWIMMING POOL								
Residential								
Public								
b. DHW (Includes thermosyphon)								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
c. SPACE HEATING (With or without DHW)								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								

* m² of collectors. ** in national currency. (1 = $US)

	TOTAL INSTALLED					AVERAGE COST** PER INSTALLATION(1983)		
	Through 1982		1983		AVERAGE SIZE* PER INSTALLATION 1983			
TYPE OF SYSTEM	Total Number	Total Area/m²	Total Number	Total Area/m²		System Cost/m²	Installation Cost/m²	Total
d. SPACE COOLING								
Single-Family Residence								
Multi-Family Residence								
Commercial Building								
e. INDUSTRIAL PROCESS HEAT								
f. PASSIVE								
New								
Retrofit								

* m² of collectors. ** in national currency. Exchange ratio to US$ (1 = $US)

4. GOVERNMENT INCENTIVES Indicate low interest loans or tax credits
5. STANDARDS AND CERTIFICATION Indicate any national performance standards. Also describe any government or industry certification programme.
6. OPERATING EXPERIENCES Describe freeze protection, corrosion, boiling protection, troubles encountered in maintenance, application of SHC system during spring and autumn seasons, degradation of components etc.
7. WARRANTIES Describe industry-wide or typical product warranty, if one exists.
8. EDUCATION AND TRAINING Describe government and trade association activities in education and training (courses, manuals, etc.) for designers, installers, etc.
9. INFORMATION DISSEMINATION Public information efforts, structure and role of information centers, information centers activities, etc. Indicate intended audiences.

Appendix 2. LIST OF PARTICIPANTS - TASK II

"COORDINATION OF RESEARCH AND DEVELOPMENT ON SOLAR HEATING AND COOLING"

AUSTRIA	Prof. G. Faninger Austrian Solar and Space Agency (ASSA) Garnisongasse 7 A-1090 Vienna	Phone: (0222) 1438177 Telex: 76560 assa a
BELGIUM	Mr. Tony Vijverman Charge de Mission Programme National de R&D Energie Service de Programmation de la Politique Scientifique Rue de la Science 8 B-1040 Brussels	Phone: (02) 230-4100 Telex: 24501 PROSCIENT BRU B
DENMARK	Mr. Ove Jørgensen Thermal Insulation Laboratory Technical University of Denmark Building 118, DK-2800 Lyngby	Phone: (02) 883511 Telex: 375 29 DTH
GREECE	Dr. A. Spyridonos Technology Application Division Nuclear Research Center Democritos, Agia Puraskevi Attiki	Phone: 651 31 11-119
ITALY	Dr. Franco Vivona CNR Progetto Energetica Via Nizza 128 00198 Roma	Phone: (06) 854383/865493 Telex: 612322 CNR PFE I
NETHERLANDS	Dr. K. A. Nater Netherlands Energy Research Foundation P. O. Box 1 1755 ZG Petten	Phone: 02246-6262 Telex: 57211
NORWAY	Mr. Fritjof Salvesen A/S Miljøplan Kjørbuveien 18 1300 Sandvika	Phone: (02) 392416 Telex: 18815 NORCON

SPAIN	Mr. A. Barcala INTA Torrejon de Ardoz Madrid	Phone: 231-6203 Telex: 22026 INTA E
SWEDEN	Mr. E. Öfverholm Swedish Council for Building Research St. Göransgatan 66 S-11233 Stockholm	Phone: (08) 540640 Telex: 10398 BFR S
U. S. A.	Dr. F. H. Morse U.S. Department of Energy Office of Solar Heat Technologies Mail Stop 5H-079 1000 Independence Avenue, S.W. Washington D. C. 20585	Phone: (202) 252-8084 Telex: (TWX) 7108220176 DOE FORSTL WSH
JAPAN (Operating Agent)	Dr. T. Noguchi Solar Research Laboratory Government Industrial Research Institute, Nagoya 1 Hirate-cho, Kita-ku, Nagoya 462	Phone: (052) 911-2111 Telex: 22916 EIDMITI J