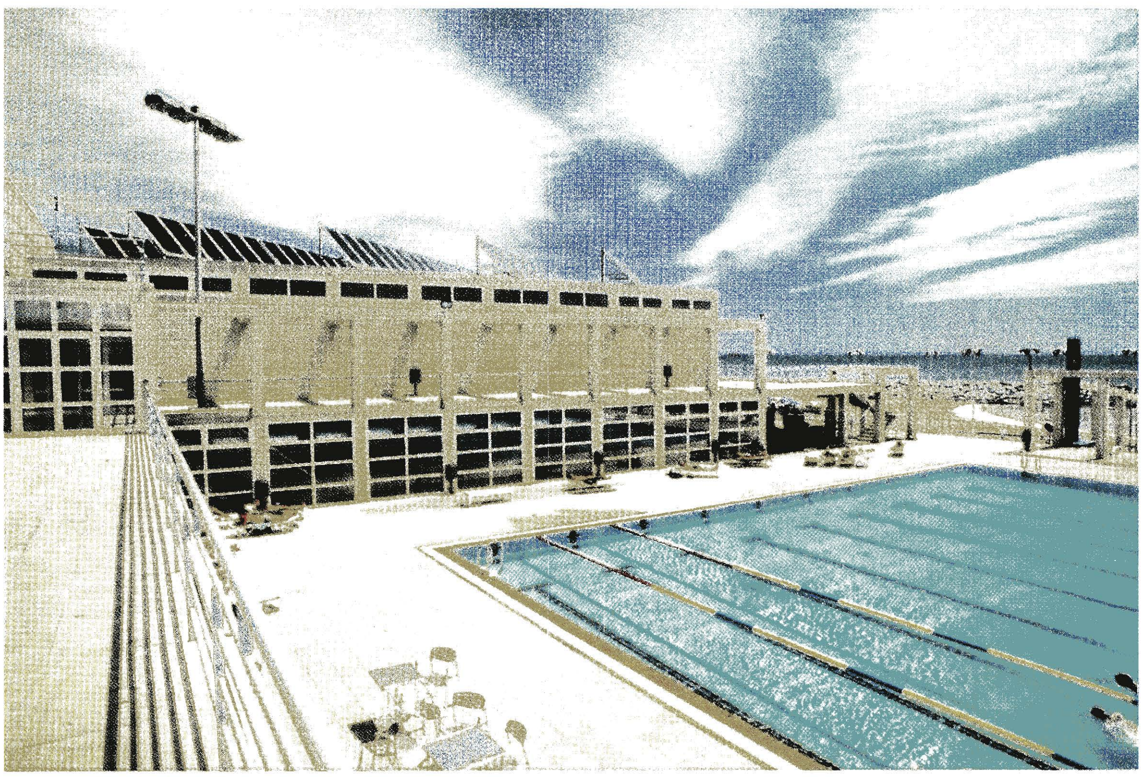
A THERMIE PROGRAMME ACTION

THERMIE

Guaranteed Results of Collective Thermal Solar Installations



European Commission
Directorate-General for Energy

RES

THE THERMIE (1990-1994)

This is an important European Community programme designed to promote the greater use of European energy technology. Its aim is to assist the European Union in achieving its fundamental objectives of:

- improving the energy supply prospects of the European Union;
- reducing environmental pollution by decreasing emissions, particularly CO2, SO2 and NOX;
- strengthening the competitive position of European industry, above all small and medium-sized enterprises (SMEs);
- promoting the transfer of technology to Third Countries;
- strengthening economic and social cohesion within the European Union.

The majority of the funds of the THERMIE Programme are devoted to financial support of projects which aim to apply new and innovative energy technologies for the production, conversion and use of energy in the following areas:

- rational use of energy in buildings, industry, energy industry and transport;
- renewable energy sources such as solar energy, energy from biomass and waste, as well as geothermal, hydroelectric and wind energy;
- solid fuels, in the areas of combustion, conversion (liquefaction and gasification), use of wastes and gasification integrated in a combined cycle;
- hydrocarbons, their exploration, production, transport and storage.

The THERMIE Programme (1990-1994) includes a provision for the enhanced dissemination of information to encourage a wider application and use of successful energy technologies. This information is brought together, for example, in publications such as this Maxibrochure. Maxibrochures provide an invaluable source of information for those who wish to discover the state of the art of a particular technology or within a particular sector. The information they contain is drawn from all Member States and therefore provides a pan-European assessment.

To guarantee the maximum effectiveness of the funds available, the THERMIE Programme (1990-1994) includes an element for the co-ordination of promotional activities with those of similar programmes carried out in Member States and with other European Community instruments such as ALTENER, SAVE, SYNERGY, JOULE, PHARE and TACIS.

JOULE-THERMIE (1995-1998)

The first phase of the THERMIE Programme ran from 1990-1994 and had a budget of around 700 MECU. From 1995 the bulk of THERMIE activities will be carried out, with a budget of 530 MECU, as the demonstration component of the Non-Nuclear Energy Programme (JOULE-THERMIE) under the Fourth EC Framework Programme for Research and Technological Development. This change is based upon a concept within the Treaty on European Union to bring all research, development, demonstration and dissemination efforts of the Union closer together.

However, to continue all the activities corresponding to the former THERMIE Programmes (1990-1994), a successor programme called Thermie II, outside the Framework Programme, is currently under discussion in the Council of Ministers.

Colour Coding

To enable readers to quickly identify those Maxibrochures relating to specific parts of the THERMIE Programmes each Maxibrochure is colour coded with a stripe in the lower right hand corner of the front cover, i.e.:

■ **RATIONAL USE OF ENERGY**

■ **RENEWABLE ENERGY SOURCES**

■ **SOLID FUELS**

■ **HYDROCARBONS**

Further infomation on the material contained in this publication, or on other THERMIE activities, may be obtained from one of the organisations listed inside the back cover.

Guaranteed Results of Collective Thermal Solar Installations

THERMIE PROGRAMME ACTION Nº SE17

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Design and Printing:
DRIBBLING

Dec. 1994

Acknowledgements

Thanks are due to the following for their contribution to this publication and to those whose material was not finally selected:

T André Rio, for the hospital in Guadaloupe.
CRES and SOLE Ltd., for the industrial application in Greece.

ENERSOFT, for the examples in Spain.

TECSOL, for the examples in France and for writing the text.

CONTENTS

1. INTRODUCTION

Solar energy is clean and inexhaustible. It reduces the dependence on fossil fuels and does not pollute the environment. However, solar installations are generally more expensive than conventional systems and it is sometimes forgotten that the high investment cost is accompanied by low running costs. Consequently, the economic advantages of solar heating systems can only be appreciated by means of a global cost approach.

Solar hot water installations are not always profitable yet. The investment pay-backtime, without subsidies, varies from 3-10 years throughout the European Union, depending on the energy that has been replaced and the country in which the solar installation is installed. In these conditions, any reduction in performance, caused by inefficient working order, will definitively condemn the technique from an economic point of view.

The best answer to this problem is perfect technical control which is now possible due to improved know-how. In practice, this is expressed by the way in which the technicians involved can guarantee the good working order of a solar system and at the same time guarantee its energy production.

1. BASICS OF "SOLAR" WATER HEATING

1.1. Thermal solar equipment

Solar systems, designed for heating water, are made up of the following parts (see Figure 2);

- the solar collector area;
- the hydraulic circuits and heat exchanger;
- the hot water storage tank.

The solar collector is used to transform incident solar radiation into heat. There are already over 3 million square metres installed throughout the European Union and most of them are used for producing domestic hot water, either in private houses or for collective installations. Many different products have been tested, the best of them are in conformity with national standards and are guaranteed by their manufacturers.

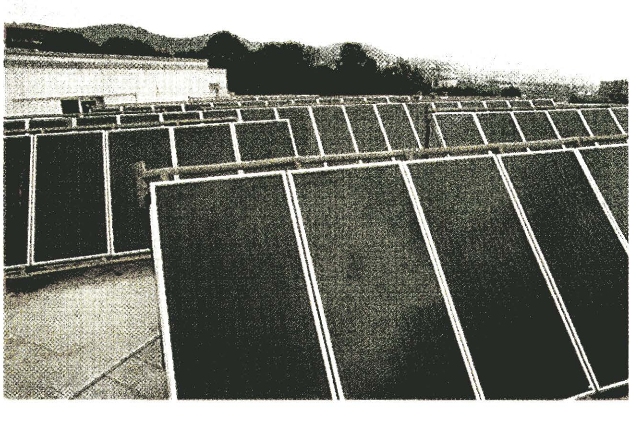

Figure 1. Detail of the flat plate collector array on the roof of the Sant Josep Residence in Barcelona.

The conventional "flat plate" solar collector consists of an absorber plate, with its hydraulic circuit, fixed behind a sheet of glass, in a water-tight case. Thermal losses are reduced by both the greenhouse effect of the glazing and the thermal insulation of the casing. This type of collector can work efficiently throughout the year, heating a heat transfer fluid up to 50°C more than the ambient outdoor temperature.

The "vacuum tube" collector is also frequently used. In this case, the absorber plate is sealed in an evacuated glass tube and the vacuum is used to reduce thermal losses. This technique has the advantage of improving system efficiency when there is an important difference between the ambient and hot water temperatures.

As these collectors are used throughout the year, an anti-freeze fluid is generally required. Therefore, the solar installation needs to have two independant hydraulic circuits, linked by a heat exchanger:

- the "primary circuit" is the circuit flowing through the collectors using an anti-freeze heat transfer fluid;
- the "secondary circuit" is the domestic hot water circuit flowing through the heat exchanger to the hot water storage tank.

Collective installations are generally equipped with two separate hot water storage tanks (see Case studies). One of them is used for storing the water heated by the sun and the other is linked to a back-up heating system which is only used when needed. In this way, the hot water running through the distribution network is supplied, in priority, by the solar system and when the solar energy supply is insufficient, the hot water is maintained at a constant temperature by means of the back-up system.

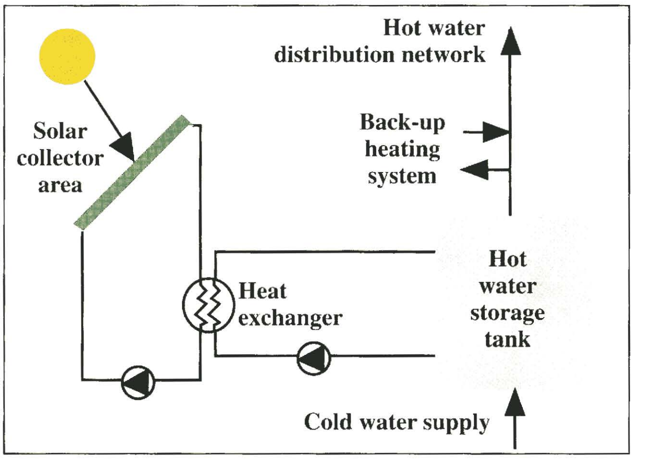

Figure 2. Schematic layout diagram for a collective solar hot water system.

Each of these components should be sized in order to offer optimal system efficiency. Only the good working order of all the parts together can make it possible to guarantee the performance of the installation and its energy production.

1.2. Energy saving and environmental protection

It is true that Southern Europe receives more sunshine than the North. But in reality, the variations are less important than generally believed (see Figure 3).

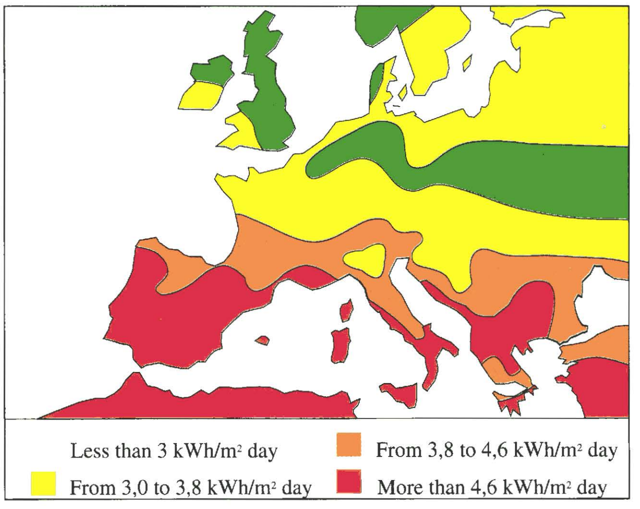

Figure 3. European insolation map: Global solar radiation on a flat surface inclined at site Latitude angle and facing South. Daily averages throughout the year.

The productivity of a solar system is in direct relationship to the insolation. But other factors can also help in saving conventional energy. For example, a solar installation can use a central heating system as a back-up during the winter and work alone in summer. In this way, the conventional energy boiler will only be used during the period of the year when space heating is needed and its efficiency is at its best.

Moreover, the use of solar energy is one of the best ways of limiting the emission of carbon dioxide and its effects on global warming. The reduction of CO_2, brought about by the use of a solar system, depends on the source of the energy that it replaces. A solar collector with an area of 1 square metre, installed near the Mediterranean, can reduce CO_2 emissions by the following amounts every year:

– 440 kg. -if the replaced energy is fuel oil (50% conversion efficiency).

– 195 kg. -if the replaced energy is gas (75% conversion efficiency).

– 380kg. -if the replaced energy is electricity (with a 50% nuclear contribution).

These figures are far from being negligible and if one considers that, in Southern European countries, every other domestic water heater could eventually be solar (as in Cyprus already) the total emission of CO_2 could be reduced by nearly 10% in these countries.

1.3. Applications

Thermal solar applications are divided into three main fields:

– individual and collective domestic hot water production;

– heating swimming-pools;

– space heating in dwellings and public building by means of the direct solar floor heating technique.

The largest market is for individual and collective domestic hot water production. However, the market for collective installations has declined since 1985. This can be explained by the strong competition from conventional energy sources and also by the number of system failures, due to a lack of technical skill amongst the professionals involved (engineers, manufacturers, installers and system managers).

Fortunately, the market for collective installations is now recovering due to the technical progress that has made it possible to guarantee system performance.

Solar systems are generally covered by a 10 year guarantee for the collectors and a 2 year guarantee for the rest of the installation. But up to now, these guarantees have never covered the **performance** of the whole system.

Future market development calls for an overall improvement in system performance. Leaving behind the days when solar collectors were sold without real assessment of their efficiency, the objective of the profession must be to offer a complete, professional service.

2. SOLAR SERVICE

2.1. Service and guaranteed service

The consumer is not preoccupied by the amount of energy marked up on the meter, especially when the units or equivalents are not clear: are the measurements in kWh, joules or toe? Furthermore, it is difficult to add up quantities of energy from different sources, such as gas in winter and electricity in summer.

When considering domestic hot water: service is the availability of hot water all the time and solar systems can guarantee this service, without harm or waste.

Guaranteed service is the difference between a company that says “we deliver quickly” and another that affirms “we deliver within an hour, or you get yor money back”. A “**guaranteed service**” must fulfil 4 conditions:

– it should be simple to understand and be clearly defined;

– it should be easily put into practice;

– the guarantor should be able to insure his responsibility;

– compensation in case of failure should be in proportion to the prejudice.

2.2. Technical constraints

In order to fulfil these four conditions, in the case of “guaranteed solar service”, we must dispose of a means of assessing the service. The easiest way is to measure the hot water consumption and verify the part of it that has been effectively heated by the solar system.

But, before being committed to the productivity of a solar installation, other conditions must also be satisfied:

– a reliable and well tested method is required for sizing the solar installation and estimating its performance;

– a complete range of high quality solar system components is required;

– installers and system managers must have real skills and their know-how must be available wherever a project is planned;

– reliable and economic means of making measurements must be available.

All these requirements concerning solar hot water production can now be satisfied.

3. THE "GUARANTEED SOLAR RESULTS" (GSR) CONCEPT

"Guaranteed Solar Results" (GSR) applied to domestic water heating means that a solar system is guaranteed to supply a minimum amount of energy each year for a given hot water consumption at a fixed temperature.

3.1. The principle

The technical consultant, the manufacturer, the installer and the system manager form a Technical Pool and agree, by contract with the Client, on the quantity of energy that will be supplied by the solar installation each year. The GSR contract lasts 4 years and is composed of 2 phases:

- **Verification phase** (first year) during which the installation should show that it is capable of supplying the amount of energy guaranteed. If the production is less than initially estimated, after functioning for a year, the Technical Pool must find a means of improving the situation, at its own expense.

– **Confirmation phase** (3 years) during which the perennity of the installations' productivity is confirmed. The contracting party has the right to correct or improve the installation during this period.

At the end of the fourth year, if the energy supplied is still less than the amount guaranteed, the Technical Pool is jointly obliged to compensate the client in relation to the deficit in energy supply. This is based on the cost of the energy, fixed by contract, that should have been saved.

3.2. Operating conditions

The Guaranteed Solar Results contract was made possible by scientific and technical progress over the last few years. Particularly:

– the development of methods for simulating the performance and validating the size of an installation;

– the development of good quality components, with technical certification. Solar collectors are part of these certified components and they represent the most important part of the investment.

– the experience and know-how of certain technical consultants, installers and system managers.

– the availability of reliable and inexpensive monitoring and tele-monitoring equipment.

3.3. The actors

This refers to companies that are part of the building trade, that is to say:

– **the solar collector manufacturer.** He has an important part in the preliminary commercial action. His technical role is to supply the collectors and guarantee both quality and performance.

– **the installer.** He is required to install the system under the control of the technical consultant. His role can be extended to cover system management, in the absence of a specific system manager.

– **the system manager.** He is responsible for the running order and maintenance; if necessary, he can be asked by the technical consultant to correct any system failures that have been observed.

– **the technical consultant.** He is responsible for designing the installation, drawing-up the specifications and helping the client to make out the orders. He is also responsible for performance monitoring and receiving warning signals of system failure. In certain cases, the monitoring can be carried out by an independent Consultant, who is not involved with the GSR project.

The first three (manufacturer, installer and system manager) act in a joint and several way as soon as the call for tender is made. In order to make the GSR contract, the technical consultant becomes part of the team commissioned to carry out the order by the client. In this way the "**Technical Pool**" is able to guarantee its engagements in a joint and several way, without the client being confronted by different partners who reject the responsibility for the non-achievement of the promised results. In case of disagreement, the partners are obliged to solve the problem amongst themselves in any way that they consider adapted to the situation, without involving the client.

This organization, with 4 actors, might seem to be exaggerated. However, it has the advantage of clearly identifying the different and essential functions. Other methods, with a general contractor for example, are perfectly possible if all the different functions are assured. The members of the Technical Pool are free to draw up agreements amongst themselves.

The system manager signs the building contract documents in the same way as the contractor. The only difference is that he does not intervene during the "construction" phase and is not paid. The project manager must negotiate a separate maintenance contract (or an agreement in conformity with an existing contract) with the client.

3.4. The framework of the guarantee

Guaranteed energy supply is established by means of a calculation method known as SOLO (see Reference 3). This method predicts installation performance results that are similar to the measurements made over long time periods. At present, it is the only method that has received the approval of all the professionals working in this field of activity. In order to get over problems of climatic risks, the guaranteed energy production is limited to 90% of the estimated annual figures (for certain climatic zones, this limit should be reviewed).

If the **average monthly hot water consumption** is less than the reference figure, the guaranteed energy production should be recalculated using the real consumption figures. However, if consumption during a given month is less than 50% of the reference figure, the energy production during that month is not included in the annual total. This precaution should not be looked on as a means of shirking responsibility: the service of supplying hot water can only be guaranteed if the need is real.

The **cost of the replaced kWh** is established by the technical consultant, in the same way as a thermal audit. This energy cost is used in pay-back period calculations and it will be seen below that it has little influence on the amount of compensation for failure to attain the guaranteed results. The reason for this is that the total compensation is limited by the cost of the installation itself.

Commissioning of the installation. As soon as the installation is completed, conformity with the specifications and good working order are controlled; the installation can then be commissioned. From this moment, the GSR contract begins. At the end of one year, the balance sheet is drawn up. If the guaranteed results are attained, the Final Commissioning of the installation is declared and ownership is officially transferred from the Contractors to the Client.

3.5. Compensation

If the annual energy supply is less than the guarantee, the contractors can improve the installation at their expense. If this is not possible, the Contractors must compensate the Client. The compensation is based on the difference between the guaranteed and the measured results, with relation to the total installation cost. For example, if the installation produces x % less than the guaranteed production, the compensation will be equal to x % of the initial investment.

The compensation will be paid at the end of the three year verification period. The surplus from certain years can be used to compensate for the deficit in others. This unique compensation is intended to maintain the gross pay-back time calculated when the feasibilty study was made. Its effect is equivalent to the annual returns over a period equal to this pay-back time.

3.6. Application limits

In order to keep over-costs in proportion to the objectives, certain limits are imposed for the application of the GSR contract.

(a). Type of installation: domestic hot water supply in new or completely renovated buildings.

(b). Seasonal requirements; regular hot water consumption during at least 8 months of the year.

(c). Consumption evaluation: based on measurements for at least two months.

(d). Recommended materials: glazed flat plate collectors or vacuum tube collectors.

(e). Minimal collector area: 50 m^2.

(f). Tele-monitoring equipment: cost should be less than 5% of the total installation cost.

4. THE "GSR" PROCEDURE

4.1. The feasibility study

The project is planned by an engineer or a technical consultancy working for a Client. The first document to be prepared is the feasibility study or preliminary plan that can show the advantages of the project as well as its technical and economic feasibility. As soon as the project is financed and the Client is in agreement, the technical consultant, responsible for the construction work, will be asked to prepare the documents required for consulting contractors.

4.2. The documents for consulting contractors

The consultation of contractors is regulated in most countries, but legislation varies from one country to another.

Consultation Documents or Specifications include all the information necessary for a contractor, in the case of a Call for Tender, in order to determine the precise cost of the work to be done.

If it is for a Public works offer, the Consultation Documents should fix the general regulations to which the contractors will be subjected and in particular, the Administrative and Technical Clauses relative to each field of activity (industry, public buildings or housing):

- The Administrative Clauses specify the financial conditions, time limits, responsibilities...
- The Technical Clauses contain a detailed description of the work to be done and recommendations for the way of doing it. These documents also include: plans, quantities and specifications of the materials to be used.

The technical conditions required for the Guaranteed Solar Results contract are included in the Technical Clauses, the administrative and financial conditions are added to the Administrative Clauses.

4.3. The call for tender

The call for tender is obligatory for certain public works, but there are no obligations for private work contracts. Bids are generally confidential, they should be received within a fixed time limit and be compared in the presence of the Client, the technical consultant and representatives of the administration involved. Generally, the lowest bid is chosen, assuming that no anomalies are found in the documents and that the Technical Pool proposes all the technical and financial guarantees required.

The Technical Pool should specify in its offer the level of the performance guaranteed as it can be greater than the minimum performance requested in the consultation documents.

5. TECHNICAL CONSIDERATIONS

5.1. Defining the needs

The needs for domestic hot water should be established with care. They are defined by the average daily consumption for each month and are generally expressed in litres per day. So, there should be 12 monthly figures; they can all be identical or for certain months (but, not more than 4) can be zero.

For **new buildings,** hot water consumption figures must be estimated from the following data:

- the number and nature of the points at which water is drawn;
- the expected occupation of the establishment;
- the required water temperature;
- the planned extensions.

In **existing buildings,** daily consumption should be measured over a period of at least two months. If necessary, a water meter should be installed on the pipe leading to the existing water heater. This meter will be re-used for tele-monitoring the solar installation. The chosen months, during which the measurements are made, should be representative of annual requirements.

In all cases, the water temperature will be the temperature of the hot water distribution circuit fixed by the regulations.

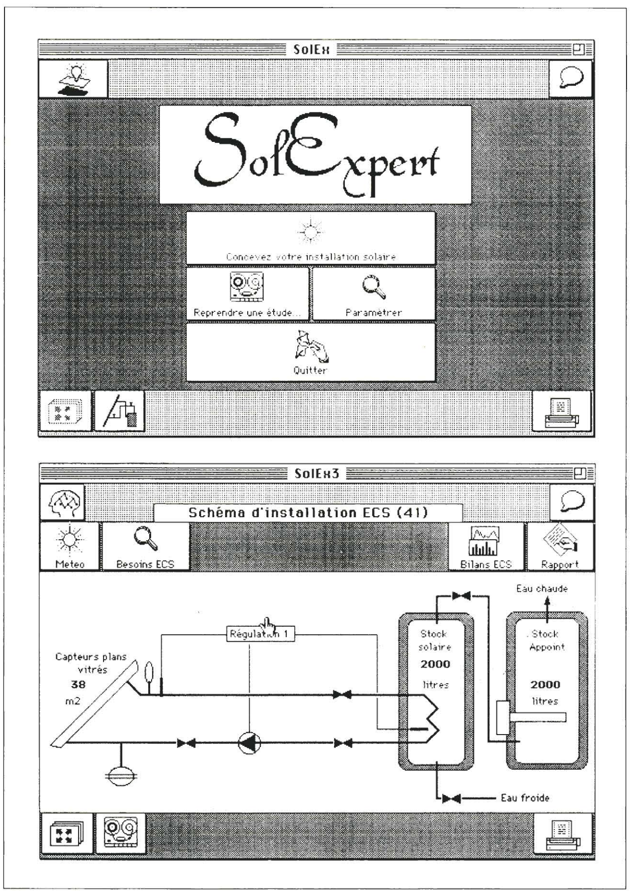

Figure 4. Examples of SolExpert screen pages: the introductory page and a proposed layout diagram.

5.2. Sizing and calculations

The different methods of calculating solar system performance are not discussed in this brochure. However, it is worth mentioning the existance of two expert systems for computer aided thermal solar installation design:

- NBSSOL (see Reference 6);
- SolExpert (see Reference 2).

Heat exchanger calculations can be critical for solar installations. As there are no certified methods, the manufacturers should be consulted. However, it is generally recommended to slightly oversize the heat exchanger. Theoretical calculation methods are available in "European simplified methods for active solar system design" (see Reference 4).

5.3. Monitoring and tele-monitoring

The particularity of thermal solar installations at present is that they always have a conventional energy back-up system. If the solar installation breaks down, it is the back-up system that supplies the hot water. So, there is no interruption in the service. However, if the breakdown lasts, the cost of the service will increase rapidly. This is the reason why the production figures of a solar installation must be checked every day.

The easiest way of evaluating the service offered by a solar system is to measure the amount of hot water used and check that it has been effectively heated by the sun.

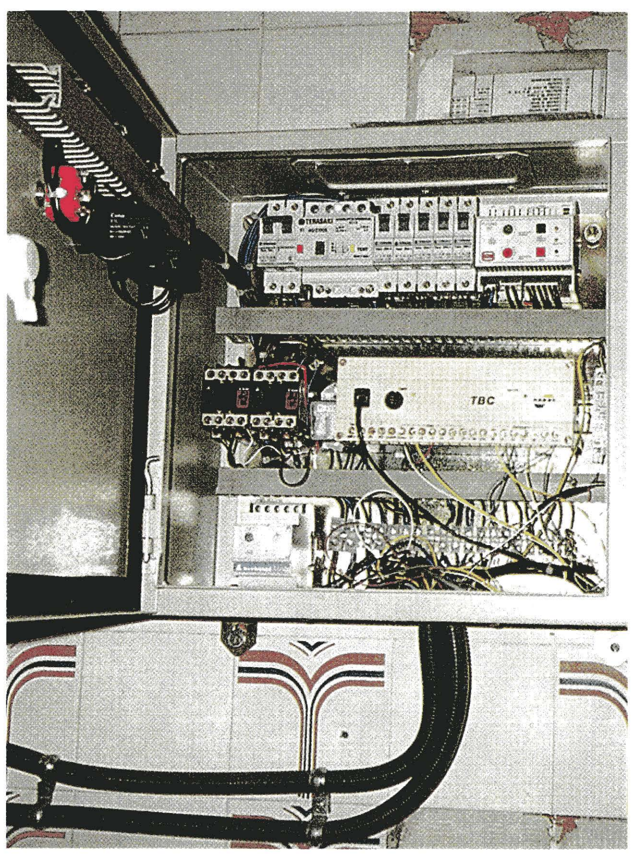

Figure 5. Tele-control switch board .

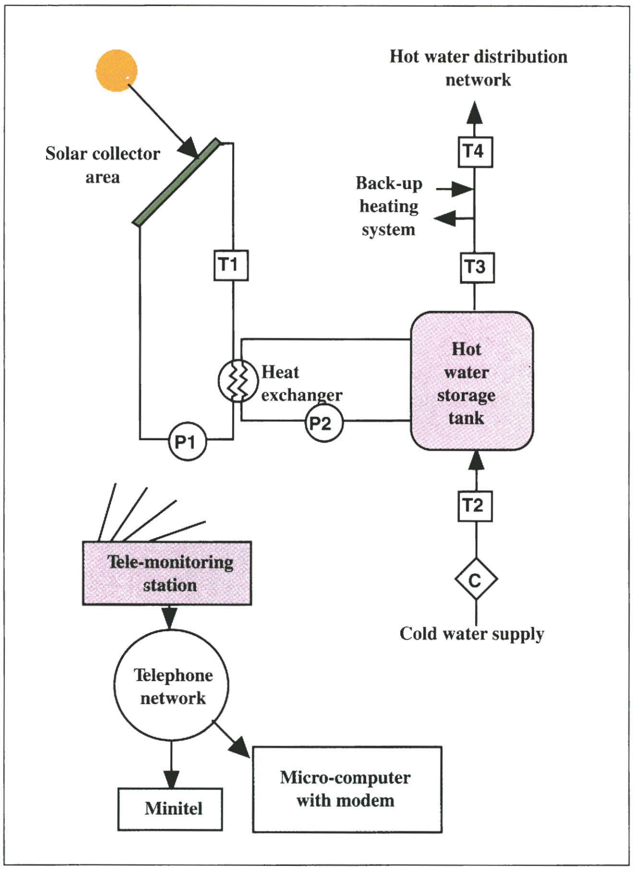

FIGURE 6. Schematic layout diagram for tele-monitoring a solar installation, showing the principal measurement positions:
C = Water consumption.
P1 = Primary circuit pump; on or off.
P2 = Secondary circuit pump; on or off.
T1 = Heat transfer fluid temperature, leaving the collectors.
T2 = Cold water temperature
T3 = Hot water temperature, leaving the hot water storage tank.
T4 = Hot water temperature in the distribution network.

It is possible to measure energy production by means of a simple heat meter. However, regular monitoring is not only necessary for evaluating the service, it also helps in system maintenance, quick detection of working order anomalies and also for preventive maintenance planning, after statistical analysis.

A tele-monitoring system is preferable for three reasons:

– The measurements can be made at a distance by the technical consultant or the system manager;

– the possibility of installing warning signals limits the number of maintenance checks and reduces the time in which a breakdown can be noticed and repaired;

– A standardized tele-monitoring system (see Figure 6) makes it possible for everyone involved to check the results at any moment. Each of the partners, including the Client, can verify the figures by means of a simple Minitel or a micro-computer equipped with a modem.

Tele-monitoring equipment, specially designed for solar installations, is now available. It is economically feasible for all collective installations, as the cost represents only 5% of the total installation costs. In this way, the monitoring equipment becomes part of the solar installation and should be fitted up by the installer, under the supervision of the technical consultant. It follows that the maintenance of this equipment is integrated into the general maintenance contract for the whole installation.

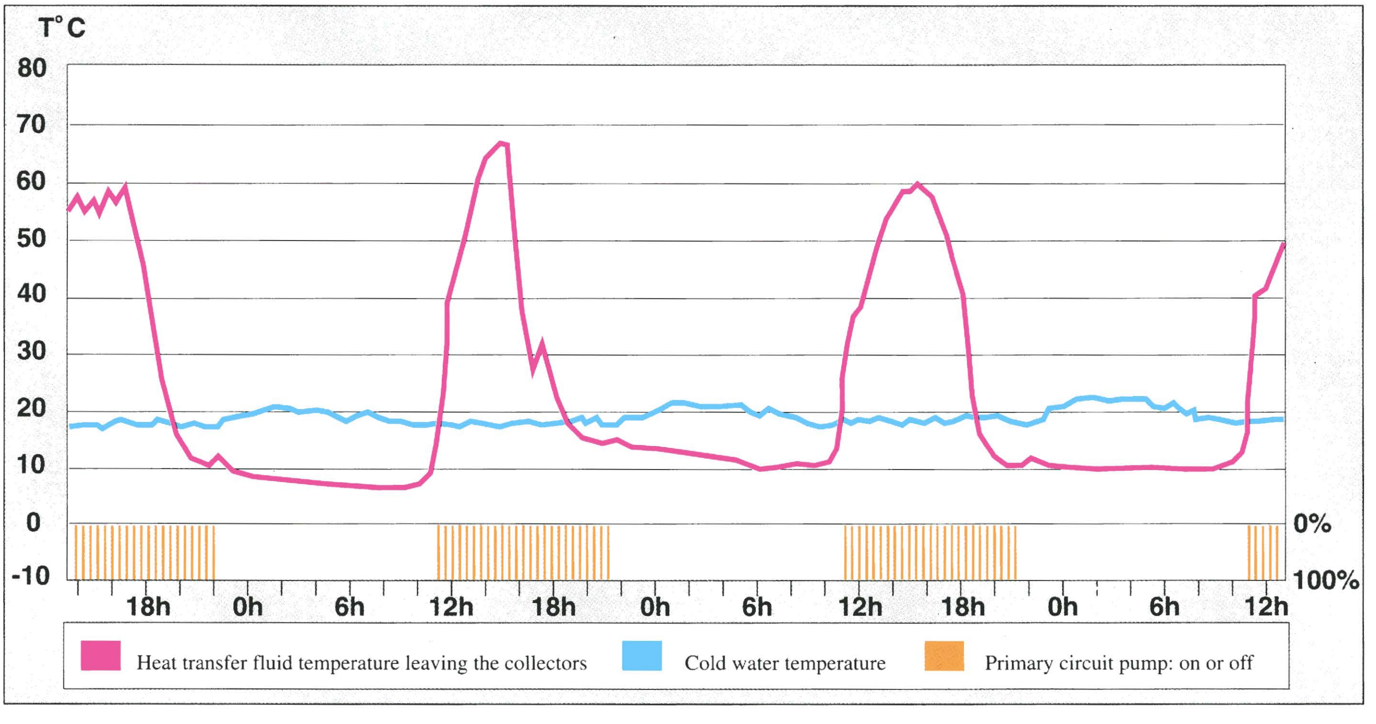

Figure 7. Graph showing an example of tele-monitored daily measurements.

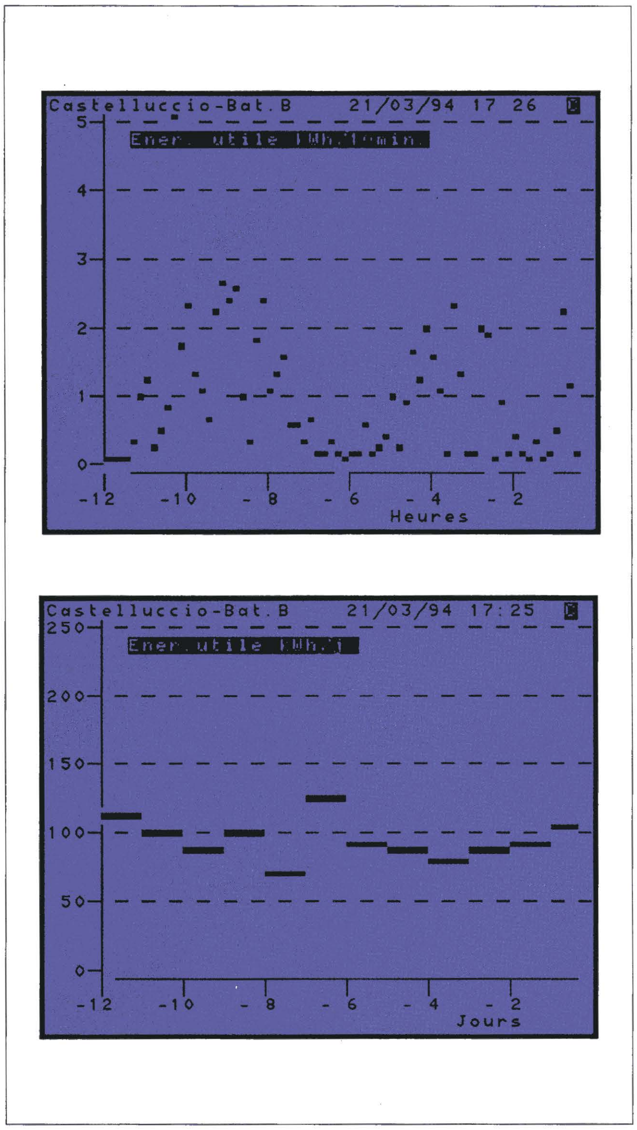

Figure 8. Examples of tele-monitoring results, as shown on a Minitel Screen. Measured energy production:
– upper page; 10 minute totals over the previous 12 hours.
– lower page; daily totals over the previous 12 days.

5.4. Guarantees and maintenance

As a complement to the GSR contract, the technical consultant generally requests serious guarantees from the different suppliers:

– a 10 year guarantee, for the solar collectors;

– a 5 year guarantee for the different water storage tanks;

– a 2 year total guarantee, covering all the other materials.

These guarantees refer to the maximum guarantees proposed by certain manufacturers. The installer can subscribe to a complimentary insurance if it is considered to be necessary.

All the fittings, electricity and plumbing should be covered by a 2 year insurance policy. This is already standard practice for all thermal equipment, without guaranteed performance. These guarantees do not concern the Client until the end of the GSR contract.

The maintenance contract for the 4 year GSR period should be included in the construction work contract. In this way, all the expenses are covered throughout the period of the GSR contract.

In conclusion, the GSR contract offers 4 essential advantages:

1. **No financial risks;** the user is guaranteed a certain annual energy supply and so the investment pay-back time is also guaranteed.

2. **No breakdown worries;** the user is not troubled by system failure. Not only are repairs and maintenance guaranteed, but it is also in the interest of the "technical pool" to carry out the repairs as quickly as possible.

3. **Easy bank loans;** the absence of financial risks makes it much easier to borrow the money needed for investment costs.

4. **Preferential funding;** subsidies for collective solar installations are now generally linked to guaranteed performance.

6. CASE STUDIES

6.1. Castres Hospital, over 5 years of guaranteed service

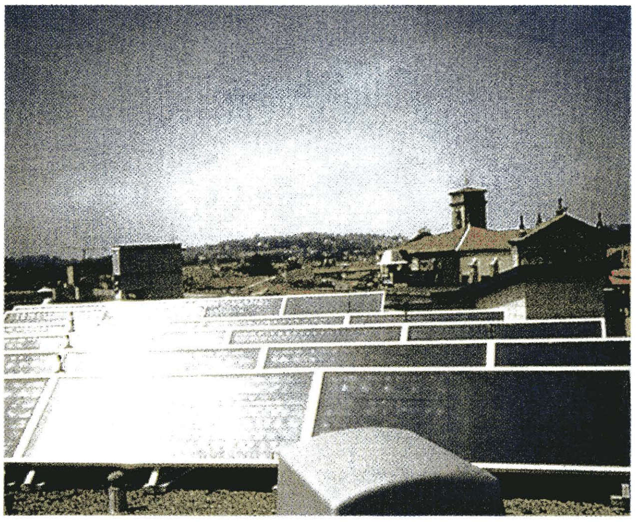

Figure 9. The solar collector array on the roof of Castres Hospital.

The first solar system with a Guaranteed Solar Results contract was installed in 1988 at Castres Hospital, in South-West France. The solar installation, with a collector area of 89 m^2, was part of a series of improvements intended to save energy. The existing central heating system is used as a back-up for the solar hot water supply during the winter and when space heating is no longer needed the furnace is closed down, leaving the solar system to operate with its own electric back-up.

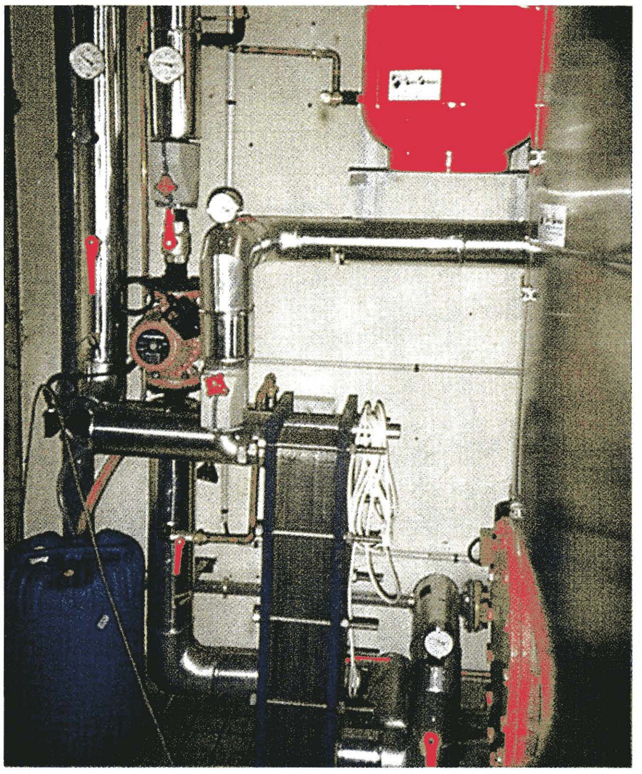

Figure 10. The technical premises in Castres Hospital showing the heat exchanger, expansion chamber and part of the hot water storage tank.

The GSR Technical Pool is as follows:

- Technical Consultants = Tecsol, Perpignan.
- Collector manufacturer = Solefil (now TSA).
- Installer / System manager = Société Amen, Castres.

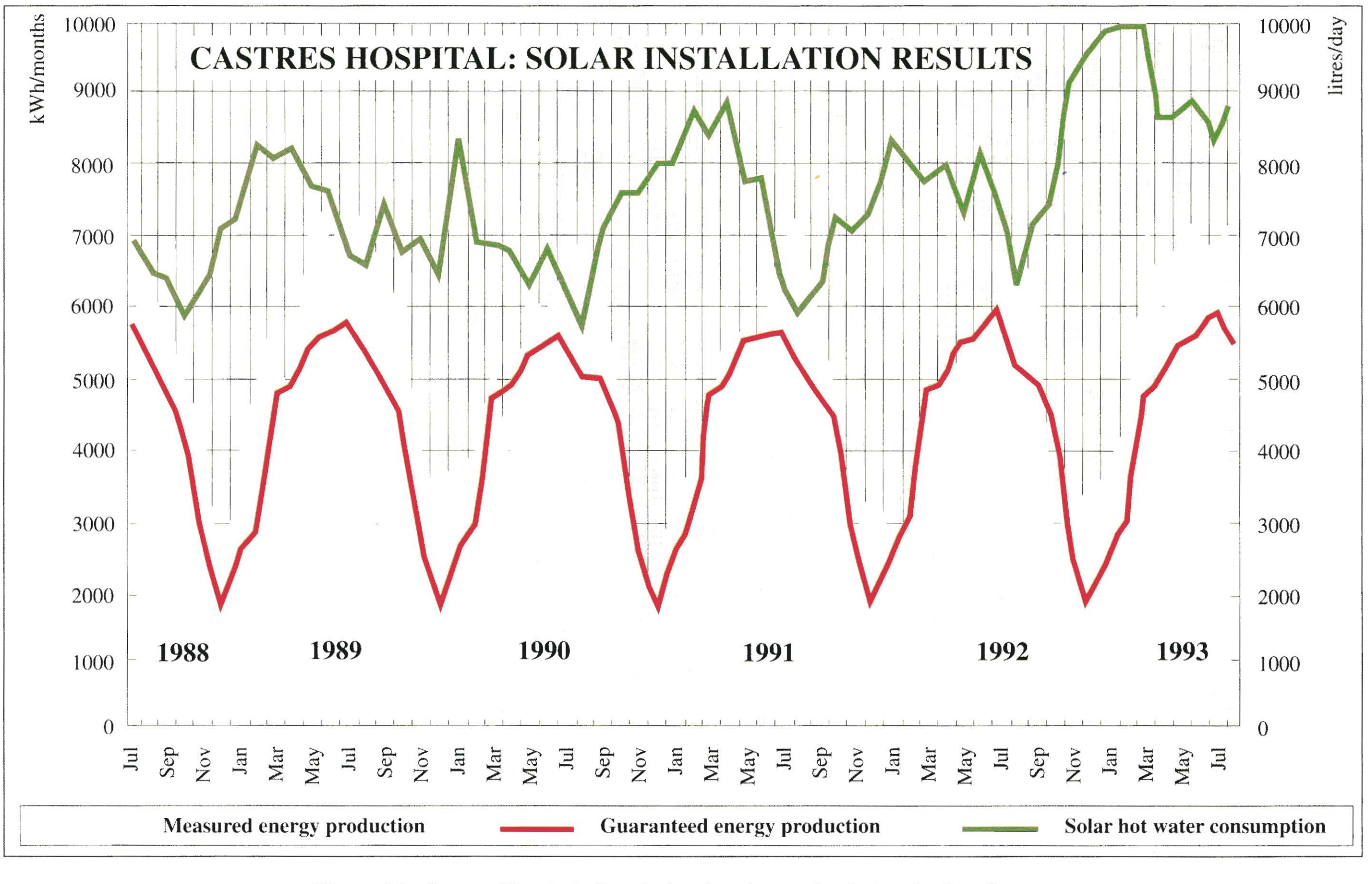

Figure 11. Castres Hospital: Graph showing the results during the first 5 years.

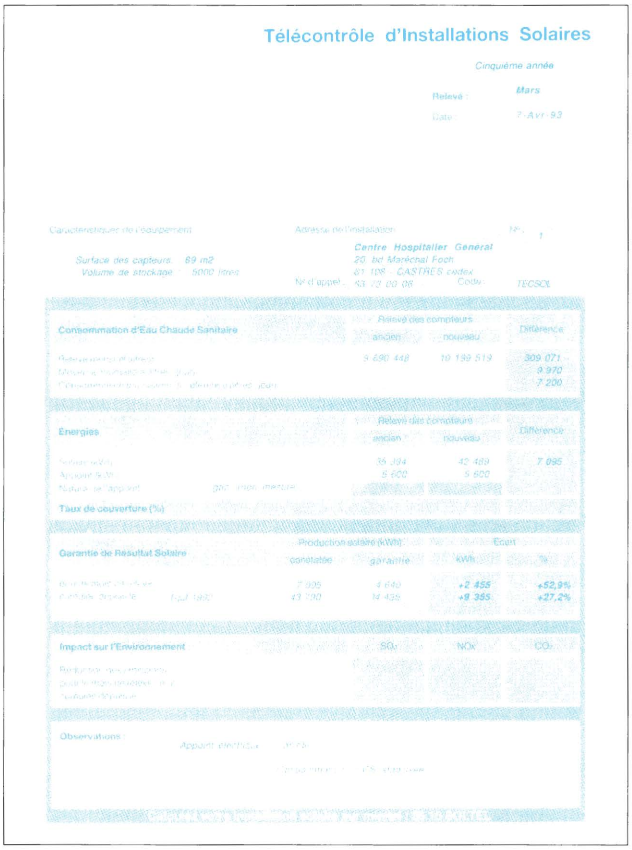

Figure 12. Example of the monthly tele-control balance sheet for Castres-Hospital

This modest solar installation gave the Tecsol Consultancy an opportunity for experimenting with the new concept for solar service, developing the tele-monitoring techniques required and clarifying the administrative procedures.

The performance of the installation at Castres (see Figure 11) has clearly justified the experimental work. The solar energy supplied over the first five years was 300,800 kWh, 20% more than stipulated in the GSR contract.

6.2. The SUNERGIE programme

After Castres Hospital, other solar installations with GSR contracts were built within the framework of a Demonstration programme aided by the European Commission as well as national and regional energy Agencies. The SUNERGIE programme was then set-up in order to diffuse the GSR concept and to revive the market for high quality thermal solar installations.

Sunergie was launched through the initiative of a European Economic Interest Grouping, made up of members of the industry and technical consultants in Italy, France and Spain. The object of the programme is to make the technical and administrative know-how of Sunergie available for all projects by helping to draw up the Guaranteed Solar Results procedure (see Figure 13).

The first phase of the programme, supported by the European Commission in 1990, is called SUNERGIE 0, because it is the phase in which it had to be shown that the experiment tested at Castres could be repeated elsewhere. This phase covers 17 installations with a total collector area of 2,300 m^2, in France and in Spain (among which the Hotel Hipocampo and the Sant Josep and Sant Miquel residences, described in the Case Studies below). The second phase, SUNERGIE I, will make is possible to build a further 15 installations, with a total collector area of 2,200 m^2, in different parts of Italy, France and Spain. Finally, SUNERGIE II, signed by the European Commission in 1992, provides for the construction of another 29 installations, with a total collector area of 3,900 m^2, throughout 5 Southern European countries (Greece, Portugal plus the 3 previously mentioned countries).

A total of 60 high quality solar installations, with a collector area of 8,000 m^2, will be built within the framework of this programme. They will be monitored daily through the telephone network. It is important to stress the interest of such a programme that helps to initiate working relations between the different members of a profession who have not had the chance to work together previously. Furthermore, the scale of the programme and the promotional activity by which it is accompanied also helps to give credibility to thermal solar techniques.

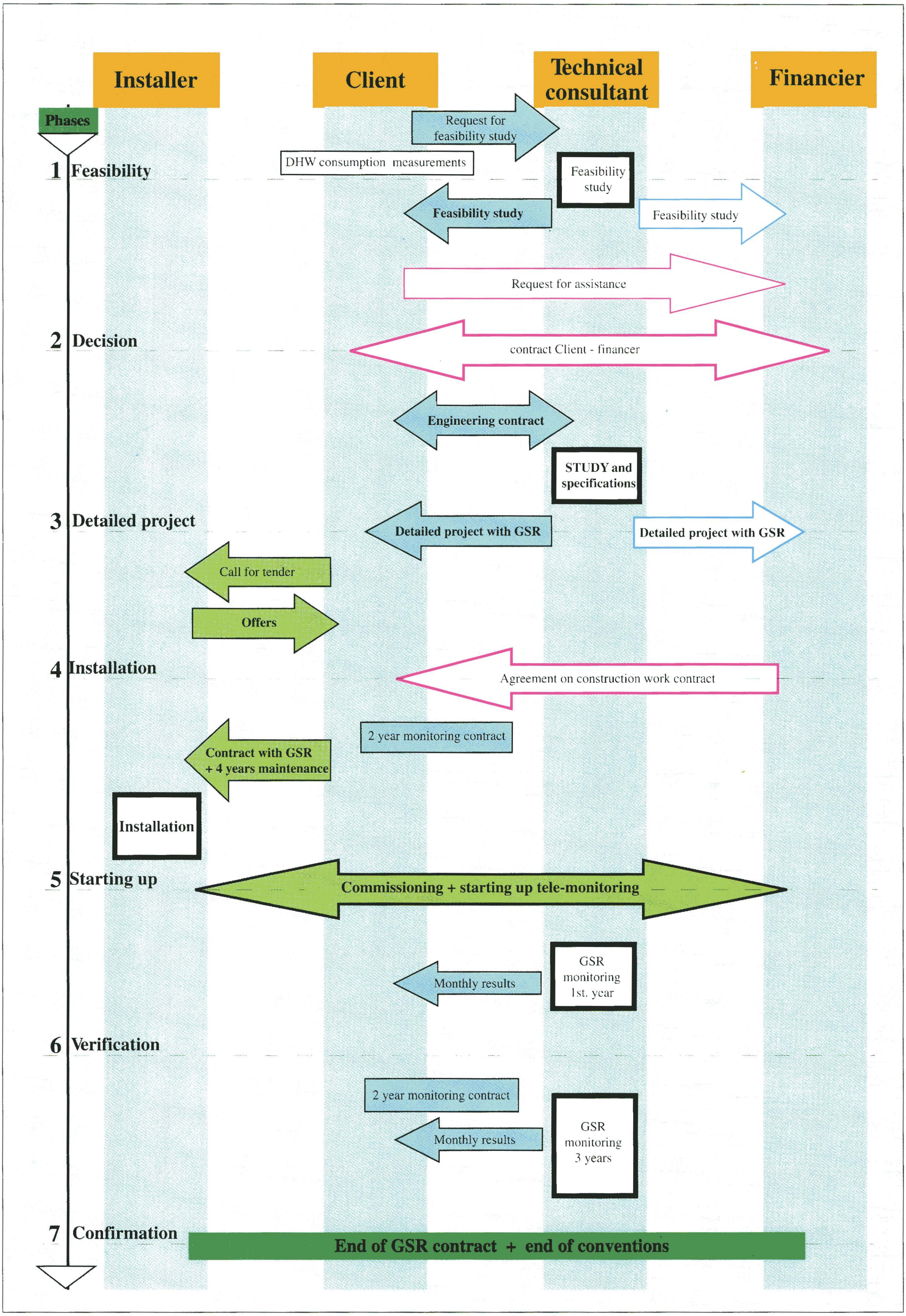

Figure 13. Chronology of a GSR project within the framework of the SUNERGIE programme.

6.3. Two residences for elderly people in Barcelona

Sant Josep and Sant Miquel are geriatric residences, with 79 and 142 residents, respectively. They are built close to each other in Barcelona and are managed by the Alba Foundation. In 1992, both of these residences were equipped with solar systems to supply domestic hot water and both installations were covered by Guaranteed Solar Results contracts.

In Sant Josep, the solar system is used for space heating, by a direct floor heating technique, as well as domestic hot water production. The installation was designed to supply only one third of the total thermal load so as to avoid over-production in summer. A solar collector area of 144 m^2 is used in connection with two hot water storage tanks with a total capacity of 9,600 litres. The water storage tanks are placed in a vertical position in order to encourage a temperature stratification: the hottest part being used for domestic hot water and rest for space heating. The low temperature floor heating system covers an area of 3,821 m^2 with 33 different circuits, controlled independently. If the solar energy is not sufficient for the needs, a natural gas furnace is used for back-up heating.

At Sant Miquel, the hot water requirements were estimated to be 6,000 litres per day (the measured consumption is a little more). A conventional solar installation with a collector area of 61 m2 is used in connection with a 5,400 litre hot water storage tank and the back-up heating is supplied by natural gas. Heat transfer is made by a heat exchanger in the hot water stotrage tank casing. A temperature differential, between the collectors and the water storage tank, controls the solar circuit pump.

The tele-control and the GSR contract are innovations in both these installations. For this reason they were granted subsidies, covering 49% of the total installation cost, from the European Commission, the Catalonian Goverment and the Spanish Ministry for industry.

Taking the subsidies into account, the pay-back period guaranteed by contract is about 5 years. During the first year of operation, the measured solar energy supply was 3% greater than the guaranteed production at Sant Miquel.

The Technical Pool for the GSR is a follows:

- Technical Consultant = Enersoft, Barcelona
- Collector manufacturer = LKN Sistemas Lecken, Barcelona.
- Installer and system manager = LKN - Sistemas Lecken, Barcelona.

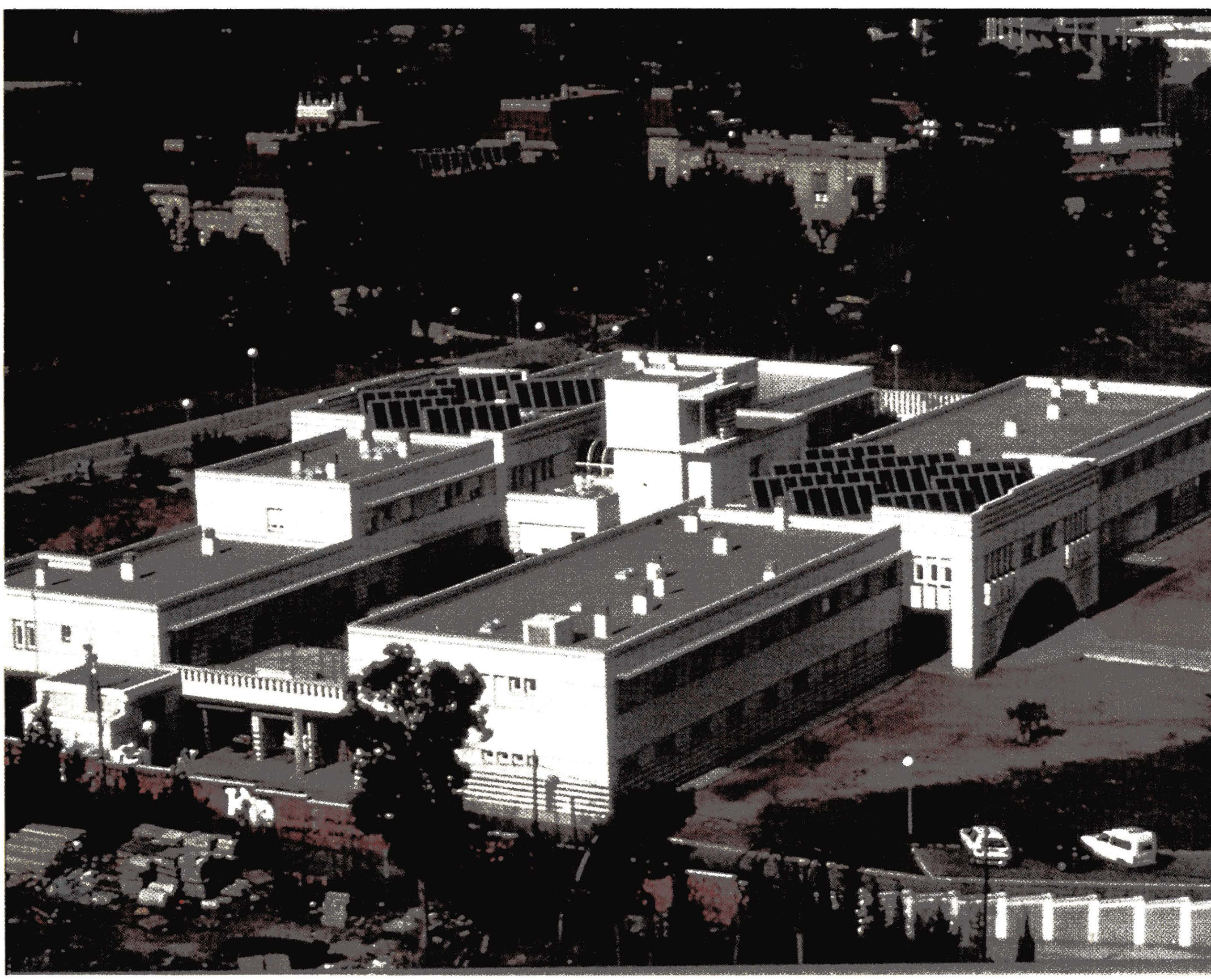

Figure 14. Aerial view of the Sant Josep Residence. Sant Miquel can be seen in the background.

6.4. A hotel in Mallorca

The hot water demand of the 400 residents at the Hotel Hipocampo Playa in Mallorca is relatively stable throughout the year. However, less energy is needed for heating water in summer, as the cold water supply temperature is higher. Therefore, the size of the installation is designed to cover the majority of the needs in summer, limiting the overall solar production to 70% of the total annual needs. A larger solar fraction would cause over-production and a drop in efficiency during summer.

The solar installation has a collector area of 162 m², an "Alfa-Laval" flat plate heat exchanger, two 6,000 litre hot water storage tanks and a fuel burning furnace for back-up heating (see Figure 15). In 1992, the total solar installation cost, including tele-monitoring and maintenance during the first two years, was 11,507,818 Ptas. (73,300 ECU) or 71,036 Ptas. (450 ECU)/m² of solar collector.

The project was built within the framework of the Sunergie programme, with tele-monitoring managed by the Tecsol Consultancy. The Guaranteed Solar Results contract began in May 1993 and during the first year the measured results were 28% higher than the guaranteed performance.

Figure 16. Hotel Hipocampo: aerial view showing the solar installation on the roof.

The Technical Pool for the GSR is a follows:

- Technical consultant = Enersoft, Barcelona.
- Collector manufacturer = MADE, Madrid.
- Installer = GESA, Gas y Electricidad, S.A.; Palma de Mallorca.
- System manager = Hermanos Canada, S.A.; Mallorca.

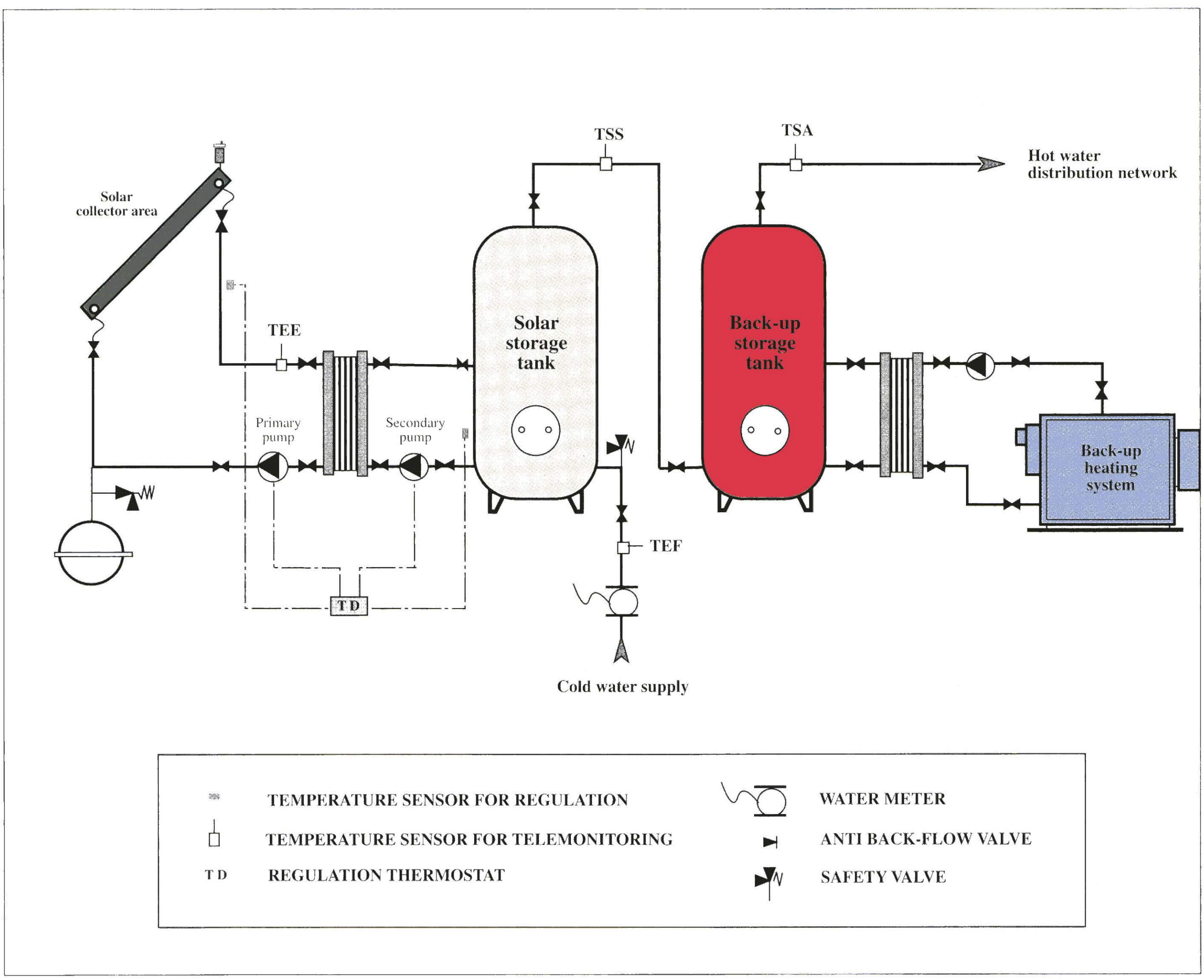

Figure 15. Schematic layout diagram of the solar installation at the Hotel Hipocampo.

6.5. A sports center near Alicante

The "Pabellón Cubierto" in Villena is a sports centre with a gymnasium. The solar installation was designed to supply hot water for the showers and 8 dressing rooms. It is made up of a 51 m^2 collector area, manufactured in Spain, and a 2,400 litre hot water storage tank with an electric back-up heater (see Figure 19).

The Guaranteed Solar Results contract was set up within the framework of the Sunergie programme and became operational on June 1st 1993.

The difficulties that appeared in the working order of this installation show the necessity of the tele-monitoring system:

- permanent monitoring showed that the primary circuit pump was working continuously during certain days in July. This anomaly was automatically brought to the attention of the system manager, for verification.
- in October, the same pump finally stopped working, the breakdown was immediately made known to the person responsible for maintenance and the faulty pump was replaced two weeks later.

As a result of this breakdown, the measured solar energy production was only 320 kWh instead of the 1,041 kWh guaranteed, during the month of October. However, bad results over one month can be compensated for by a good performance during the rest of the year. Between the beginning of June and the end of November, the guaranteed energy production was 3,574 kWh and inspite of the negative results during October, the measured energy supplied was 4,021 kWh, which is 12% more than guaranteed.

This example shows the importance of the GSR concept for the system manager and the owner of a solar installation. Firstly, system breakdowns, which are sometimes inevitable, are immediately reported and secondly, the members of the Technical Pool, responsible for the installation, are keen to carry out repairs as quickly as possible in order to avoid having to make compensation payments.

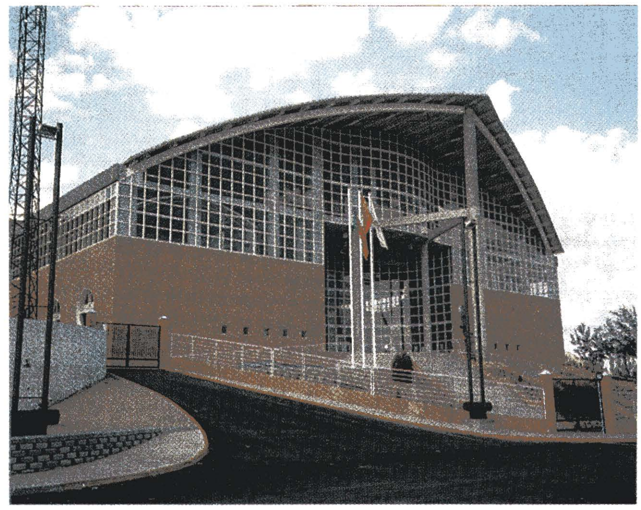

Figure 17. The "Pabellón Cubierto" in Villena

Figure 18. The collector array on the ground next to the "Pabellón Cubierto"

The Technical Pool for the GSR is as follows:

- Technical Consultant = Enersoft, Barcelona.
- Collector manufacturer and installer = Sistemas LKN, Barcelona.
- System manager = Instalaciones Ribera, C.B.; Alicante.

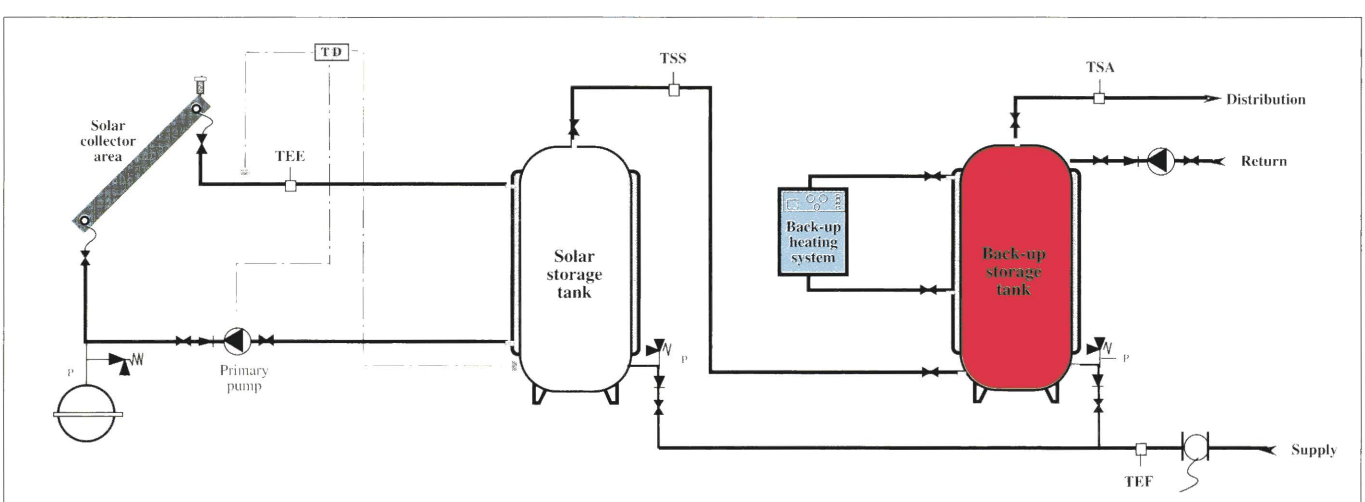

Figure 19. Schematic layout diagram of the solar installation for the "Pabellón cubierto" in Villena.

6.6. An example of renovation

The solar water heating system in Bastia Hospital, in Corsica, was completed in 1984. It broke down soon after owing to the corrosion of the solar hydraulic circuit that was exposed to the sea air. The French Agency for the Environment and Energy Management, in co-operation with the European Commission, helped to finance the renovation of the installation. This time, however, the installation was insured by a Guaranteed Solar Results contract.

Most of the original equipment, including the 402 m^2 collector area and the hot water storage tanks (3x8,000 litres) were re-used. Nevertheless, the collectors were not new and it was possible that their efficiency had decreased. Therefore, when the GSR contract was made out, the deduction of the guaranteed results in relation to the calculated performance figures was established at 15% instead of the usual 10%.

The total energy produced during the first 9 months was 165,000 kWh, 1% more than the total energy supply guaranteed for this period.

The Technical Pool for the GSR is as follows:

- Technical consultant = Tecsol, Perpignan.
- Collector manufacturer = Solefil (now TSA).
- Installer/System manager = SEITHA, Corsica.

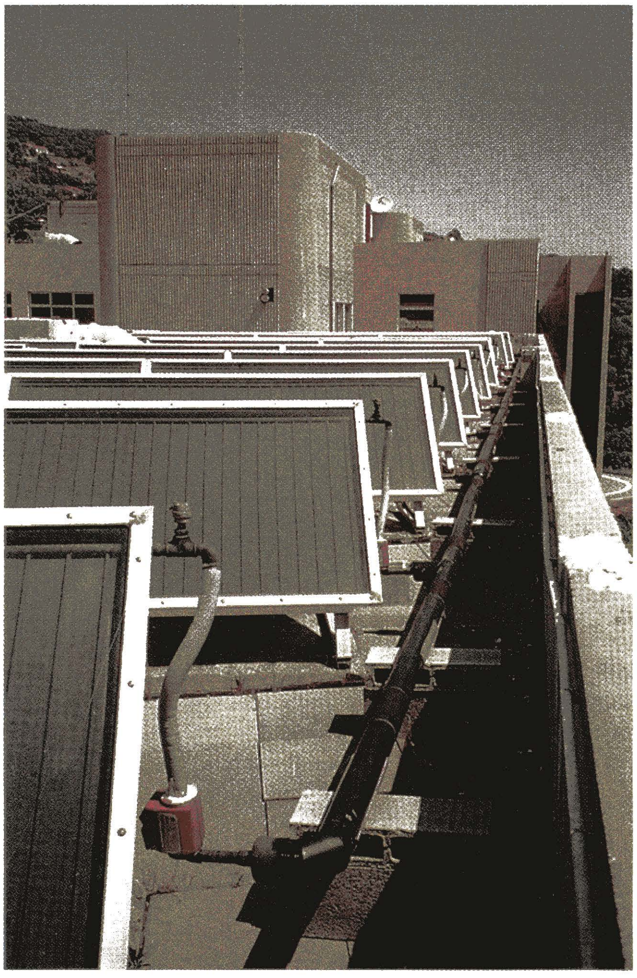

Figure 20. Part of the collector array on the roof of Bastia Hospital

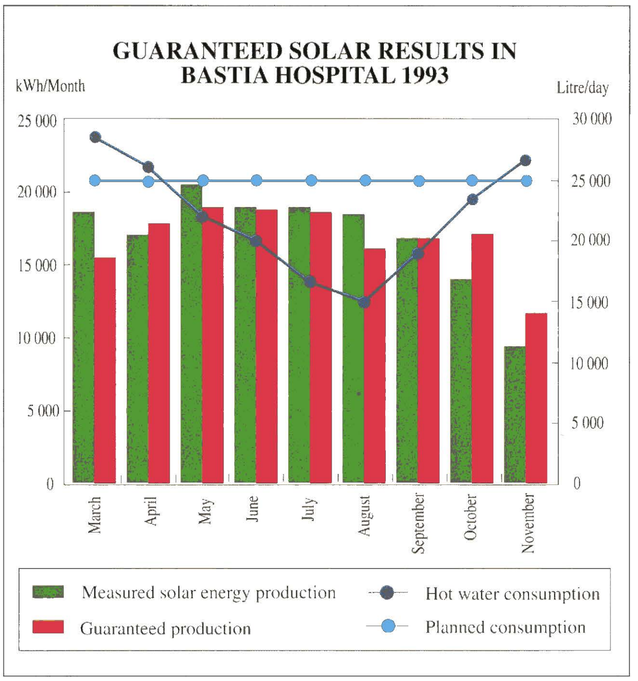

Figure 21. Graph showing the results over the first 9 months. The energy produced during this period was 1% greater than the guaranted supply.

6.7. A hospital in Guadeloupe

The hospital Pointe à Pitre-Abymes in Guadeloupe contains 600 hospital beds, a maternity clinic, an out-Patients service and operating theatres. The buildings, covering a total of 62,000 m^2, are suppplied with hot water from nearby technical premises.

In 1992, a solar installation and a heat recovery system, working on waste heat from the air-conditioning plant, were added to the existing fuel burning hot water system. The solar installation was designed to heat the pre-heated water coming from the heat recovery system. The solar installation is composed of collectors with a selective surface, covering an area of 462 m^2. They are connected to two hot water storage tanks, with a capacity of 10 and 8 m^3. The storage tanks are installed in the boiler-house next to the existing heating system, which is now used as back-up. The back-up system is only called into use when the centralized energy management system considers it to be necessary.

Both the production of solar hot water and thermal waste recovery are covered by a Guaranteed Results contract.

The guarantee has been in operation since December 1992. It amounts to 85% of the results estimated by calculation, that is to say:

- Recovered energy = 178,125 kWh/year (35%).
- Solar energy = 332,540 kWh/year (65%).
- Total useful energy = 510,665 kWh/year (100%).

The calculations were made by the Technical Consultant using a special computer simulation programme for mixed systems, "Waste heat recovery + Solar", developed by Mr. René Gilles. This programme was validated after performance measurements were made at a similar installation in St. Pierre Hospital on Réunion Island.

A tele-control system centralizes the measurements and sends working order data by modem to the micro-computers that handle the monitoring programme.

The Technical Pool for the GSR is as follows:

- Technical consultant = André Rio, Consulting Engingeer; Marseille.

- Collector manufacturer = Giordano (capteurs C2S); Aubagne, France.

- Installer/System manager = GEMSA.; Pointe à Pitre, Guadeloupe.

- Tele-control = Steafa Control.

Figure 23. The technical premises in the Pointe à Pitre - Abymes Hospital, showing the "active" equipment for the heat recovery and solar systems.

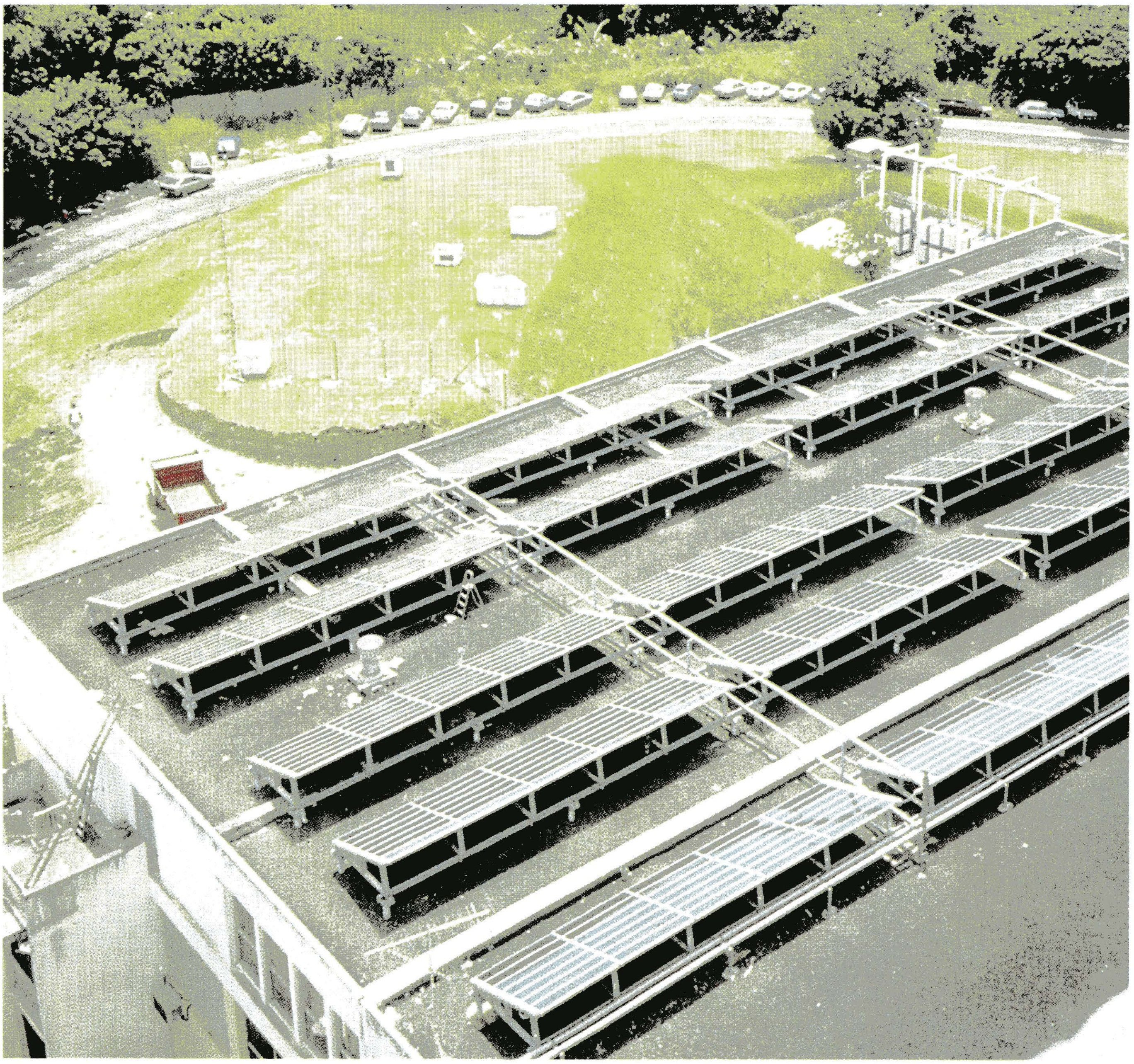

Figure 22. Part of the solar collector array for the Pointe à Pitre-Abymes Hospital.

6.8. An industrial application in Greece

The Guaranteed Solar Results concept takes on a different form in Greece, in order to guarantee "third party financing".

"Third party financing" concerns the installation of a solar system and its maintenance on a turn-key basis, with the cost of the service counterbalanced by the value of the energy supplied. To achieve this goal, an "energy service company" is formed to:

- finance the solar installation;
- supply the technical expertise;
- monitor working order and results;
- ensure system maintenance.

This concept is similar to the GSR contract, in which a "technical pool" guarantees solar production. However, "third party financing" goes one step further, as the "energy service company" is responsible for financing the project as well as the energy supply. In this way, the energy user can exploit a solar system without an initial investment or risk and the "energy service company" has the incentive to maintain the equipment until the return on the capital investment (with interest) is achieved

The procedure was developed by the Centre for Renewable Energy Sources (CRES) in Greece. However, it is only possible to encourage investors if the pay-back period is short. Therefore CRES proposes technical help for telemonitoring and financial subsidies for large solar installations in order to encourage this method of financing thermal solar installations.

The first example concerns a solar hot water production system for the industrial process needs of the Achaia Clauss Winery in Patras. The installation is composed of a 300 m^2 collector area and a 10 m^3 hot water storage tank.

The energy user pays the "energy service company" for the energy supplied, according to the following tariffs:

- 12 Drs. (0.043 ECU) / kWh during the first three years and 11 Drs. (0.04 ECU) / kWh during the following three years.

In 1993, the cost of the fuel that was replaced by solar energy was 95 Drs. (0.34 ECU) / litre.

In this particular case: the solar collector manufacturer SOLE Ltd. is also the "energy service company". CRES provided a subsidy amounting to 50% of the total installation cost and is also responsible for tele-monitoring.

During the first months of operational service, the solar energy supplied amounted to an average 450 kWh/day. Taking the subsidy into account, the investment will be returned in 5 years and after 6 years, the Achaia Clauss Winery will become the owner of the installation.

Figure 24. The Achaia Clauss Winery.

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The SUNERGIE projects (0 and I) ***Programme for the Dissemination of Collective Solar Hot Water Heaters in Southern Europe*** **- supported by the European Commission have the following contract numbers: SE 138/89 FR and BU 60/91 FR.**

The projects described in case studies: Residences Sant Josep and Sant Miquel, Barcelona and Hotel Hipocampo Playa, Mallorca, have been achieved within the project Sunergie 0. The case study: Sports Centre "Pabellon Cubierto", Villena (Alicante) within the project Sunergie I.

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Within each member state there are a number of organisations recognised by the European Commission as an Organisation for the Promotion of Energy Technology (OPET). It is the role of these organisations to help to co-ordinate specific promotional activities within Member States. These include staging of promotional events such as conferences, seminars, workshops or exhibitions as well as production of publications associated with the THERMIE Programme.

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Produced by:

Generalitat de Catalunya
Departament d'Indústria i Energia
Institut Català d'Energia

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By order of:

The European Commission
Directorate-General for Energy (DG XVII)
Strategy-Dissemination-Evaluation (D/1)
200, rue de la Loi,
B-1049 Brussels, Belgium

ISBN 84-393-3297-1

9 788439 332978