# CENTRE FOR RENEWABLE ENERGY SOURCES

# Large Scale Solar Heating Plants Potential in Greece

An analysis requested by “iC **consulenten Ziviltechniker Ges.m.b.H”** on the behalf of Company SOLID (AT)

Installation of central solar system, surface area 283 m$^2$, for hot service water, in Sani Beach Hotel, Halkidiki.

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## *Preface*

The objective of this report is from one hand to present the current situation of the Large Scale Solar Heating (LSSH) Plants technology in Greece and from the other to present the possibilities that a new company (in our case SOLID) has to enter in this market.
As it will be seen in the report, there is no well-defined sector of LSSH Plants in Greece. This means that there are no specialized companies for LSSH plants, and no special design and construction practice for them. Consequently, for some aspects examined in this report, there exist no specific information. An example is the market position of the various companies and their distribution and promotion methods. In these cases, the information related to the whole solar thermal market sector has been used by choosing, whenever applicable, the specific elements related to the LSSH plants.
Chapters follow the requested list of the contract annex, except for the first two points that have been inverted. Moreover, the last chapter has been focused on the existing opportunities for a Company entering in the Greek solar thermal market.

## *Chapter 1: LSSH Plants updated general information*

The application of active solar systems in Greece started in mid 70's. The use of electric heaters in almost every Greek household, in combination with the oil crisis, and the rising price of electricity during this period, provided the impetus for the solar market to develop (EBHE – the Greek Solar Industry Association- was created in 1978). The advertising campaigns of large firms, helped a lot in the initial phase for the establishment of the solar market.

Until 1987 the market was steadily rising. In 1984-1986 a large advertising campaign supported by the Greek government, combined with financial incentives, boosted the sales of glazed solar collectors up to 218,000 $m^2$ yearly. It was considered that there were about 300 "manufacturers" of solar systems at that time. All the systems were locally produced except from some imported, mainly from Israel.

Since 1987 the market's growth rate has stabilised mainly because:

- The financial constraints slowed down the rate of construction of new buildings
- The oil price started going down as the oil crisis ended
- The electricity tariffs remained low resulting in the decrease of the competitiveness of solar systems.

The campaign of 84-86 mentioned above as well as a new one performed in cooperation with the Public Power Corporation in 1995, helped the solar systems to penetrate considerably in the residential sector.

However, the application of central solar systems in the tertiary and the industrial sector is still low. The Operational Programme for Energy (1996-2000) supported a significant number of solar systems in Hotels and Industry by financing up to 45% of the capital cost.

In 2002 the installed collector area was about 3000000 $m^2$. The 95% is domestic hot water (DHW), mainly of thermosyphon type. About 1.000.000 households are avoiding 1.800.000 ton $CO_2$ each year by using a solar system which can provide up to 80% of the energy needed for hot water.
Although the above data show that in Greece solar thermal technology is widely used, there is still a large potential. Less than 25% of the houses have already installed a solar system. The figure is very low compared with the potential, having in mind that in similar cases (Cyprus, Israel) the percentage is over 90%.

An average thermosyphon type system at present (2003) has a collector surface of 2,4 $m^2$ a storage volume of 150-200 litres and costs around 1000 €.
A wide market survey have shown that more than 90% of the owners of solar systems are satisfied and if they would replace the old solar system they would invest on a solar system again.

The motivations to buy a solar system are [Tsoutsos, 2001]:

- Savings (expected pay back period 4-6 years)
- Safety (compared with electric heaters) and trouble free operation
- Improved quality of life (availability of hot water)

To buy a solar system in Greece is as easy as to buy an electric heater. As the most roofs are flat, the installation is also easy (reasonable access to the roof, simple selection of the appropriate position/direction).

The most of the collective (central) systems (about 150.000 sq.m.), installed mainly in hotels or industries, were subsidised by 50%. The low oil price is resulting to payback periods longer than 5 years and make the central solar system solution less attractive for the investors.
Further the solar firms have not put heavy efforts to exploit this market yet. The most common practice is that they just respond to the clients interest.

There is no important 'technical innovation' or new marketing methods introduced.
Solar assisted space heating is not included in any price list of any company.
There are very few examples of using solar system for space heating. One of the reasons is that the solar system is considered as space heating system and not as energy saving system. As the solar fraction for heating is low, the solar space heating are underestimated. However, solar thermal systems they can be in some cases more cost effective than heavy insulation practices.
Table 1 and Figure 1 present the estimation for the solar collectors production and sales in Greece, updated to 2002 [Travassaros, 2002].

| Year | National Production $m^2$ | Imports $m^2$ | Exports $m^2$ | Total sales (Home market) $m^2$ |
|---|---|---|---|---|
| 1982 | | | | 90.000 |
| 1983 | | | | 106.000 |
| 1984 | | | | 106.000 |
| 1985 | | | | 174.000 |
| 1986 | | | | 185.000 |
| 1987 | | | | 134.000 |
| 1988 | | | | 118.000 |
| 1989 | | | | 120.000 |
| 1990 | | | | 145.000 |
| 1991 | | | | 162.000 |
| 1992 | 150.000 | 5.000 | 6.000 | 149.000 |
| 1993 | 150.000 | 4.000 | 35.000 | 119.000 |
| 1994 | 166.000 | 4.000 | 57.000 | 113.000 |
| 1995 | 186.000 | 4.000 | 75.000 | 115.000 |
| 1996 | 200.000 | 5.000 | 80.000 | 125.000 |
| 1997 | 212.000 | 3.000 | 85.000 | 130.000 |
| 1998 | 197.900 | 2.100 | 90.000 | 110.000 |
| 1999 | 220.250 | 4.750 | 100.000 | 125.000 |
| 2000 | 232.600 | 7.400 | 110.000 | 130.000 |
| 2001 | 242.550 | 7.450 | 120.000 | 130.000 |
| 2002 | 224.500 | 5.500 | 120.000 | 110.000 |
| | | | | **2.696.000** |

**Table 1: solar collectors production and sales in Greece**

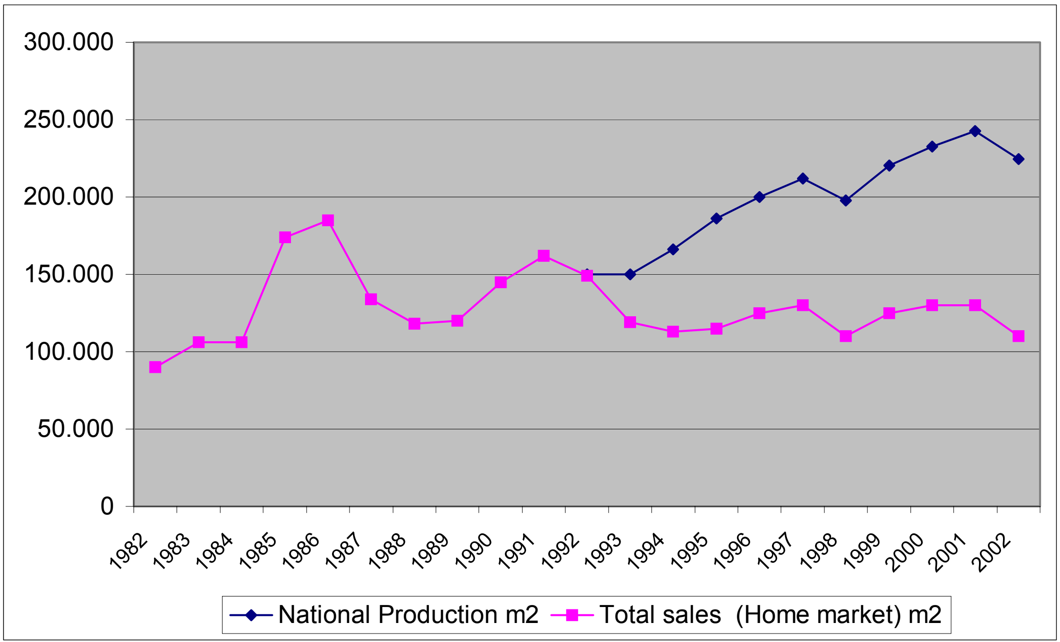


**Figure 1 Solar collector production and sales (estimated)**

The main characteristics of the collectors technology adopted in Greece are listed bellow:

Collectors Surface 1.5 to 8 $m^2$
Absorber material:
- Steel or stainless steel rollbond
- Aluminium or copper bonded on copper or galvanised steel tubes
- Copper bonded on copper tubes
- Copper welded or soldered on copper tubes

Surface treatment:
- Black paint
- Selective paint
- Selective surface

Insulation:
- Many variations starting with Glasswool 30mm to combined hard PU-CFC free + rockwool totally 70mm.

Transparent cover:
- Normal window type glass 3-4 mm
- Solar tempered glass 3-4 mm
- Plastic

Casing:
- Aluminium extruded (anodised or polyester painted)
- Formed Aluminium or steel sheet
- ABS

## *Chapter 2: LSSH Plants market*

### Hotels Sector

The hotels sector is most probably the most promising one for the future implementation of LSSH Plants. Apart from having a large potential, it presents an already developed market. Consequently a new solar company has simply to participate in this existing market while in other sectors with similar potential the market is weak or has still to be created.

Over 100 hotels have at present large or medium size central solar thermal plants, manufactured by 15 different constructors [Karagiorgas, 2001]. The average size of the central solar plants for hotels is 257 $m^2$, the largest one is sized 2 783 $m^2$ (Cretan Village, Aldemar SA), and the total size is 28820 $m^2$. Figure 2 shows a size distribution of the central solar systems in the Greek hotels.

Here follow some selected elements of the available material for the solar hotel sector that can be interesting for the purposes of this report:

- The most developed market exists in the island of Crete. In fact, 41.40 % of the market is met in Crete, only 2.10% in Northern Greece, while the remaining 56.5% (15,285$m^2$) is spread across the rest of the country.
- Sol Energy (importing Chromagen products) and Calpak companies have the most important share of market, either in the total stock (Calpak for period 1985-2001) or in recent solar projects (Sol energy for period 1997-2000)
- It is estimated that thermosyphonic solar thermal systems installed in hotel units cover surfaces of 35,000 $m^2$. We can therefore reach the conclusion that they hold an equally significant share in the market of solar thermal systems.
- Although only 10 (thus 10%) of the hotels have collectors surface of more than 500 $m^2$, these systems hold a market share of 30.17 %. The Hotel names, collectors' areas and contractors of the "top ten" are shown on table 2.

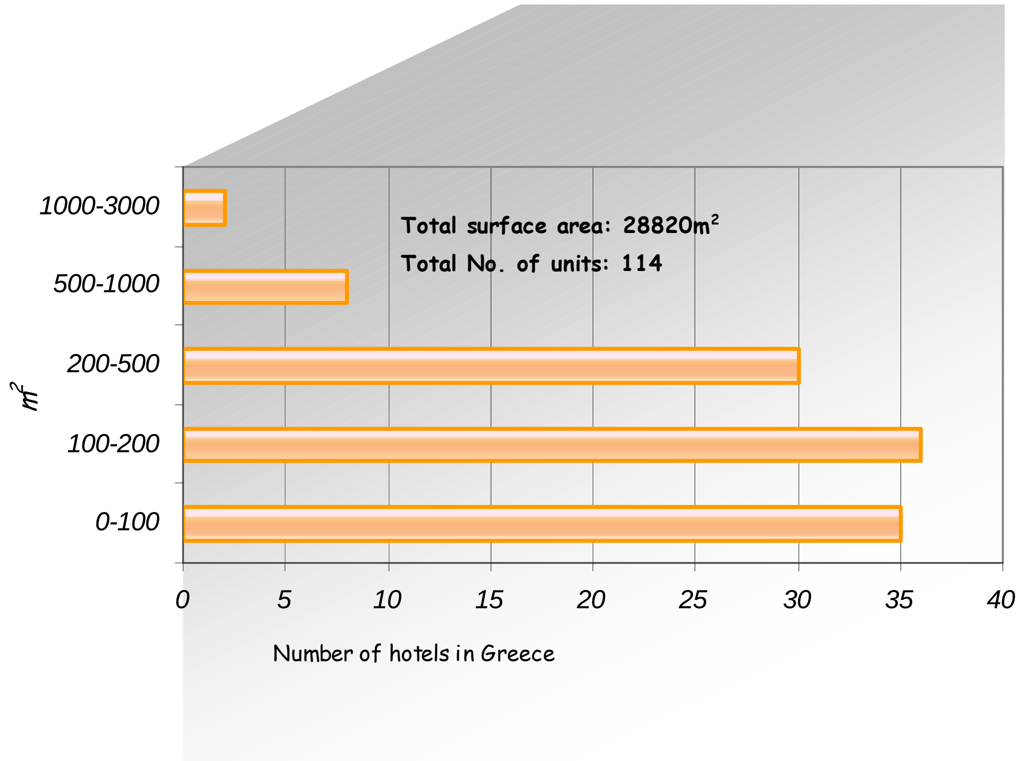


**Figure 2: Size distribution of central thermal solar systems in Greek hotels**

| HOTEL | SURFACE AREA ($m^2$) | CONTRACTORS |
|---|---|---|
| Aldemar (Cretan Village etc) | 2,783 | Sol Energy |
| Rodos Palace | 1,115 | Fyrogenis |
| Greta Maris | 660 | Calpak |
| Grand Hotel | 600 | Calpak |
| Kontokali Hotel | 600 | Calpak |
| Kerkyra | 600 | Calpak |
| Lyttos Beach Club | 593 | Sol Energy |
| Aeolos Beach | 588 | Calpak |
| Corkyra Beach | 577 | Calpak |
| Robinson Lyttos Club | 579 | Sol Energy |
| TOTAL | 8,695 | |
| | 30.17 % of total | |

**Table 2: Ten hotels equipped with central thermal solar systems with size over 500 $m^2$**

Figures 3 and 4, show the evolution of the market in Crete and the “rest of Greece” (“Rest of Greece” includes all other installations except Crete and the Northern Greece).

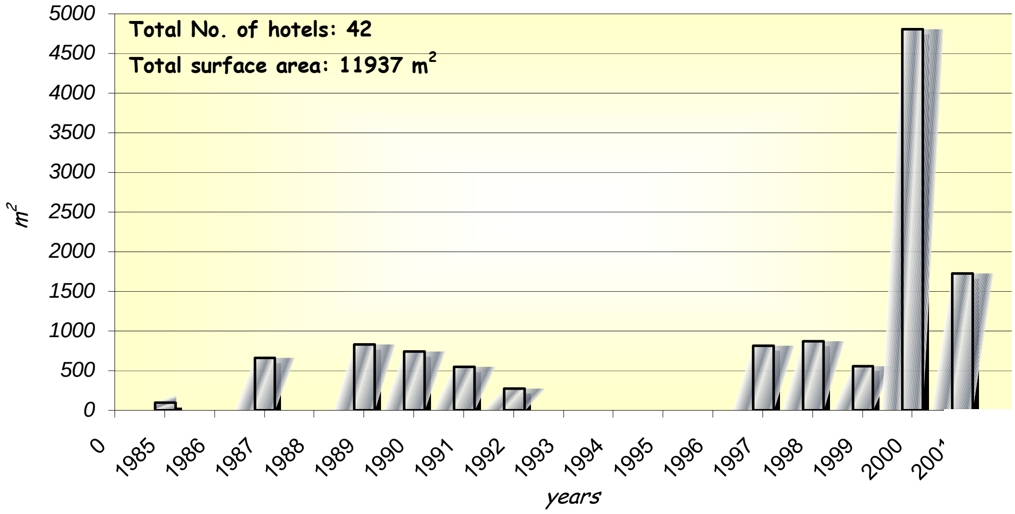


**Figure 3: Crete - Market development of central solar systems in hotel units**

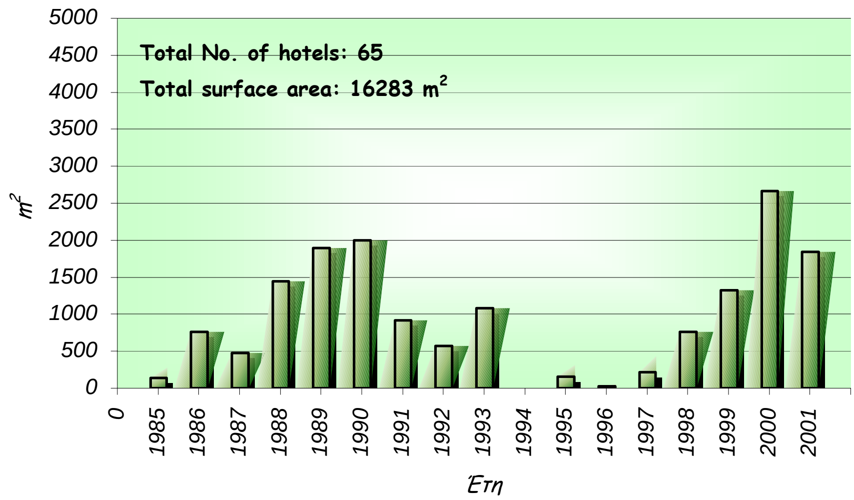


**Figure 4: Rest of Greece - Market development of central solar systems in hotel units**

Due to the importance of the hotel sector we have included a list of the main hotels in Greece in Annex 2.

## Industry Sector

In the possible solar **industrial applications** for hot water, five main industrial sectors can be distinguished, promising a good acceptance of large solar thermal systems. These are industries with relatively low energy consumptions, where the fraction of energy provided by the solar thermal system to the industry's energy load is quite significant. Solar thermal systems are particularly effective in industries that require water temperatures in the range 40 – 80 $^{0}$C.

Five industries with good potential applications of solar thermal systems are the following [Karagiorgas et al, 1998]:

- **Food industry** (Dairy products, cold cut and process meat factories, pastry and cake confectioneries, olive oil refineries, tinned goods, slaughter houses)
- **Agro-indusries** (Solar drying, horticulture-nursery greenhouses, slaughterhouses, meat processing, livestock landings)
- **Textiles** (Tanneries, leather treatment, cloth, refineries, textile treatment workshops)
- **Chemical industry** (Cosmetics, detergents, pharmaceuticals, wax, distilleries, breweries)
- **Beverage industry** (Wineries, liquor and wine distilleries, breweries, soft drinks)

In an extended analysis for the promotion of solar heating systems in the industrial sector [Kanavos, 2001], the technical potential for solar water heating systems has been estimated. The results, divided by industrial sub-sector, are presented in table 3 and practically confirm the above declarations on "good potential applications".

| CODE | Industrial Sector | Surface of solar collectors substituting DIESEL ($m^2$) | Surface of solar collectors substituting LPG ($m^2$) | Surface of solar collectors substituting LSHFO ($m^2$) | Surface of solar collectors substituting HSHFO ($m^2$) | Surface of solar collectors substituting NG ($m^2$) | Total surface of solar collectors substituting PETROLEUM FUELS & NATURAL GAS ($m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | Iron and Steel | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Chemical and Petrochemical | 21,226 | 155,921 | 238,992 | 0 | 805,156 | 1,221,295 |
| 3 | Non-Ferrous Metals | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Non-Metallic Minerals | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | Machinery + Construction + Transport Equip. | 17,689 | 1,834 | 11,006 | 0 | 25,878 | 56,407 |
| 6 | Mining and Quarrying | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Food and Tobacco | 235,847 | 99,056 | 707,541 | 0 | 815,507 | 1,857,951 |
| 8 | Paper, Pulp and Printing | 31,839 | 55,031 | 148,584 | 0 | 183,961 | 419,415 |
| 9 | Textile and Leather | 29,481 | 4,586 | 377,355 | 0 | 444,179 | 855,601 |
| 10 | Other Industry | 749,994 | 333,855 | 69,182 | 1,572 | 334,903 | 1,489,505 |
| | **Total Industry** | **1,086,076** | **650,283** | **1,552,660** | **1,572** | **2,609,583** | **5,900,174** |

**Table 3: Technical potential for solar water heating systems by industrial sub-sector**

Legend: LPG=Liquefied Propane Gas, LSHFO=Low Sulphur Heavy Fuel Oil, HSHFO=High Sulphur Heavy Fuel Oil, NG=Natural Gas.

## Residential Sector

Only sporadic applications on central solar heating systems exist in the residential sector. The common practice is the use of thermosyphonic systems, even in multi-floor buildings. However, recently some of the active solar companies have expressed their interest in the application of forced circulation systems, mainly of small scale.
In fact, some changes are expected on this sector and some opportunities may arise in the short and mid term future. One important change is related to the new Regulation for Rational Use of Energy and Energy Conservation. This Regulation refers to the entire building sector and will change the Energy Concept of both existing and new buildings. Some aspects that may affect the utilisation of solar thermal systems especially in the residential sector are listed bellow:

- The Energy Design of any new building will be compulsory. This will investigate the energy demands of a building or settlement for heating, cooling, lighting and domestic hot water and will prove that the final annual energy consumption of it will not exceed the set limits for each area and use.
- The results of the Energy Design will be recorded on a special document, the **Energy Identification Sheet** of the building. This sheet (that will include some labels similar to those used currently to characterise the consumption of domestic appliances) will be compulsory for the buildings existing before the new Regulation for Rational Use of Energy and Energy Saving after the passing of six years.

It is certain that the **Energy Identification Sheet** will affect strongly the building value. Consequently, the application of solar thermal systems will become an appealing option for the constructors of new buildings as well as for the owners of existing ones that are willing to improve their commercial value.

## Other Sectors:

Apart from the main sectors examined above there are some other sectors that, although with minor market, they may offer important opportunities, especially due to their visibility impact.
The sport centres sector is, for example, offering a potential for realisation of LSSH plants, especially if combined with the air conditioning of sport halls. The solar assisted air conditioning of a municipality sport hall in a town like Athens may have a particularly high visibility for a special reason. In the area Athens, the temperature level during summer exceeds some times an alarm threshold and some municipalities offer air-conditioned buildings for the elderly or high-risk people. Consequently, the social impact created by a solar cooled sport hall used for the summer need described above, may be very high.
The sector of schools has also a high visibility although it has the disadvantage of not presenting a load during summer.
Last but not least, Monasteries may offer some special advantages for the implementation of solar thermal systems. Some of the reasons are listed bellow:

- The responsible persons of Monasteries are often sensible to environmental issues and willing to invest on them. CRES has already collaboration with Monasteries in various sectors like environmental studies and district heating system design.

- A solar plant that serves a Monastery offers a high visibility impact to the visitors. It is worth to notice here that some of the visitors are decision makers.
- Monasteries are very sensible in the aesthetic integration of every technical construction. Although this seems to be a barrier it may turn to be an advantage for a Company that has experience in roof integrated collectors or solar roofs. Such a plant may become an example and a proof for the possibilities of aesthetic integration of solar plants on the buildings.

### Technical and economic potential:

In the study of [Kanavos, 2001], the feasibility of TPF schemes and of the creation of an ESCO are examined for the industry sector. Some of the results are listed bellow and may be valid also for the services and the residential sector.

- There is a remarkable theoretical techno-economic potential for solar water heating systems in the Greek industry.
- The "mutual benefit" TPF financing schemes are the optimum financing mechanisms that maximise the real potential.
- The establishment of an ESCO dealing with the promotion of solar water heating systems in industry is absolutely feasible and constitutes a real market opportunity for a profitable business.

An ideal ESCO should have the following characteristics:

- Excellent knowledge and wide expertise in solar water heating systems in order for the reliability of the relevant installations to be maximised.
- Good borrowing ability in order for low loan interest rates to be achieved.
- Deep knowledge of the mentality and other relevant characteristics of the Greek industrial sector.

In what concerns the residential sector some useful statistical data are presented in Chapter 6. As it has been mentioned, most roofs are flat; this fact facilitated the implementation of solar systems. However, the population density in some towns is high and may often be not enough for LSSH plants. Consequently, other solutions should be examined like those of façade collectors or collectors used for parking coverage.

### Barriers

Some of the main barriers [Tsoutsos, 2001] faced by the solar thermal sector today are listed bellow:

- Lack of a rational marketing planning and sufficient marketing activities.
- Low motivation and environmental awareness of the population
- Lack of information and instruction from the side of craftsmen, designers etc.
- Low level of acceptance by decision makers of the building sector (architects, house technology planners etc.)

Among special barriers for LSSH plants are:

- The trouble free operation (one of the strengths for the use of thermosyphonic systems) is not so certain.
- Longer payback times may occur (compared to those for thermosyphonic systems) since large scale systems have to compete with auxiliary fuel boilers and not with electricity.

- The expenses for DHW of large consumers often represent only a small amount of their total energy expenses; thus the possible savings by a solar plant are not important for them and they often remain indifferent.

## *Chapter 3: Competitors – position and methods*

There are no data available for the market position of Companies especially for LSSH plants. Consequently, data for the whole business of solar companies are presented. Nevertheless, some interesting data on the hotels sector that are presented later, reflect the whole LSSH plants market situation.
The larger companies for the last decade were MALTEZOS, FYROGENNIS and STIEBEL ELTRON. They remain in the top positions but they are loosing market share.
MALTEZOS, STIEBEL ELTRON, THERMOHELLAS have new shareholders and management.
The solar companies market position is seen in figure 5 [Travasaros, 2002].

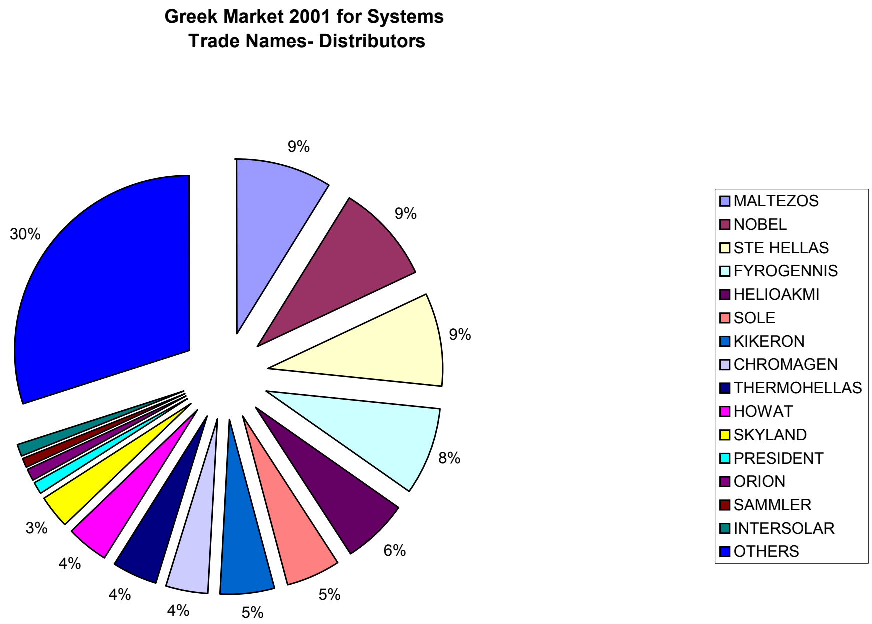


**Figure 5 : Solar Companies market position**

In what concerns the hotel sector, figure 6 shows the market share (on basis of surface area) of central thermal solar systems in hotel units in Greece (for the period 1985-2001), while figure 7 shows the share related to recent market situations (for the period 1997- 2001).

The data used for figure 6 are:

**Total surface area: 28820** m$^2$
**Total No of units:** 114
**Total No of constructors:** 15

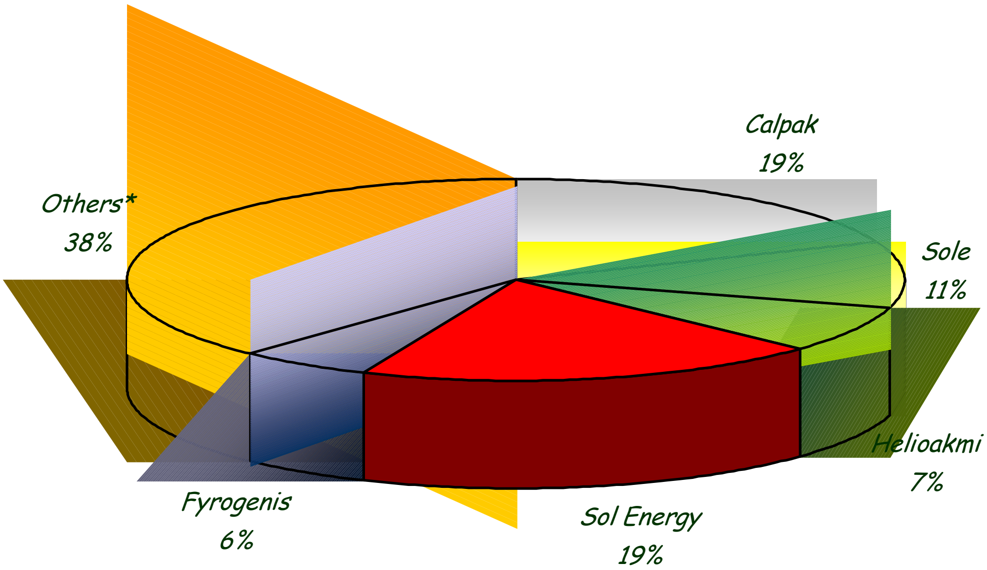


**Figure 6: Market share (on basis of surface area) of central thermal solar systems in hotel units in Greece (1985-2001)**

***Others:** Caloria, Dimas, Thermohellas, Intersolar, Karras, Cyprus, Maltezos, Xylinakis, S.H.E., FOCO.

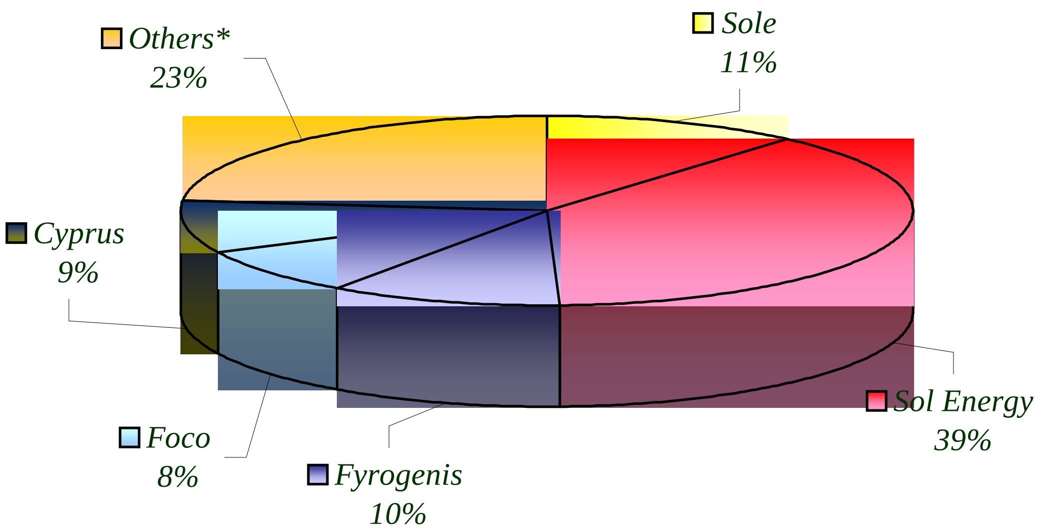


**Figure 7: Market share of central solar systems in hotels (1997-2001)**

The data used for figure 7 are:
**Total surface area:** 15656 $m^2$
**Total No of units:** 58
**Total No of constructors:** 12
**Others:** Caloria, Thermohellas, Intersolar, Dimas, Karras.

## Marketing and promotion methods

Starting from the whole solar thermal market (including small systems), the situation is presented bellow.

The small manufacturers are active only locally. They combine manufacturing, distribution and installation. Medium size companies are using independent installers who are also selling the systems. Larger size manufacturers are active almost all around Greece and some of them co-operate with distributors on an exclusive basis.

The two main elements for the promotion of a solar system today are its high quality and its convenient price. [Tsoutsos, 2001]. Usual argumentation for the promotion of a solar Company's product includes the innovative technology used and the high quality of the materials.

Often the brand name of the company plays an important role in the systems promotion. In fact, some use their successful development in sectors other than solar (like HVAC equipment) as a guarantee for their solar products.

In the history of the Greek solar thermal market development, some widespread promotion measures have had success. Two of them, during the period 1994-1995, are listed bellow:

- A TV campaign
- A direct mailing promotion through the bills of the Public Power Corporation (the National distributor of electricity in Greece)

The second measure could be adopted for LSSH plants: a direct mailing to selected large users (hotels, industries, hospitals etc.) may be beneficial.

The advertising actions on central solar thermal systems in general (and consequently on LSSH Plants) are very rare, while the advertisement of thermosyphonic systems on technical magazines is common practice.
However, advertisement has been reduced dramatically in the last years. The unique promotion tools seem to be exhibitions and related press.
The way how the large central systems are currently promoted is the following: whenever a call for a financing support measure is active, solar companies contact directly the possible end users and present them the “convenient opportunity” of a solar installation. This is the case for the larger part of the realisations up to now and a prove for it is the fact that the growth of the solar installations in hotel units during the last years (1999 – 2001), as seen in figures 3 and 4, coincides with the available subsidies from the Operational Program of Energy of the Hellenic Ministry for Development.
Only a very small percentage of the installations do not follow this “rule”; those last may be an indirect consequence of the previous cases; i.e. a successful realisation (in a hotel for example) becomes known and “attracts” the interest of another hotel administrator that is asking for a similar realisation, possibly in the framework of a financing project. Thus, taking advantage from the financing programmes is the main (and perhaps the unique) “method” for the promotion of LSSH Plants in the Greek market today.
There are some exceptions from this rule, e.g. the Company “Sol Energy” (dealing with products of Cromagen), had some advertising of central solar plants in technical and also in tourism magazines.
There exist no specific sectorial analysis for the solar thermal companies in Greece that could offer some systematic information on their marketing and promotion methods. However, from the information available [ICAP, 2000] for the heating systems sector (the nearest one to the solar thermal sector) some data have been found. At least two companies (Fyrogenis and Stiebel Eltron) that are selling solar thermal systems are active in the space heating market and are included in the report. The advertising means they are using are only the newspapers and the magazines (no TV or Radio). The budget dedicated to the newspapers covers 80% while that for magazines only 20% of the total advertising expenses. To show the relative position of those companies in the whole sector, in 1998, Stiebel Eltron shared the 47,7 % of the total advertising expenses of the category “*companies for burners and heating boilers*” and 14 % in the category “*companies with other heating equipment*” while Fyrogenis participates only in the last category with 1,5%.
Since environmental concern is still limited in Greece, the main motivation for the realization of a solar thermal system remains that of economic interest (savings). The expected payback period of the existing systems is 4-6 years. Therefore, similar payback periods should be achieved for the Large Scale Systems in order to be accepted.
As it is obvious, different market prices exist from the various companies and the more costly companies have some argumentation, other than economic, for the promotion of their products. It is worth mentioning here the case of Fyrogenis: its higher prices are counterbalanced with a longer guarantee time (10 years, even if all other members of ESIF have agreed to offer a 5 years guarantee).

# *Chapter 4: Technical description of existing LSSH Plants*

## General description and remarks

The most common aspects of the Greek LSSH plants are mentioned in the following list:

- Most of the plants are constructed with relatively small collectors (often 2 to 3 $m^2$). Consequently, the collectors' field has many hydraulic fittings. SOLID's plants are made with large collector modules (12 $m^2$) and with few connections since many collectors are connected in series.
- Usually the flow adopted is high (could be 50 $l/m^2$ h) , judging from the power of the pumps that are implemented. A couple of kW pumping power for plants with few hundreds of collectors $m^2$ is common practice. Fixed flow is usually implemented. On the other hand, in SOLID's practice low and variable flow is implemented (about 10 to 20 $l/m^2$ h). This results to less pumping power requirements (a 400 W pump can usually be enough for a SOLID plant up to 300 $m^2$ of collectors).
- It is still common in Greek plants (even recently constructed) to implement either black painted (non selective) absorbers or those with semi-selective paint. SOLID is using only selected surface absorbers.
- Neither integrated roof collectors nor solar roofs are used in Greece up to now, whereas SOLID has a large experience on this field.
- The design of the plants becomes often a procedure based on simple estimations and previous experiences and not an engineering work. Usually, the collector constructing companies are taking care of the (basic) design of the plant.
- The lack of training (on solar technology) of the local installers-technicians that may be involved in the construction of a LSSH plant is often a source of errors in the installation. Main aspects that are not well known are the following:
    - Effects of the operating temperature on the collector's efficiency. It seams that this very basic but not well understood aspect, together with the effort for low cost plants, results often in the installation of too low accumulator volumes (like 20 $l/m^2$ or even lower) or in the common use of tanks that are kept in high temperatures by an auxiliary source (e.g. a steam boiler in an industrial plant).
    - Behaviour of the solar plant under stagnation conditions.
    - Stratification of the accumulators. In fact, at least in small central solar plants, the error of connecting the primary collectors circuit to the upper part of the tank has been mentioned in various cases. Moreover, horizontal tanks are used too often.
    - Very little is known on low flow control strategy and/or variable flow and on the control of the collector's temperature output. Consequently, simple collectors configurations with many large modules connected in series are not implemented.
- The lifetime of the large plants varies and depends certainly on the year of installation. Old plants had often problematic collectors in what concerns frames, non tempered glasses, collectors internal humidity troubles, inappropriate tube and tank insulation etc. Some of these problems and lacks of correct design and installations occur also in recent plants [Tsiligiridis, 2002]. The lack of data and the dependence on too many parameters makes it difficult to give a number for the lifetime of the large plants. However, some critical considerations can be made:

- In numerous plants the problem of maintenance has been the dominating factor for the plant lifetime. Some large plants have had a very short lifetime due to the fact that it was unclear who has the responsibility for their maintenance. Thus, nobody has cared about their correct operation, some serious fault happened and the plant has been abandoned and deteriorated. SOLID's strategy of propose a maintenance contract with the user could an effective way to overcome this problem.
- The lack of detailed design and the use of some components of low quality had in some cases affected negatively the lifetime of the plant. It has been experienced that when the necessary repairs became too frequent or the efficiency of the plant was too low due to incorrect design (over- dimensioning, bad control or improper connection to the auxiliary heating plant etc.) the end user had less care (or not at all) about the solar plant and sometimes has abandoned it.

There is at least one exception to what mentioned above on the high flow usually implemented on the existing solar thermal systems. This is that case of the central solar plants realised by the company "Sol Energy". As it has been reported in a description of the solar plant of "Robonson Lyttos Club" [Nomikos, 1999] the Company Sol Energy Hellas (using products of Chromagen) applies successfully the low flow strategy on its LSSH plants. The main advantage presented is the possibility to achieve easily the delivery temperature. However, the collectors applied in the above plant are relatively small (2,6 $m^2$).

## Representative plants descriptions

A description for two representative plants is following.

**MEVGAL**

Mevgal S.A. is a dairy industry situated on the outskirts of the city of Thessaloniki. Its main industrial activity is the production of dairy products (butter, cheese, milk, etc.). Steam is required by the various dairy processes of the plant (pasteurization, sterilization, evaporation and drying) and hot water is required for the operation of the Cleaning in Place (CIP) machine of the factory, which is used to clean and disinfect the utensils and machinery of the factory. Originally, steam was provided by steam boilers running on heavy oil, which were fed cold water from the water supply grid. The water requirements of the steam boilers are 150 $m^3$/day.

The solar system was installed in 2000 and consists of two parts. The first system consists of 216 $m^2$ tube-fin, flat plate collectors with a black paint coating, located on the roof of the factory office building connected in series with 111 $m^2$ vacuum tube collectors. The closed-loop primary circuit of system 1 has a closed expansion vessel and two vertical, parallel, 2,500 litres, closed solar storage tanks located in a specially designed room adjacent to the boiler room of the factory. The water heated by the solar collector system 1 circulates in a water-glycol closed loop and heats the water in the solar storage tanks via flat-plate heat exchangers. The hot water produced by the solar system is used to pre-heat the water entering the steam boilers of the factory. The second system consists of 398 $m^2$ tube-fin, flat plate collectors with a selective paint coating, located on the roof of the cheese factory. The closed-loop primary circuit of system 2 has a closed expansion vessel and two horizontal, in series, 2,500 litre, closed solar storage tanks located on the roof of the cheese factory. The water heated by the solar collector system 2 circulates in a water-glycol closed loop and heats the water in the solar storage tanks via flat-plate heat exchangers. The hot water produced is used to either feed the CIP machine or the solar storage tanks of system 1.

Today, the system is operational and in excellent working order. A potential problem to the future operation of the system is the increased amount of soot in the exhaust fumes of the steam boiler, which result in the deposition of soot on the collector surface and a reduction in efficiency of the collector.

The installation was financed with a Third Party Financing contract, whereby a Third Party (that is CRES) financed the installation of the system and the user had no initial investment. The user (Mevgal S.A) is paying the amount of energy supplied by the system on a monthly rate. The amount of energy supplied is determined by monitoring procedures undertaken by CRES. Once the user pays the initial investment of the system back, with interest, the system will become its exclusive property.

**ACHAIA CLAUS**

Achaia Clauss S.A. is a winery situated on the outskirts of the city of Patras. Its main industrial activity is the production of red, white and rose wine. Hot water (60–75 $^0$C) is required for the washing and sterilization of the bottles in the bottling factory. The hot water consumption of the bottling process is 100 $m^3$/day. Originally, the hot water was provided by a steam boiler running on diesel fuel, which heated the water in two parallel, horizontal, 3000 litre storage tanks (via a submerged heat exchanger) located in the boiler room of the plant according to the needs of the bottling process.

The solar system was installed in 1993 and consists of the following items; 308 $m^2$ sandwich-type, flat plate collectors coated with black paint located on the roof of the winery; closed-loop primary circuit with an open expansion vessel and two (2) parallel, horizontal, 3,000 litre, closed solar storage tanks located on the roof of the winery. The water heated by the solar collectors heats the water in the solar storage tanks via submerged heat exchangers. Anti-freeze protection is provided for in the closed loop on very cold winter days by activating the pump and circulating the water when the temperature drops below 5 $^0$C. The hot water leaving the solar storage tanks is fed to the two, original storage tanks where the auxiliary heating of the water is provided for by the steam boiler. A re-circulation branch has been included which consists of a hydraulic branch connecting the solar storage tanks with the original storage tanks. When the water in the solar storage tanks exceeds the temperature of the water in the original storage tanks a pump is activated, which circulates the hot water from the solar to the original storage tanks. In this way, hot water produced by the solar collectors during the hours that the factory is not operating is utilized and energy is saved in the early hours of operation of the plant as the auxiliary heat required from the steam boiler is reduced.

The system operated for 6 years yielding a mean performance of 300 kWh/year/$m^2$. Due to administrative and financial difficulties of the company, the necessary maintenance work on the system was not carried out and this inevitably led to corrosion problems and inefficient operation of the system. Today, the system has been shut down due to the severe corrosion problems encountered by the system (25% of the collectors have either cracked glass covers or deformation of the plastic collector frame or rusting of the absorber plates). According to the monitoring results, a large amount of heat was lost from the solar storage tanks during the night hours due to the poor insulation of the tanks. Also, due to this fact, the impact of the re-circulation branch was minimal.

The installation was financed with a Guaranteed Solar Results (GSR) contract, whereby the user paid no money for the installation of the system, but paid the manufacturer the amount of energy supplied by the system on a monthly rate, based on a fixed rate per kWh decided upon before the installation of the system. A third, independent party, in this case the Centre for Renewable Energy Sources (CRES) undertook the monitoring of the system, which determined the energy supplied by the system. When the user paid the initial investment of the system back, the system became the exclusive property of the user.

It is worth to notice that in the described plants above as well as in many similar plants in Greece low storage capacities are implemented. For a solar thermal plant installed in the industrial sector (especially in dairy industries), the small storage volume is mainly due to the nature of the load profile (that matches quite well the solar plant production).

## *Chapter 5: Market prices*

Prices of LSSH plants present a large variation. The following list of recently constructed plants offers a view of the market prices.

**List of solar thermal projects subsidized through the Operational Program of Energy of the Hellenic Ministry for Development.**

| A/A | Company Name | Total Budget (€) | Collector Area ($m^2$) |
|---|---|---|---|
| 1 | Kapsis Tourist Complex | 70 432 | 120 |
| 2 | Dafnila A.E. | 90 975 | 342 |
| 3 | Novart Pigi AEBE | 96 845 | 201 |
| 4 | Faiax AETA | 104 915 | 376 |
| 5 | Sarantis ABEE | 612 293 | 1344 |
| 6 | Lyttos Tourist Enterprises | 156 272 | 235 |
| 7 | Rhodos Tourist Enterprises | 202 494 | 800 |
| 8 | Gr. Sarantis ABEE | 695 524 | 1330 |
| 9 | G. Vlamakis | 49 889 | 362 |
| 10 | Top Holidays | 23 771 | 100 |
| 11 | Coutroulis Bros | 262 949 | 647 |
| 12 | C. Lentzakis | 279 677 | 600 |
| 13 | Calypso A.E. | 127 659 | 544 |
| 14 | Akti Hersonnissou | 22 230 | |
| 15 | ETXEC | 115 627 | 480 |
| 16 | ITANOS | 26 999 | 140 |
| 17 | Cori | 98 312 | 200 |

| | | | |
|---|---|---|---|
| 18 | Mirambelo A.E. | 170 083 | 350 |
| 19 | Galanis Group AXTE | 48 422 | 132 |
| 20 | Agapi Beach A.E. | 114 013 | 345 |
| 21 | Candia A.E. | 125 898 | 380 |
| 22 | GETOXEC | 1 210 564 | 2785 |
| 23 | Avdis A.E. | 169 919 | 381 |
| 24 | Bell Hotels | 123 991 | |
| 25 | S. Sfakianos AEXTE | 103 888 | 254 |
| 26 | Sourmeli O.E. | 13 690 | 40 |
| 27 | Corali Gouvon AEXTE | 57 813 | 240 |
| 28 | DASKHOTELS A.E. | 70 531 | 400 |
| 29 | Doral | 23 757 | 50 |
| 30 | F.G. Lambrinos | 49 889 | 308 |
| 31 | Sani A.E. | 104 181 | 283 |
| 32 | Asimenia Akti A.E. | 48 936 | 178 |
| 33 | Tyras A.E. | 172 120 | 1008 |
| 34 | Nicodimos Hotel Enterprises | 40 058 | 84 |
| 35 | Chryssi Ammoudia | 18 899 | 120 |
| 36 | Caragiannis O.E. | 15 003 | 30 |
| 37 | Rethymno A.E. | 8 862 | 30 |
| 38 | Filoxenia A.E. | 46 632 | 175 |
| 39 | Galaxy A.E. | 14 966 | 46 |
| 40 | Lyrakos Clinic | 28 613 | 50 |
| 41 | Zinon Hotel | 12 765 | 30 |
| 42 | Pythagorion AEXTE | 12 579 | 30 |
| 43 | Caratzi M & A A.E. | 50 818 | 336 |
| 44 | Mediterranean | 75 828 | 440 |
| 45 | Pegassus A.E. | 27 292 | 115 |
| 46 | Ilissia Hotel | 24 446 | 88 |
| 47 | Rhodos Pallas | 214 233 | 895 |
| 48 | Moulagiannitou Bros | 15 286 | 53 |
| 49 | Akrogiali Gatsios | 14 878 | 32 |
| 50 | Cefallinia Tourist Devel. Comp. | 49 303 | 250 |

Notes:

1. All projects concern applications in hotels except projects # 3 (office building), 5 (cosmetics industry) and 40 (private clinic).
2. All projects received a subsidy of 50%, except project 6, for which the subsidy was 35%.
3. In all projects concern flat plate collector applications, except in projects 14 and 24, where cylindrical collectors were used.
4. All applications concern hot water production, except of project 5 that deals with solar thermal cooling.

The medium plant cost is 342 €/$m^2$ while the minimum cost is 138 €/$m^2$ while the maximum is 665 €/$m^2$.

The reasons for such a wide deviation are various: from the different quality of collectors used to the different cost included for the plant realisation (e.g. the necessary infrastructure like technical room for boilers etc.) up to the market policy of the solar companies for the promotion of their products.

One example for a "low price policy" is reflected in the economic evaluation of solar thermal systems in industrial applications under the Procesol project [Procesol, 2000]. In this evaluation and in all published documents (articles, brochures) it has been referred that the "average total cost of a solar system for industrial applications in Greece is approximately 180 €/m$^2$, no VAT included. The 180 €/m$^2$ is most probably an "offer", more than a real market price, in order to boost the industrial market for solar thermal plants.

Figure 8 shows the allocation of the system component costs as percentages of the total cost of the system.
The largest cost of the system (54%) is the collector, followed by the storage tank and heat exchanger (24%).

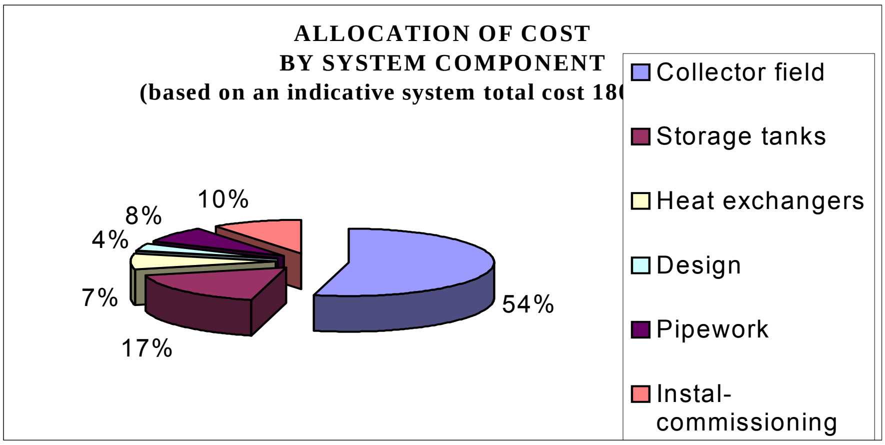


**Figure 8: Allocation of cost by system component**

Table 4 shows the payback period of solar systems when they replace conventional fuels in the industrial sector. Column 3 of the table displays the payback period of the investment cost of a solar system in an industrial application when replacing conventional fuels (diesel, LPG, heavy oil and natural gas) and column 5 of the table displays the payback period when the system receives a 50% public subsidy. From the data in Table 4 it is evident that the solar alternative is particularly appealing when replacing diesel fuel or LPG, especially if the system is subsidized. This is not the case for heavy oil and natural gas, especially in the case without subsidies. Diesel and LPG are common conventional fuels used in large market sectors (i.e. hotels, wineries, tanneries etc.) in Greece.
The assumptions used in calculating the data of Table 4 are:

- Interest rate = 8%,
- Boiler efficiency = 0.8-0.85

- Solar collector performance = 800 kWh/year/m$^2$
- Process coupling factor = 0.8.
- Total investment cost of system = 180 € /m$^2$

| Fuel Type | Fuel price 3/2000 | No subsidies 180 €/m$^2$ | | Subsidies 50% 90 €/m$^2$ | |
|---|---|---|---|---|---|
| | | Payback (years) | IRR (%) | Payback (years) | IRR (%) |
| Diesel | 0.628 €/kg | 3.6 | 26.7 | 1.8 | 55.1 |
| LPG | 0.540 €/kg | 4.2 | 22.6 | 2.1 | 47.2 |
| fuel 1500 | 0.295 €/kg | 7.7 | 9.7 | 3.9 | 24.9 |
| Natural gas | 0.02 €/kWh | 9.6 | 6.3 | 4.8 | 19.5 |

**Table 4. Economic evaluation of solar industrial plants**

# *Chapter 6: Data for Market Potential*

## Industry Sector

A concrete estimation of the solar potential for the industry sector has been presented in the Chapter 2.

## Tourism Sector

Tourism is one of the most important fields of economic activity with significant contribution to the Greek economy. Its contribution on the country's GDP is of the order of 17% (the estimates of World Travel & Tourism Council (WTTC) were 16.7% of Greece's GDP for the year 2001).

Therefore, it may turn useful to provide some characteristics of this sector as presented in the study of "Strategic Foresight Hellas Ltd" [SFH, 2002].

The tourism sector is still growing: In 2000 the number of hotels in Greece showed a rise of 23.6% in relation to 1990. More particularly, in 2000, 7936 units were recorded against 6423 units in 1990; in other words in a period of ten years 1513 new hotel complexes went into operation. A significant growth is also expected for the Olympic Games "Athens 2004".

In the whole of 1999 there was a total of 60,256,902 overnight stays, 76% of which concern foreign visitors. July and August are the months with the highest number of overnight stays on an annual basis, while the majority of overnight stays are recorded in the areas of the Southern Aegean, Crete, the Ionian Islands and Attica. Finally, in 1999 the average annual hotel occupancy was 63.5%.

In Greece, contrary to most other countries, hotels fall under six different categories in a classification using criteria relating to their construction and not to the quality of the provided services. It is Luxury hotels (Lux), A', B', C', D' and E' class hotels. However, EOT (the National Tourist Organisation) has already promoted a process of change in the classification of hotels from Class to Stars, the purpose being to introduce a 1 to 5 star scale grading hotels not only according to factors related with their construction but also to the level and quality of services provided.

In 2000 the largest share in the country's hotel capacity was held by class C' units, which account for 50% of the country's total hotel capacity. Class D' and E' units follow with 20.8%, class B' units with 18.6%, class A' units with 9.7% and finally luxury units with 0.9%. Table 5 shows the hotel capacity of the various categories.

| YEAR/ CATEGORY | LUXURY | A | B | C | D-E | TOTAL |
|---|---|---|---|---|---|---|
| 2000 | 79 | 766 | 1.474 | 3.967 | 1.650 | 7.936 |
| 1995 | 60 | 621 | 1.328 | 3.719 | 1.659 | 7.387 |
| 1990 | 45 | 470 | 1.571 | 2.722 | 1.615 | 6.423 |

**Table 5: Number of hotels in Greece (1990-1995-2000)**

*Source: Hotel Chamber of Greece*

In regard to the geographical distribution of the country's hotel capacity in the year 2000, the largest concentration of hotel beds is found in Crete, the Dodecanese and Sterea Hellas follow. In Crete more precisely 115 432 bed-places were recorded in 2000, which correspond to 19.7% of the total number of bed-places in the country. In the Dodecanese, 103 649 bed-places were recorded (17.7%) and in Sterea Hellas 90 870 bed-places were recorded (15.5%).

In 2000, the majority of luxury bed-places were found in Sterea Hellas, which includes Athens, the rate of concentration was 29.3%. The majority of Class A' beds is gathered in the Dodecanese with 29.1% concentration, while Crete features the majority of class B' and C' beds with a share of 19% and 17.9% respectively. Macedonia gathers the majority of D' and E' beds with a 28.9% share.

It is worth pointing out that the geographical distribution above has shown no significant signs of alteration from year to year in the period 1991 – 1999.

On the basis of the number of bed-places, class C' hotels account for the largest portion of the country's hotel beds in 2000 (around 36%), while class A' hotels follow with a 25% share and category B' with a 24% share (see figure 9)

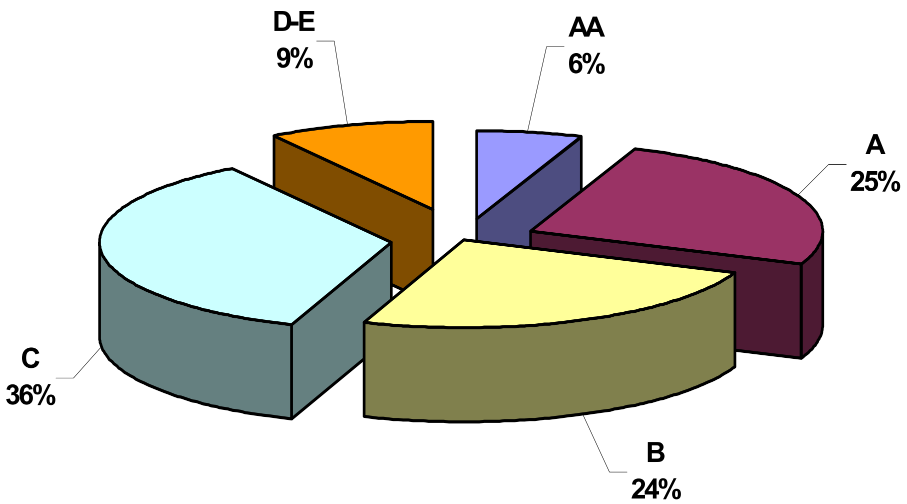


**Figure 9 : Distribution of the country's hotel capacity (on bed-places) by class (2000)**

## Buildings Sector in general

Although an estimation of the solar market potential is not available for the building sector in general, some data have been selected to identify its characteristics.
In table 6, some important information on the number of buildings and their heating and cooling demand is summarised.

| Buildings state of art 1996 | Number of buildings | | Avg. heat demand (incl. domestic hot water) [ MWh/y] | | Avg. cooling demand (if cooling installed) [ MWh/y] | |
|---|---|---|---|---|---|---|
| | New | Existing | New | Existing | New | Existing |
| Single-family homes | 35183 | 2.51 $*10^6$ | 6.1 | 7.0 | 7.4 | 8.4 |
| Multi-family homes | 17146 | 0.24 $*10^6$ | 28.3 | 31.9 | 36.1 | 41.3 |
| Services sector | 16524 | 0.42 $*10^6$ | 21.6 | 18.5 | 29.9 | 26.3 |

**Table 6: Building stock and average heating/cooling demand in 1996**

Legend: The term "new" refers to those buildings constructed during 1996

*Source: [Karagiorgas, 1998]*

In table 7 a distribution of the buildings in the various areas is presented, while table 8 shows the types of the urban areas buildings [Tripanagnostopoulos, 2003]. Table 7 also shows some future perspectives.

| **Total number of buildings in Greece** | **3 800 000** |
|---|---|
| In urban areas | 1 000 000 |
| In semi-urban areas | 800 000 |
| In agricultural areas | 2 000 000 |
| *Total number of new buildings until 2010 (estimation)* | 500 000 |
| *New buildings in urban areas (estimation)* | 150 000 |

**Table 7: Buildings distribution in Greece**

| **Total number of buildings in urban areas** | **1 000 000** |
|---|---|
| Single family houses (basement +1 floor max) | 600 000 |
| 2 floors apartment buildings | 150 000 |
| 3 or more floors apartment buildings | 150 000 |
| Shops | 45 000 |
| Industries – Laboratories | 20 000 |
| Schools | 5 000 |
| Churches – Monasteries | 4 000 |
| Parking buildings | 3 000 |
| Hotels | 2 000 |
| Hospitals | 1 000 |
| Other uses | 20 000 |

**Table 8: Urban building types in Greece**

# *Chapter 7: Financing methods*

This chapter is limited to present the financing opportunities for solar plants. As already mentioned most of the plants have been constructed by receiving subsidies from a financing mechanism. The user usually pays the rest of the investment, except from the cases of TPF; two such cases have been presented in Chapter 4, together with their technical description. Although the TPF method has not been used widely, the general feeling is that this method has a large potential if applied in high quality plants constructed with an agreement for their maintenance. The important potential of such activities has been also shown by the results of the "solar ESCO" analysis, presented in the paragraph "Technical and economic potential" of Chapter 2.

## Financing opportunities for solar thermal projects in Greece

In Greece there are no financing programmes specially addressed to solar systems.
A deduction of the 75% from the taxable income (applicable to privates and used up to know for thermosyphonic systems installation) is not valid anymore and seems that will not be applied again. This measure has been cancelled for two reasons: a) it was unfair since persons with higher income (and, thus, higher tax rates) would save more money than others with a lower income and b) it is a complication for the Greek taxation system that is going under a simplification procedure.
Actually (02/2003) there exist an undergoing effort stimulated by EBHE, for the definition and application of a simple and effective financing support measure. CRES will be probably involved in this effort.
The current financing opportunities are the same for any energy related equipment, including solar. Therefore, the solar technology has to compete with other Renewable Energy and Energy Saving technologies.
In Greece, within this last direction, one can at present (02/2003) supply for financial aid to the National Operational Programme for Competitiveness (Framework CSF III), the so-called "EPAN" programme. The "EPAN" programme is the extension of the previous programme "OPE- Operational Programme of Energy"

### Layout of the National Operational Programme for Competitiveness "EPAN programme"

The Measure 2.1 of Subprogramme 2 of the National Operational Programme for Competitiveness (NOPC) / CSF III (2000-2006) is devoted entirely to providing State support (grants) to private investments in: **a)** renewables, **b)** rational use of energy and **c)** small-scale (<50 $MW_e$) cogeneration. The total budget of Measure 2.1, for the 2000-2006 period of CSF III, is 1.07 billion Euro, of which 35.6% or 382 million Euro is the public subsidy available to RES/RUE/CHP investments. About two-thirds of the total available subsidy (~ 260 million Euro) are foreseen to be awarded specifically to RES investment projects.

The main provisions of Measure 2.1 of NOPC, concerning public support of RES investments, are as follows:

- Public subsidy (grant) on the total eligible RES investment cost:
  - Wind parks, conventional solar thermal units : 30%
  - Small hydro, biomass, geothermal, high-tech solar thermal units, passive solar : 40%
  - Photovoltaics 50%

- Level of subsidy (%) is independent of the geographical region of the country
- Required own capital : 30% (min) of the total investment cost
- Minimum investment cost required : 44,000 Euro
- Maximum investment cost subsidised : 44 million Euro

Grants are awarded to RES projects by Measure 2.1 of NOPC following rounds of public calls for RES investment proposals and subsequent competitive evaluation of the submitted proposals (per round).

A RES investment-subsidy programme, very similar to that of Measure 2.1 of NOPC/CSF III, existed also in the Second Community Support Framework (CSF II ; 1994-1999) for Greece. This CSF II programme granted cumulatively about 92 million Euro of public subsidies to 78 RES investment projects, having a total budget of about 213 million Euro (i.e. mean subsidy rate ~ 43%) and a total installed capacity of 161 $MW_e$ + 102 $MW_{th}$. This programme was very instrumental in stirring up substantial RES activity and in materialising a large number of commercial-scale RES projects in Greece, particularly in the period 1997-2000.

*A critical presentation of the EPAN programme relevant to solar thermal technologies*

As conventional solar technologies, units with efficiency higher than 45% are considered. The efficiency must be measured following certification procedures and according ISO 9806-1 and EN 12975-2. According this last, the efficiency is referred to temperature difference of 30K and to solar radiation 800 W/m$^2$.
As far as conventional solar technology is concerned, it is obvious that the EPAN programme can give financial help to projects with size higher than 140m$^2$ and up to 150000 m$^2$ (a typical cost of system in Greece is considered equal to 320 €/ m$^2$).

As high tech solar technologies, units with efficiency higher than 55% are considered. The efficiency must be measured following certification procedures and according ISO 9806-1 and EN 12975-2. According this last, the efficiency is referred to temperature difference of 30K and to solar radiation 800 W/m$^2$.
Typical examples of "high tech" solar technologies are:

- production of hot water of high temperature using flat plate collectors of particularly high efficiency
- production of hot water of high temperature using vacuum collectors
- production of hot water of high temperature using parabolic trough collectors
- space heating-cooling
- water heating for industrial purposes
- combination with heat pumps

As far as high tech solar technology is concerned, it is obvious that the EPAN programme can give financial help to projects with size higher than 70 m$^2$ and up to 75 000 m$^2$ (a typical cost of system in Greece – for instance solar air conditioning-is considered equal to 600 €/ m$^2$).

For investments higher than 440.000 € (attributed to projects sized 1500 or 900 $m^2$), an extensive energy audit in the industry or in the building with focus on the point to retrofit is needed, eventually with an energy bus. For lower investments, a simpler audit is needed, related to energy and hot water consumptions.
Typical eligible threshold cost of systems are:

1. 300€ for the conventional solar technology
2. 500€ for the high tech solar technology

Conventional solar technologies, with efficiency lower than 45% are not eligible

*Additional opportunities for financing solar technologies*

Furthermore, there are additional opportunities for financing the investments in solar thermal sector, by supplying to general aid programmes, where solar technology has to compete with other general purpose and usually productive heavy equipment.
In this kind of investment, we can distinguish the following possibilities:

- The investments, of renovation type, undertaken by the SMEs. The National Bank of Greece is the Body, which manages this programme. Overall project budgets up to 44000 € are eligible (to match the minimum threshold budgets of the EPAN, not eligible there). This budget is to be split to various equipments, therefore the solar thermal is expected to absorb up to 20 000 € (which attributes to 70 $m^2$ of solar installation)

- The National Development Law especially popular within the hotel businesses. In there, usually productive heavy equipment is eligible. The law is applied mainly for newly constructed buildings and plants.

In these last programs the opportunities for financing solar projects are rather few.

**Layout of the National Development Law**

Several versions of the National Development Law have been enacted in Greece over the last twenty years, starting with Law 1262/82, then Laws 1892/90 and 2234/94, and, presently, with Law 2601/98. The initial versions (Laws 1262/82 and 1360/83), which operated for a number of years in conjunction with the European Community's VALOREN Programme, as far as investments in development of indigenous energy sources were concerned, provided an extra 15% capital subsidy, over the regular capital subsidy given to "traditional" investments, for "… investments in oil or electricity substitution by gas, processed wastes, renewable energy sources and heat recovery…".

Subsequent versions of the National Development Law retained the favourable treatment of RES investments, with regard to capital subsidies, and widened its field of application, not only to oil or electricity substitution, but also to direct exploitation of renewable energy sources.

Generally speaking, the subsidies provided by the National Development Law are region-related (the less developed region receives the highest subsidy), and can take the form of:

i) Direct capital subsidy (i.e. partial funding of the investment's total capital cost);

ii) Interest-rate subsidy (i.e. partial funding of the interest paid on loans related to the investment;

iii) Tax deduction (from the taxable net profits) of part of the investment cost;

iv) Increased depreciation (accelerated repayment) of fixed assets related to the investment (in earlier versions of the Law)

The present National Development Law 2601/98 provides two options (subsidy packages) to investments and/or equipment -leasing programmes in electricity generation and in cogeneration from renewables:

a)
- Capital subsidy : 40% of the total investment cost
- Interest-rate subsidy: 40% of the interest paid on loans related to the RES investment
- Leasing subsidy : 40%

or, alternatively:

b)
- Tax deduction : 100% of the total investment cost
- Interest-rate subsidy: 40% of the interest paid on loans related to the RES investment

Although investment subsidies provided by Law 2601/98 are, in general, region-specific, the above 40% subsidy for RES-to-power projects is uniform throughout the country. For the remaining RES applications, i.e. those related to heating or other uses (e.g. cooling or water desalination), subsidy rates depend on the particular geographical region where the RES investment is made, but even then the applicable rates are higher than those generally applicable.

An important requirement of Law 2601/98, as regards the support of RES investments, is that of Article 6, par. 25a, according to which the application for financial support (subsidies) under the provisions of the Law should be accompanied, among other documents, by a valid installation permission, already issued by the Ministry of Development for the given RES-to-power project (this permission is practically not required for a solar thermal system). Such a requirement, which poses considerable time constraints on the potential investor, through a long, tedious and many times frustrating permitting process, has been relaxed in the Operational Programme for Energy (O.P.E.; see below), where the installation permit is needed only at the time of signing of the O.P.E. grant contract, concluded between the State and the investor.

Another important general requirement of Law 2601/98 (Article 6, par. 4a) is that the potential investor's own capital contribution to the project cannot be lower than 40% of the total investment cost.

Law 2601/98 is being implemented through the Ministry of National Economy and the minimum investment cost required is 176,000 Euro with the maximum subsidy granted 14.7 million Euro.

Table 9 shows a break down of the projects that have been funded by this law, since it came into force until the end of 2001. It is expected that L.2601/98 will be an important funding tool in the future as well. The National Development Law is presently under revision and the Ministry of National Economy will release a new draft by the end of 2002.

| Renewable Energy Technology | Number of projects | Installed Capacity (MW) | Total Investment (MEuro) | Subsidy |
|---|---|---|---|---|
| **Wind Energy projects** | 19 | 140,9 | 197,8 | 40% - 45% |
| **Small Hydro** | 5 | 3 | 6,2 | 40% - 45% |
| **Total** | **24** | **143,9** | **204** | **40% – 45%** |

**Table 9: Break down of the projects - National Development Law**

# *Chapter 8: Opportunities for promotion and support*

## Cooperation opportunities

The opportunities for some collaboration could be divided in three levels:

1. Possible business partnership
2. Help for market penetration
3. Help for promotion of LSSH plants technology

For the first opportunity, two main directions should be investigated:

- Some collaboration with one of the EBHE members. In fact, not all of the EBHE members are necessary competitors. Some of them are simply assembling solar panels and sell thermosyphonic systems since this is the main market request but they may be open to collaborate with SOLID. The EBHE members' addresses are listed in Annex 1.
- A collaboration with a so-called "technical company" that is willing to enter into the solar thermal sector. Up to know, an investigation has been done and there is no such a company already active in the sector; however, some of them are interested and the feeling is that they would accept a collaboration once the client (final user) has been found and has decided to realise the plant. The whole list of the "association of technical companies" as well as relative information on their categories and activity fields can be found in the site of their association (www.sate.gr)

A business collaboration with a Company that is neither involved in the solar thermal sector nor in technical constructions that are somehow close to solar (like HVAC) is not recommended.

CRES could have a role in the realisation of some LSSH plants, if requested to do so. More specifically, the following actions could be taken by CRES:

- Dimensioning and basic design for a future LSSH plant
- Supervision from the designing up to the construction phase

- Monitoring
- Evaluation and reporting

In any case, it has to be clear that CRES can offer the above services if requested but will act, in any means, with impartiality.

In the second level, some companies that could evaluate market actions or investigate on the best solution for a business partner could be:

- Pouliadis (www.pouliadis.gr )
- Europartners Ltd (www.europartners.gr )
- Strategic Foresight Hellas, Ltd (http://stratefore.netfirms.com)

In the third level a possible collaboration could be done for the organisation of an event, conference etc. dedicated in LSSH plants or for the participation to an event with a more general subject. A concrete example follows for such an opportunity.
The Institute of Solar Technology, as seen in its internet site, (http://ist.meng.auth.gr) has the following aims:
"·To encourage research, development and exploitation of renewable energy sources.
To scatter information in the area of renewable energy sources utilisation through conferences, workshops and publications.
To establish international collaborations and aid in technology transfer in the area of renewable energy sources.
To propose more efficient policies for the better diffusion and actual application of renewable energy sources."
IST has already organised seven National Conferences on Renewable Energy Sources (in 1982, 1985, 1998, 1992, 1996, 1999 and 2002).
In its last Conference (Patra, 6-8 November 2002) one of sponsors was "Maltezos" one of the most active Greek solar thermal industries.
A new Company (or, alternatively, a group of Companies, specialised on LSSH Plants) could sponsor a specific event on LSSH plants. If requested, CRES could have an important role in the organisation of the event in general and in the selection of the potential "large" users to be invited.
Companies, NGOs or Institutes that are involved in the solar or related sectors are listed bellow:

- National Observatory of Athens (www.noa.gr)
- Solar Laboratory of the National Centre of Scientific Research "Demokritos" (www.demokritos.gr )
- RENES group of National Technical University of Athens (Email: renes@central.ntua.gr)
- University of Patras, Physics Department. Contact person Y. Tripanagnostopoulos (Email: yiantrip@physics.upatras.gr )
- EXERGIA (Energy & Environment Consultants) – www.exergia.gr
- LDK (www.ldk.gr )
- Greenpeace (www.greenpeace.gr )
- WWF (www.wwf.gr )

## Projects

The possibility for the indirect promotion of SOLID plants trough its participation in European proposals should not be underestimated. This is well known and there is no need for further discussion; thus we just refer to the sectors that could be more promising for an EC project.

- Solar cooling and heating plants
- District heating solar assisted plants, eventually using the solar collectors as coverage (roof) of parking areas
- Soft programmes of “supporting measures type” (like Altener –Save) focused on the promotion of LSSH plants technology.

Further than new projects, the involvement in some on-going projects may also be beneficial. To give a concrete example, we shortly present the project “Hotres” in which CRES is coordinator.

**HOTRES**

“HOTRES” is an ALTENER program running until April 2003. Its aim is the stimulation of the renewable energy technology (RET) applications in the tourism sector. Among other actions, the following are included in the project work plan:

- Creation of informative business folders
- Technical business meetings between manufacturers, suppliers and hoteliers
- Site visits
- Some pre-design studies for the implementation of RETs in hotels and one detailed design study.

Although the project is near its end, it seems to offer some important opportunities for the future of LSSH Plants development. The reasons are following:

- Most probably there will be follow-up activities with similar objectives as HOTRES.
- In the framework of HOTRES the solar thermal technology has taken a central place. At least half of the pre-design studies as well as the detailed design study will be done for solar thermal systems.
- In the informative business folders, a part from solar systems for DHW and swimming pool heating, solar cooling technologies are included.

Given the above information, one way a LSSH plants Company may benefit from HOTRES project is the following: contact those hotels or complexes of hotels when they will received a pre-design study and make directly offers for the installation of solar plants.

A business meeting has been foreseen for March 2003 (possibly the 17$^{th}$). A company interesting to participate should examine this possibility with ESIF.

## Other opportunities

- Solar Village (a discussion for some repair and maintenance actions is ongoing). It is a high visibility installation, a reference for the central systems in Greece.
- Olympic Village. Its high importance is well known and it would be an important success for a Company to install solar systems in it. However, any installation should be ready before “Athens 2004”. This means that, if it is not already late for such a proposal, the available time for its realisation is short.

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*ANNEX 1*

# GREEK MANUFACTURERS OF SOLAR SYSTEMS

1 **CALPAC - CICERO HELLAS Ltd**
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Tel. 9247250-0741.20901 Fax. 9231616

2 **CALORIA S.A.**
24-26 A. Panton, 176 71 Kalithea
Tel. 9231156 Fax. 9235830
Contact: E. Anagnostopoulos

3 **FOCO Ltd**
447 Acharnon, 111 43 Athens
Tel. 2531114-2184630 Fax. 2532873
Contact: C. Travassaros

4 **MALTEZOS S.A.**
51 Amfitheas Av., 175 64 Paleo Faliro
Tel. 9302015-8 Fax. 9305019, 4116345
Contact: Harris Maltezos

5 **SIEMENS S.A.**
Paradisou & Artemidos, 151 25 Maroussi
Tel. 6864575-2681246 Fax. 6864562-2681246
Contact: Panousakis

6 **SAMMLER S.A.**
251 Filadelfias Av. & A. Papagou
136 71 Kato Acharnai
Tel. 2316677 Fax. 2320337
Contact: V. Michalopoulos

7 **STIEBEL ELTRON HELLAS A.E.**
134 Macedonias Str., 54248 Thessaloniki
Tel. 031.312136-7 Fax. 031.313376
Contact: Th. Stavropoulos

8 **SOLE S.A.**
19 G. Papandreou Av.
14452 Metamorfosis
Tel. 2819200-2817024-8077196 Fax. 2825690
Contact: P. Lamaris

9 **SHE**
1 Nikitara & Filis
133 41 A. Liosia
Tel. 2480490-2474150  Fax. 2480347
Contact: G. Gambierakis

10 **HELIOAKMI Ltd**
Nea Zoi-Aspropyrgos 19300
Tel. 5580620-27  Fax. 5580623
Contact: Chr. Papadopoulos

11 **THERMOHELLAS S.A.**
Industria Area Acres-Megara 19100
Tel. 0296.80626-83488  Fax. 0296.82502
Contact: G. Gavojannes

12 **DIMAS S.A.**
2nd Km Argous-Nafpliou
42 ARGOS
Tel. 0751.29110-20920  Fax. 0751.62671
Contact: C. Dimas

13 **MELPO-DIMITRIOU & Co**
3 El. Venizelou
123 51 Ag. Barbara-Egaleo
Tel. 5611842-46  Fax. 5611811
Contact: J. Dimitriou

14 **INTERSOLAR ABETE**
Demosthenous 267
176 74 Kallithea
Tel. 9416057-9428044  Fax. 9309119
Contact: I. Paradissiadis - N. Kalogeropoulos

15 **GIALIDAKIS ABEE-HOWAT**
Paralia Aspropyrgou
Stefani 19300
Tel. 5571788  Fax. 5576415
Contact: G. Gialidakis

16 **FYROGENIS SA**
20th km Athinon/Lamias Nat. Road
14565 Ekali
Tel. 8136301  Fax. 8235301
Contact: M. Kourtzis