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COMMISSION OF THE EUROPEAN COMMUNITIES

Multiannual Programme
of the Joint Research Centre
1980-1983

1980 Annual Status Report

Solar energy

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Published by the
COMMISSION OF THE EUROPEAN COMMUNITIES

Directorate-General
Scientific and Technical Information
and Information Management

Bâtiment Jean Monnet
LUXEMBOURG

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Printed in Italy

ISBN 92-825-2342-X
Catalogue number: CD-NE-81-007-EN-C

SOLAR ENERGY

1980

Research Staff: 60
Budget: 5,735,000 ECU

Projects:

1. ESTI - European Solar Test Installation
2. Habitat and Low Temperature Applications
3. Solar Power Plants: Materials
4. Photoelectrochemistry and Photochemistry

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1. INTRODUCTION

The reduction of the dependency of the European Community from non-renewable or imported primary energies, through the development of alternatives able to complement or replace present energy sources, is the main motivation of the european activities on solar energy.
In accordance with this general energy policy of the Commission, and with the JRC's role in the frame of this policy, the objective of the JRC Solar Energy Programme is to contribute to the development and application of solar energy technologies within the Community. The specific activities of the JRC have two main orientations:

— to develop and to operate test facilities, for thermal and photovoltaic converters, which give a concrete significance to the central role of the JRC in the field of testing procedures and methodologies. This part of the programme is particularly important and is intended to provide assistance and information to european institutions and organisations working in the field, giving a contribution to the evaluation of the potential of solar technologies in the European Community.
— to pursue exploratory research in certain specific areas: some effort is devoted to basic reasearch and exploring studies in particular field, where preliminary information seems to be useful for orienting future development work.

The programme is structured into four projects:

Project ESTI (European Solar Test Installation)

This project deals with the realisation of a large indoor and outdoor testing facility, for thermal and photovoltaic converters, and with related "methodology" service.

Project Habitat and low temperature applications

Study and modelling of integrated systems for heating and cooling, including seasonal storage technologies allowing the use of solar energy during all the year.

Project Solar Power Plants: Materials

A contribution, through materials research for absorber surfaces stable at high temperature, to improve the performance of thermomechanical power plants.

Project Photoelectrochemistry and Photochemistry

Basic research on new processes for the conversion and storage of solar energy.

2. RESULTS

2.1 ESTI (European Solar Test Installation)

OBJECTIVES

The final goal of solar energy research consists in the development of a cost effective solar energy conversion technology. Any progress in this field requires a comparison of continuously improving devices; in view of the inherent variability of the incident radiation it is essential that this comparison is made under the same well-defined and reproducible conditions. These conditions should take into account the climatological and irradiation situation of the place chosen for installation.
The project ESTI intends to treat part of these problems by means of laboratory measurements: this requires the construction of "indoor" test facilities and the definition, selection and validation of suitable testing methodes.

There are a number of critical problems for the indoor method, as for example the true correlation between indoor and outdoor results, the eventual non-linear superposition of external parameters or the non-reciprocity between an artificially enhanced treatment and the real long time behaviour of a given device. A caution application of the indoor method is therefore necessary, especially during the initial phase. On the other hand, the advantage of being able to measure technical and scientific progress against reproducible and always available reference conditions should by far outweigh those difficulties. Moreover, indoor stations could have a substantial economical impact in so far as these facilities would provide useful and repeatable guarantee conditions. This would allow: to verify if material corresponds to specifications, to differentiate between meteorological and material risks and to eliminate additional costs due to too large safety margins. This reduction in risks both for producers and for users in considered to be an essential step for the development of a cost effective solar industry.

Since the main obstacle to a large scale use of solar energy lies in the high cost per unit of useful energy, it is necessary to decrease investment costs and to maximize the total energy output. Due to unavoidable and non-negligible non-converter costs and in order to increase output, the conversion efficiency must be high. Moreover, besides of purely economic reasons, there exists the basic requirement for any alternative energy source that the life time of the conversion system should be large against its energy pay-back time. Since this condition is to some extent in contradiction to the economic tendency to diminish material and maintenance costs, a careful evaluation of any "progress" is a first prerequisite.

In view of giving a contribution to the definition and the knowledge of these two important parameters, conversion efficiency and lifetime, main tasks of the Project ESTI are the following:

— to develop, and to operate, test facilities for thermal and photovoltaic converters
— to promote EC collaboration in solar testing in order to define common performance criteria and standard procedures.

The activities and the results are reported giving firstly a description and the state of the art of facilities, and after subdividing them into the three following research areas:

— thermal conversion
— photo voltaic conversion
— qualification and endurance testing.

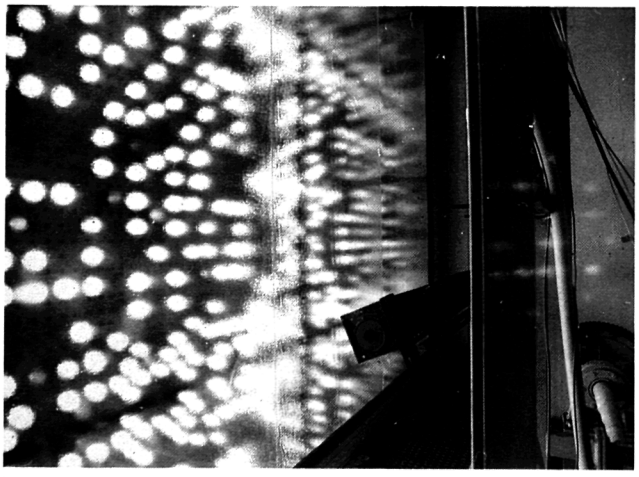
FACILITIES

The facilities are subdivided in two groups, for
(i) performance measurements (light simulators, indicated as LS)
(ii) qualification and ageing tests (facilities indicated as AT)
The various facilities foreseen are the following:

Light Simulators

LS0 : a simulator using Xenon lamp and producing sunlight on a small test area of 20×20 cm^2. Used for calibration of solar cells and for reference purposes.

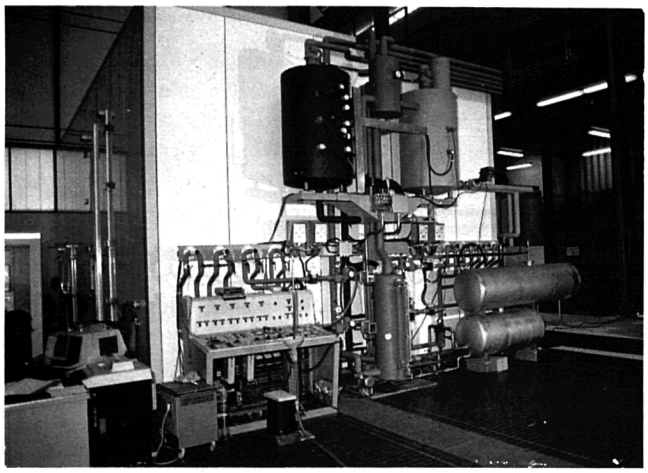
LS1 : installation able to perform measurements on a test plane of 3×4 m^2 under uniform and uncollimated light and over a range of temperature conditions from —40 °C to +60 °C.
The light source consists of 295 discharge lamps (250 W each) producing an uniform irradiance which may be selected between 250 and 1170 W/m^2. Four test loops are available for thermal conversion efficiency measurements.



Light source of LS1

LS2 : installation to perform measurements under collimated light.

LS3 : a large area pulsed solar simulator allowing measurements on photovoltaic modules and arrays under good irradiation uniformity and without cell heating.

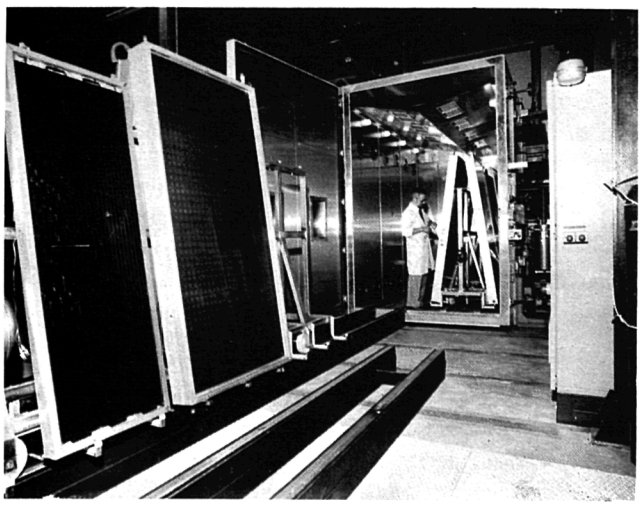


Control and data acquisition systems for LS1

Ageing Test Facilities

AT 0 thermal cycling of photovoltaic modules

AT 1 ageing in corrosive atmosphere (SO_2, humidity, ozone)



AT1 facility: load of collectors

AT 2 ageing under intense ultraviolet irradiation

AT 3 measurements of rain penetration and mechanical resistance to snow and wind loads (static and dinamic)

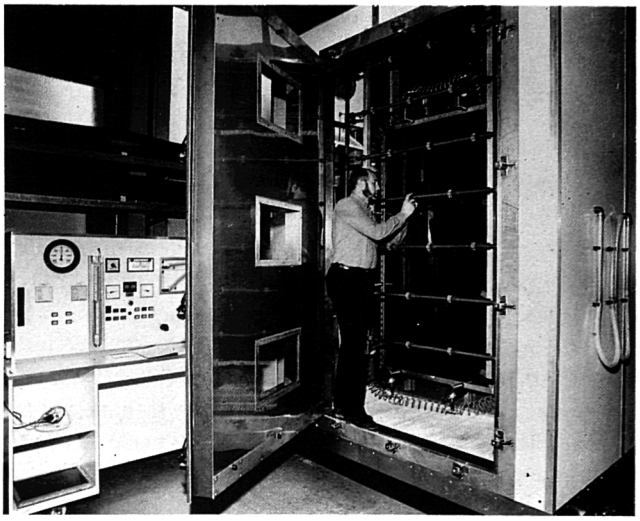
AT 4 hail gun for testing resistance to impact forces

AT 5 overpressure and leakage tests

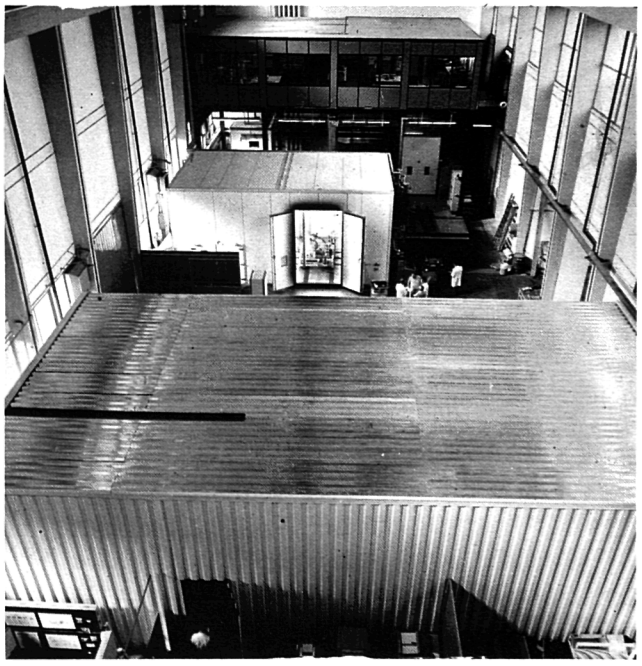
AT 6 testing of thermal degradation for complete collectors

The situation at the end of 1980 is the following.
The light simulators LS0, LS1, LS3 are available and operational; LS2 is operational in a first version, and the complete design of a large size facility is available.
The ageing test facilities AT O, AT 1, AT 3 are operational, AT 2 is also in operation with a proof-of-concept version. AT 4, AT 5 are in the assembling stage, AT 6 is in the design phase.

The development of significant test procedures simulating various atmosphere requires the execution of outdoor correlation tests. A correlation test field (CTF 1) for outdoor, clean air measurements is in preparation at Ispra.



AT3 facility



View of the hall with "indoor" test facilities of ESTI

THERMAL CONVERSION

During the first period the LS1 facility was tested and put into operation; the four test loops for the determination of the efficiency of thermal collectors were also tested, checking the precision of the measurements. Accuracy in the measure of these thermal efficiencies is based on very precise determination of the coolant flow, of the temperature difference between inlet and outlet of the coolant, and of the light intensity. The flow is measured by means of magnetic flow meters, giving an accuracy better than 0,5%. The accuracy in the temperature difference measurements, made by quartz thermometers, is about 10^{-2} °C.

Pyranometers are measuring light intensities.
The tests showed that LS1 installation is working at the expected conditions, full light intensities may be used within the complete temperature range from —40 °C to +60 °C.

The validation of collector performance measurements obtained under simulated indoor conditions requires outdoor experiments for reference purposes; a special mork-up circuit was prepared and tested, to be used for outdoor measurements in order to normalize indoor results.

After the verification that the complete installation and the data acquisition systems are working well, the routine tests started. Several commercial collector were tested, with the measurement of thermal efficiency. In order to have a comparison with other results, a measurement was made on one of the collectors (the CEC-4 collector) tested in the round-robin test by 19 European laboratories in the frame of the Indirect Action. The comparison was made among the following results:

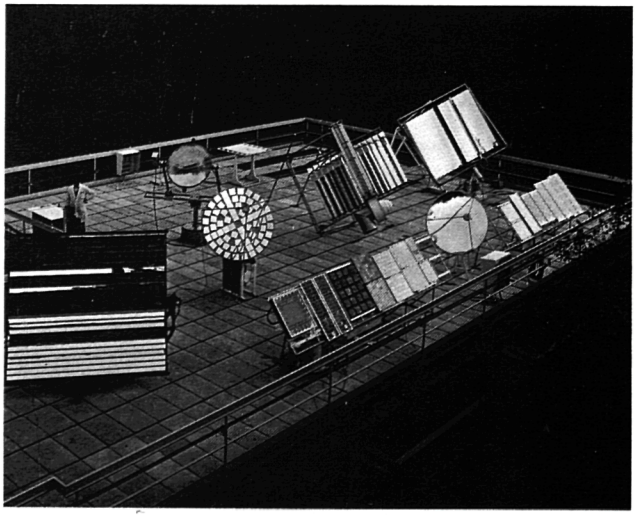
— CEC Round Robin Test 1979/80
— ESTI indoor LS1 1980
— ESTI outdoor 1980

The three measurements were in good agreement considering the error limits.

PHOTOVOLTAIC CONVERSION

The pulsed solar simulator LS3 was installed, during the first part of the reporting period, in a large, light-tight test room, specially built. The simulator was tested and put in operation. Various facilities for outdoor testing were reinstalled in one place, on the roof of a building in the "solar area", and were connected with the station computer. Always for the outdoor tests a multiple mirror concentrator has been constructed for the efficiency measurements on solar cells as a function of concentration ration (or "number of suns").

During the reporting period a number of "secondary standard cells" has been produced, using the facility for calibration of solar cells, and several photovoltaic modules have been measured (determination of performances).



Outdoor tests for photovoltaic modules

An important activity in the frame of this project is the coordination of the European Working Group on Photovoltaic Testing, with the participation of 12 experts coming from national organizations or industries. This Working Group is preparing Specifications, recommended for measurements on photovoltaic cells and modules, as contribution to a harmonisation of methodologies and procedures. This work is made through periodical meetings, with contributions and discussions, and round robin tests for solar cells with participation of different laboratories. During 1980 the final version of Specification n. 101, "Standard Procedures for terrestrial photovoltaic performance measurements" was edited, and a draft was prepared for Specification No. 201, for qualification tests.

QUALIFICATION AND ENDURANCE TESTING

The activities during the reporting period were mainly concentrated on the installation of several facilities (this work was proceeding according to schedule); the facilities AT 1, AT 2, AT 3 were installed, tested and put in operation; AT 4, AT 5 were assembled with the main components; AT 6 was designed.

The facilities in operation at the end of 1980 are able to make tests of collectors and photovoltaic modules under the following conditions:

— thermal cycling
— damp cycling
— intense ultraviolet irradiation
— rain penetration
— mechanical resistance (static and dynamic)

The first tests on thermal collectors were started, in order to have a first information on the behaviour of the components submitted to the actions of separated parameters which produce negative effects on the lifetime of the collectors.
In view of the necessary correlation with the results of outdoor experiments, three prototype circuits were also built and were ready for operation at the end of the year.

DATA ACQUISITION

The main effort was concentrated up to now on the development of the data acquisition system for the ESTI project. To ensure a flexible and individual control of the different facilities, combined with a powerful mass storage facilities and computer power at a reasonable price a two-level computer hierarchy was adopted. A central computer (type PDP-11/60) connected via serial interfaces to small peripheral computers (type PDP-11/03). The peripheral units interface directly with the experiments, in each facility, for control and datas collection; they send the data of each experiment to the central processor for treatment and storage.

Main part of this data acquisition system of the ESTI project was installed during the reporting period and is now in operation. The experience already made confirmed the expected

performances of the two level design.

Another activity was started, the study and the design of a small, mobile data acquisition system for photovoltaic field measurements: this system could be important in the future for a good exploitation of results of demonstration projects.

2.2 HABITAT AND LOW TEMPERATURE APPLICATIONS

OBJECTIVES

The project is mainly concerned with the study and modelling of integrated systems for heating and cooling. Different schemes are considered in view of an evaluation of the potential of the systems and an improvement of the economics of solar energy applications. As far as the low temperature applications are concerned, unsophisticated technological processes and devices will be studied in relation also to agriculture. All these studies, included techno-economic assessment, are closely linked to the corresponding activities of the Indirect Action, the Energy R and D Programme of the EC Commission managed by the General Directorate of Research and Science.

Specific objectives are reported, following the suddivision into subprojects.

Meteorological data

One of the essential basis for the evaluation of a solar system is the availability of suitable solar data. The purpose of this activity is to set up a fully instrumented laboratory and to treat the collected data as input in mathematical models useful for the calculation of performances of systems.

Outdoor Performance Testing of solar collectors

Study of the behaviour of collectors integrated in a system, using a large outdoor facility.

Seasonal Storage of sensible heat

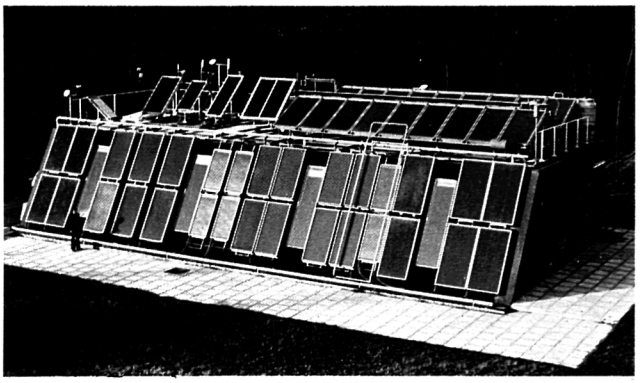
The economics of space heating solar systems is penalized in most of Europe by the limited sunshine hours available during the periods for which heating is needed. These limitations can be partially overcome by seasonal storage. This activity is oriented to develop and to study the behaviour of seasonal storage technologies, using sensible heat in large, ground systems.

Thermochemical Storage at low Temperature

The purpose of this activity is the selection and the study of chemical latent heat storage systems and related technologies suitable for practical applications.

Solar Space Heating System

The objective is the evaluation, with experiences made in a Solar Laboratory, of the practical performance of various solar space heating systems, using a common methodology and extrapolating through mathematical models the results obtained to other climatic conditions.



The solar laboratory

Assessment of Passive Systems

An activity starting from basic configurations of passive walls, tested at small scale, and including evaluations of various solutions.

Solar Space Cooling Systems

As for the space heating, also evaluation of the performance of solar cooling systems is necessary. Experiences are made in the Solar Laboratory in view of an optimization of the systems to given climatic conditions.

METEOROLOGICAL DATA

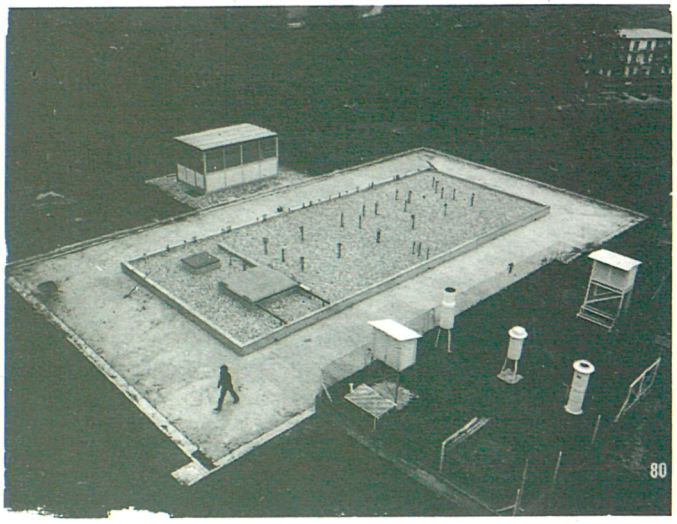
Using the fully instrumented meteorological station, many data were collected under a hourly basis: global radiation on inclined planes (0, 45, 60°), diffuse radiation on horizontal surface, direct radiation normal to beam, hours of sunshine, air temperature, wind speed and direction. All the data were transcribed on magnetic tapes available to any users in the form of daily averages or hourly averages.
New forms of presentation of data are being experimented, in order to try systems eventually easier and more suitable for the use from the side of designers of solar systems.

SEASONAL STORAGE OF SENSIBLE HEAT

In addition to the 50 m^3 concrete water storage included in the Solar Laboratory and already operated, two other facilities were prepared during 1980 and are near to the start of operation:

— a large, 375 m^3 water concrete reservoir buried in the ground
— a system of vertical heating tubes in the soil.

These ground systems for thermal energy storage could be interesting when they have large size and could be convenient for groups of buildings in community systems. The operation should give information on the economy of solutions: these economic constraints are severe and an optimisation will be necessary. The two systems which have been built will also be compared with other experiences in the EC, using different techniques or different soil characteristics, in order to define mathematical models to extrapolate the behaviour in various conditions.



Large water concrete reservoir for heat storage

OUTDOOR PERFORMANCE TESTING OF SOLAR COLLECTORS

Measurements were performed on the various types of collectors used in the different solar heating and cooling experiments carried out in the Solar Laboratory, in order to collect as much as possible data on the behaviour of these converters.
A particular effort was devoted to the study, design and preparation of a large outdoor test field, which will not only be complementary to the indoor facilities of ESTI, but will also tackle what has been recognized as the essential problem of collector testing, that is the correlation between the behaviour of the collector as an integrated part of a system and its performance under accelerated, or simulated, degradation when tested as a single component.

THERMOCHEMICAL STORAGE AT LOW TEMPERATURE

During the research phase of the last years a large screening was made, with thermodynamic calculations and experimental measurements, in view to define promising salts to be used as storage medium. As a result the reciprocal salt pair Ba $(OH)_2 \cdot 8H_2O$-KNO_3 was individuated as interesting because the storage capacity of this salts mixture is about four times that of an equivalent volume of water (a patent is pending).
The activity of the reporting period was devoted to design and construction of a pilot unit for thermochemical heat storage at temperatures around 65 °C using the above mentioned salt pair.
Technological problems have to be studied and solved in designing the unit, namely the stratification phenomena which may occur in a large dense-packed volume of storage material, and the compatibility of the container material with the salt mixture at the operating temperature.
A promising solution to these problems is the encapsulation of the storage material in small polypropylene capsules. A storage unit based on this principle was studied and designed; the equivalent heat capacity is of 100 litres of water. The construction of the units was started; the experiments should show if the system is convenient for a day-night storage purpose.

SOLAR SPACE HEATING SYSTEMS

The experiences, oriented to the evaluation of the practical performances of various solar heating systems, are performed in the Solar Laboratory. This laboratory, built in 1976, has a useful surface of 160 m^2, subdivided in three areas:
(i) experimental area, with technical devices (ii) data acquisition and treatment area (iii) meeting room.
The experiences made in this laboratory take into account the consequences of the occupancy habits of the people working in the laboratory (open doors, window, current failures, etc.). These effects can influence noticeably the overall performance.

The experience for the winter 1979-1980 was completed, using a hybrid system corresponding to a modified version of the system tested during the winter 1978-1979. The system is a combination of (i) thermal collectors (ii) heat pump (iii) long term storage vessel with water; the monitoring was particularly designed in order to be able to exploit at a maximum the results of the experience. The global performance was significantly improved with the above mentioned modifications, putting in evidence how sensitive a solar system is to the optimization and to the "quality" of the components (collectors, heat pump, regulation, internal heat distribution system, etc.).
The analysis of the experimental data gave many indications on the performances, main results being the following:

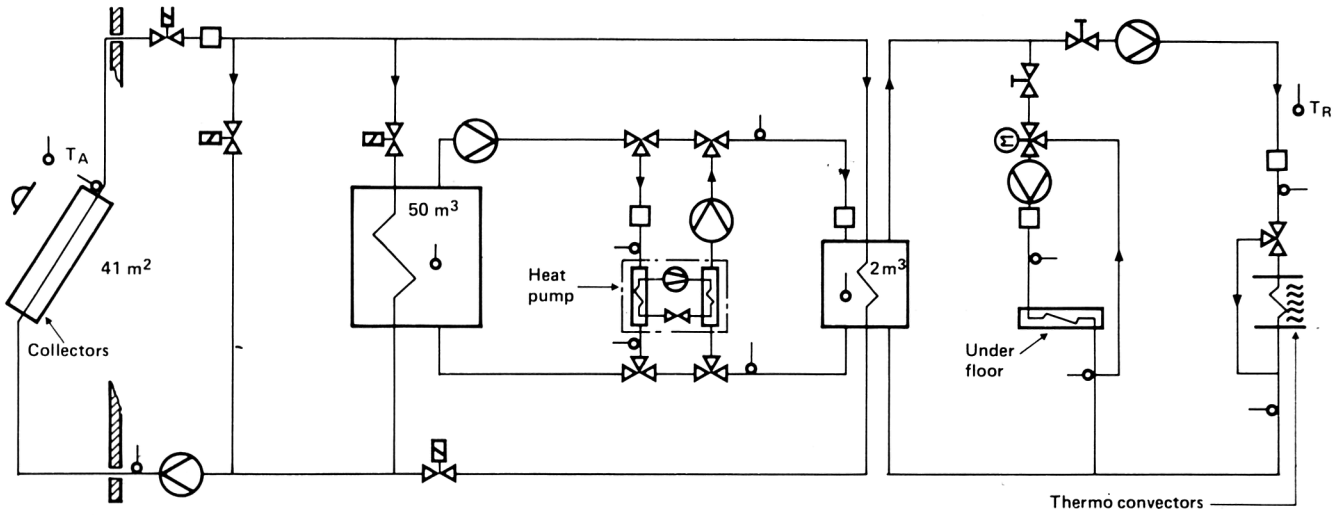
primary energy saving	63%
average efficiency of solar collectors:	35%
coefficient of performance of heat pump:	4.0

The system is therefore interesting from the energy conservation point of view. It was also possible to verify the validity of a computer model previously developed, which could allow the optimization of systems and the assessment of their performance in different climatic conditions.

ASSESSMENT OF PASSIVE SYSTEMS

One of the objectives of this activity is an investigation on small scale basic configurations of passive walls: collector storage units. These units consist in a water vessel for the heat storage and a structure positioned on its outside face, which acts as solar collector and thermal insulation of the storage. The building wall of bricks or concrete receives heat from the storage vessel and acts as room heating surface.
Four types of solar collector storage units were tested during the winter season 1989-80, using different systems and materials for the light transparent and thermal insulating structure covering the storage reservoir.

For the experiences, the collector storage units are mounted in a rig. Behind each storage vessel a brick wall represents the building wall. The back side of the rig and its sided walls are thermically insulated. The heat flowing through this thermal



Hybrid solar heating system of the J.R.C. solar laboratory

insulation corresponds at "normal" operation of the system approximately to that transferred into the room behind the storage wall.

These systems have been monitored in various weather conditions to study their behaviour.

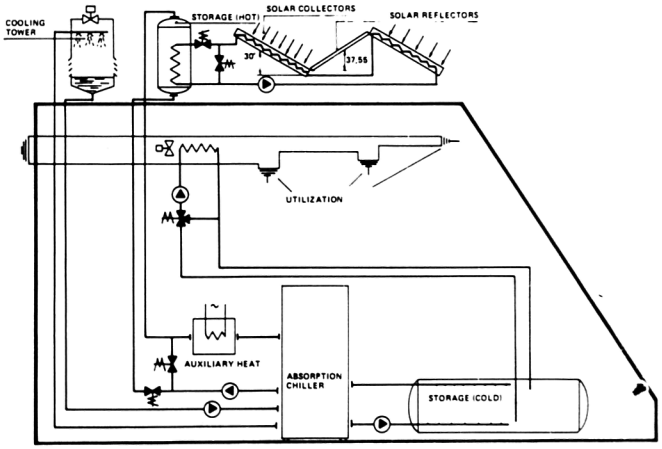
These results demonstrated experimentally that collector storage units of the proposed construction are suitable to maintain the temperature of sufficiently irradiated outside walls above the room temperature for a large part of the winter season. The investigations performed enable to study in more detail methods for further improvements of such systems.

In the same field, another objective is the assessment of the possibilities of passive systems on buildings for the local Ispra climate: a study was started through a collaboration contract and a design is in preparation.

SOLAR SPACE COOLING SYSTEMS

Using the same Solar Laboratory as for the space heating experiments, experiments and assessments are made on solar space cooling systems. The results could be important for the demonstration of the feasibility of combining space heating with space cooling in regions of Southern Europe. These systems could also be of interest for developing countries in the field of food and medicine preservation.
During the summer 1980 main devices of the experiment performed during 1979 were maintained: a total of 36 m² of black-crome selective collectors, and a lithium-bromide absorption machine. However some modifications were made, such as a simplification of the circuit, and the addition of a large cold store, in order to be able to accumulate cold water during the intermediate months of May and June, for the very hot months of July and August.

As a result of the experience, in the system "thermal collectors - water storage - absorption chiller" an average efficiency of the collectors of 31% was measured, with a chiller efficiency of 52% and an overall system efficiency (as a ratio of cold



Scheme of the solar cooling system

produced and solar irradiation) of 10%.

Experiences were made also on other technologies: a conclusion is that for small systems (up to 15 kW cooling power), Rankine cooling systems seem to be less interesting due to more complexity and lower efficiency.

In order to complete the studies on solar cooling systems a zeolithes pilot experiment was designed as possible system for low temperature tests; the experience will be performed in the summer 1981.

2.3. Solar Power Plants Materials

One of the components of a solar power plant where the choice of materials plays an important role is the absorber surface. Improvements of its spectral selective properties can considerably increase its photo-thermal conversion efficiency. Solar receivers which make use of concentrated light have absorber surface temperatures of at least 300 °C.
At this temperature most of the selective coatings developed for domestic water-heating are not sufficiently stable for prolonged use. The principal reason for this instability is that the various thin films present in these coatings are liable to be

destroyed by diffusion processes. The objective of the activity is to produce and to investigate selective surfaces which are more stable at high temperatures. The production method is based on the principle that a rough surface composed of a large number of small and separated single crystals can acts as a trapping centre for solar light, while the long-wave infrared radiation is not affected by the single obstacles thus keeping infrared emittance low.
The activities included in the project are covering the following aspects:

— preparation of absorber surfaces
— determination of selective properties by various measuring methods
— life time testing of the specimens.

During the reporting period, an important effort was devoted to the construction of a new vacuum chamber for production of alloys by indipendent evaporation of different metals.

The spectral layers of pure Chromium deposits characterised at various temperatures have been examined, in respect to its thermal degradation and its structural resistance to oxidation, by using a scanning electron microscope. At 300 °C after 1800 hours exposure to air the original structure was perfectly conserved.

The selective surfaces of chromium deposited on stainless steel substrates show a good thermal stability in air and vacuum. They have about the same optical properties as the nickel surfaces studied earlier, but can withstand higher temperatures.

Investigation is now concentrated on chromium nickel alloys (preparation and characterisation).

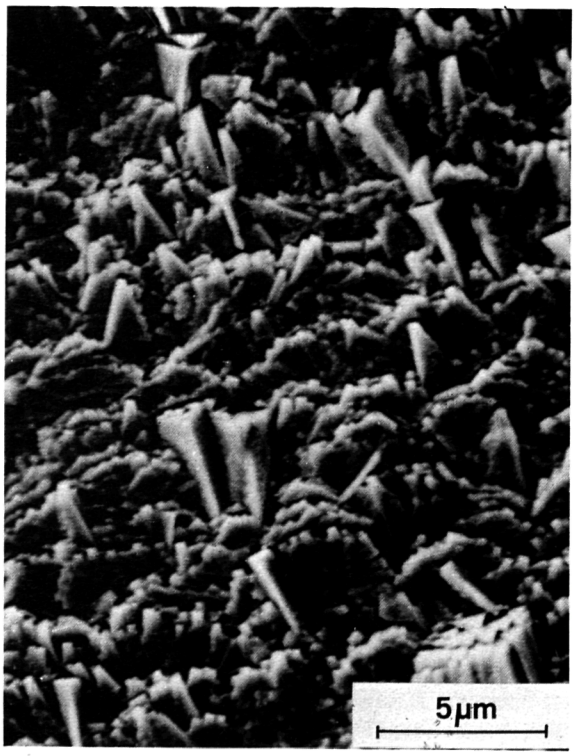
2.4. Photoelectrochemistry and Photochemistry

Research is at present devoted to two conversion techniques still in a state which does not allow a short term application, but they may play an important role in the long term future.

Photoelectrochemistry

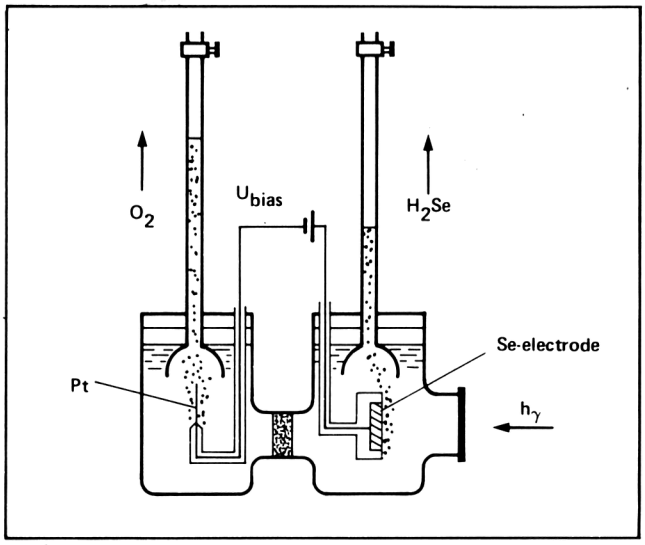
Semiconductor/electrolyte (SE) - photocells have attracted in the last few years growing interest for solar energy conversion. These cells are simple in construction: no junction has to be grown as in solid state cells - the semiconductor/electrolyte junction is formed just by the contact of the semiconductor with the electrolyte.
Additionally, the electrolyte is an excellent contact medium being transparent and covering uniformly the semiconductor surface. These features may essentially contribute in the future to an economic production of solar cells.

SE-solar cells can be used like solid state solar cells for the direct conversion of light into electrical energy (regenerative mode of operation).
During the reporting period two subjects were mainly studied. The first is based on the photoelectrochemical behaviour of hexagonal selenium investigated in the previous periods, trying to find an application in a cycle for water decomposition and hydrogen production. The experimental results were not satisfactory, and the chemical recycling and the regeneration of electrode material seem to be less interesting than foreseen. The second research subject was the study of ferric oxide as potentially interesting semiconductor material. Relatively important transient effects exist, which can be modified by preparation. The influence of redox reagents on the transient



Pure chromium surface produced by vapour deposition

Pure chromium surface after 1800 hrs 300°C-air



Schematic view of the photoelectrochemical cell

behaviour was examined. The experimental results support the interpretation of the overall behaviour by the hypothesis of a back-reaction of the photogenerated species with electrons originating in the conduction band.

Photochemistry

During the reporting period only preliminary studies and preparatory work were performed in this field which is new for the JRC. An experimental programme has been defined, to observe and detect main phenomena and to understand the mechanisms of different reactions involved in photosynthesis.

3. CONCLUSIONS

Following the previous 1977-1979 programme, which was in many sectors mainly preparatory, 1980 as first year of the multiannual programme 80.83 is confirming, with the important increase of practical realisations, the central role of the JRC in the support to the Commission and to the activities in the European Community oriented to an extended application of new, efficient "solar technologies".

The JRC Solar Energy Programme is active in the field of assessments and definition of methodologies both for the components (solar energy converters) and the systems.
Concerning the evaluation of the components, the project ESTI is mainly involved. The more important facilities of the European Solar Test Installation have been built during the 1980 and the project is reaching the full operational stage. The two more important parameters involved in the correct and economic utilisation of solar energy converters (both thermal and photovoltaic) i.e. the efficiency and the lifetime, can be measured and evaluated with high accuracy and reproducibility.
Solar radiation simulators and ageing test facilities, for accelerated degradation, are now available in the ESTI installation, which is one of the more complete testing station in the EC, available to give contributions to national organisations and industries involved in the solar energy applications.

The activities of the ESTI project are useful in the field of methodologies from two points of view:

— performance of measurements with high precision facilities
— definition of standard procedures, to be used by national institutions or private companies and helpful for a harmonisation of definitions and methodologies.

These accurate and common "reference measurements" are useful for the manufacturers, in view of good designs, and for the users, to know the expected performance of components.

Concerning the evaluation of systems, the project habitat is mainly involved. Each component is used in a system: quality and types can be very different. It is important for the decision makers to know what could be the potential of each system, using different techniques and for different objectives, in practical conditions: for instance how much energy can be saved using solar heating systems, with or without energy storage, and with different storage systems. The potentially more attractive technologies should be supported or stimulated with some priority in respect to others. The Solar Laboratory of the Project Habitat is making full-size experiments, with complete monitoring, and the results are carefully analyzed in order to evaluate energy needs, energy used, solar energy contribution, efficiencies, energy saved.
The systems which are studied are oriented to improve the economics of the system with an utilisation of the thermal collectors extended in a large period of the year: this is made coupling the heating system (thermal collectors plus heat pump) with different seasonal storage techniques (ground systems) more suitable for Northern Europe regions, or with cooling systems for the summer periods, suitable for Southern Europe regions.
All these activities of evaluations and assessments are made in support to the EC Commission and are in good connection with the activities and the organisations of the Indirect Action - Programme Energy R and D managed by the General Directorate XII for Research and Science.

The other research areas are for longer term applications, whether is a matter of selective surfaces for solar receivers, or is a matter of photoelectrochemistry; these activities are similar to those exploratory researches in progress in some national laboratories, and connections are existing.
JRC Solar Energy Programme is a good example of the activities corresponding to the central role of a communitary Centre, in the frame of the support to the Commission's programmes for research, development and demonstration.

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