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Utilization of Solar Energy in Cyprus

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1. INTRODUCTION

1.1 General

Cyprus, situated in the Eastern Mediterranean, is a small developing island. Its total area is less than 10,000 sq.km. and its population less than a million.

In spite of the political turmoils that it went through, and is going through, Cyprus managed during the years after independence in 1960 to develop and sustain an economy which, in the years 1980-1984, grew at the very rapid rate of about 5 percent (at constant prices).

Traditionally Cyprus relied entirely on imported oil and oil products to satisfy the increasing demand for energy resulting from the growing economy. The two energy crises of 1973 and 1979 did not leave Cyprus unharmed. The balance of payments problems were aggravated and the world economic recessions that followed affected a small and vulnerable island economy. They provided, however, an opportunity to realize the significant role that energy conservation and renewable energy sources can play in meeting the increasing costs of energy. In fact, they are the only options available for Cyprus in this field.

A favorable natural and economic climate was conducive to developing a locally based solar water heater industry in Cyprus, which began as early as 1960. Since 1974 this industry has expanded further at a dramatic rate with remarkable success, and with little direct government intervention.

In this paper an attempt is made to describe the use of solar energy in Cyprus, first setting the overall energy scene and then examining in detail the current status of utilization. The government's and other sectors' activities (technical, financial and fiscal) are also critically examined, in an attempt to assess the reasons behind each measure taken, the problem encountered in their implementation and their successes as well as failures. Finally, conclusions are drawn.

1.2 The Energy Scene

The total annual energy consumption* in Cyprus**, with a population of 524,000, is 1.075 million tonnes of oil equivalent (Toe)***, which corresponds to a per capita annual consumption of 2.05 Toe, a figure comparable to that in the other Mediterranean countries (e.g., Spain 1.9 Toe and Greece 1.6 Toe) and corresponding to a reasonably high standard of living.

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*in 1984

**government controlled area

***including unbilled energy to the area occupied by Turkish invasion forces.

The energy needed to produce gross domestic product (GDP) is 1.17 Toe for each £1000 (£1 = US $1.50); this figure is comparable to that for Greece (1.15), but significantly higher than that for other EEC countries (e.g., 0.73 for France). This can be explained by the relatively low efficiency of generation of electricity and proportionately large energy consumption by energy-intensive industries in Cyprus (e.g., cement and bricks).

The contribution of domestic resources to meeting the energy needs in the country is estimated to be 4.5 percent; solar energy (solar water heaters), wood (for cooking, including making of charcoal and heating in the mountain regions), and very little wind energy account for the domestic contribution. Thus about 95.5 percent of the total energy is supplied by imports, consisting of oil and oil products.

The low population, almost exclusive reliance on oil for meeting energy needs, the high cost of electricity ($0.105 per KWh), a reasonably high level of technology, and the popular acceptance of solar energy and wind energy (even without any incentives) make the renewable energy options, particularly solar energy, extremely viable from the technical, social, and economic points of view.

It is obvious that the importation of oil is an increasing burden on the economy of the country. In 1984, imports of oil represented 20 percent of total exports of the country and 30 percent of the foreign exchange earnings; the only encouraging aspect of the situation is that the amount of energy needed to produce GDP £1000 (at constant prices) has decreased from 1.25 Toe in 1975 to 1.17 Toe in 1982.

Historically, Cyprus has relied exclusively on the importation of oil and oil products for its energy needs. Presently Cyprus imports annually about a half million tons of oil products and a half million tons of crude oil, (which is processed in the national refinery). In 1982, a study on possible diversification to coal was conducted and it indicated that the switchover to coal for generation of electricity and for use in cement factories* might be economically attractive. However, the environmental aspects connected with the large-scale use of coal and the creation of handling facilities for coal (including additional harbour facilities) are serious problems. Since a clean environment is absolutely essential for the survival and growth of the tourist industry and maintenance of traditional values, the environmental aspects of a switchover to coal and corresponding protection measures have to be studied thoroughly before a decision in the matter can be made. A comprehensive study on a switchover to coal is in progress. The demand for energy in Cyprus is not large enough to consider the importation of natural gas and the construction of a nuclear power plant. Thus oil is the only alternative in the near future for the necessary imports of energy; even if a decision to shift to coal were taken immediately, it would take five years to be effective to any significant extent.

*a partial switchover to coal has been made.

Table 1

Annual Consumption of Oil in Cyprus, by Sector

Sector	Annual Consumption (percentage)	
	Electricity	Total (Electricity Included)
Residential and Commercial	45.5 percent	23.0 percent
Industry	24.5 percent	34.5 percent
Transport	-	25.5 percent
Agriculture/street lighting	7.0 percent	9.0 percent
Unbilled Consumption*	23.0 percent	8.0 percent

*represents the consumption made in the area under the Turkish invasion Force, the proceeds of which are presently unrecoverable.

It may be remarked that the generation of electricity accounts for 36 percent of the total energy requirements of the country and that the efficiency of production of electricity from oil, corresponding to 0.344 Toe/1000 KWh, is low compared to the international values typified by 0.22 to 0.23 Toe/1000 KWh.

The main features of the present situation are thus as follows:

1. Energy conservation in all sectors, particularly in the generation of electricity and in energy intensive industries (like cement), will pay rich dividends.

2. Coal is the only possible diversification of imported energy.

3. Renewable energy forms represent the only domestic resource; the conditions for exploitation of renewable energy resources are ideal in Cyprus.

2. HISTORY AND STATUS OF SOLAR WATER HEATING IN CYPRUS

2.1 Relevant Socioeconomic Data

In 1979, a survey on "Household Energy Use" was conducted by the Statistics and Research Department of the Ministry of Finance. The main findings of the survey are as follows:

1. The forms of energy used by households in Cyprus are electricity, gas, oil, solar, wood and charcoal.

2. For heating, LPG (liquified petroleum gas) is the most widely used form of energy, followed by oil and electricity. Of the 1,000 households in the sample, 59.6 percent used gas for heating (45.50 percent used gas only and 14.1 percent used a combination of gas with electricity, oil, and wood), 28.8 percent oil (18.4 percent oil only and 10.4 percent a combination of oil with other forms of energy), and 9.5 percent wood (4.8 percent wood only). Wood is mainly used in the mountain areas. 8.9 percent of homes, located mainly in coastal and plains areas, did not have any form of heating. About 17.4 percent of households used more than one form of energy for heating, mainly gas with oil (5.8 percent), gas with electricity (3.7 percent), gas with wood (2.8 percent), gas with electricity and oil (1.3 percent) and oil with wood (1.1 percent).

3. For cooking 99.3 percent of households used gas (93.5 percent gas only and 5.8 percent a combination of gas with electricity, wood, oil and charcoal). Only 0.7 percent of homes used other forms of energy exclusively (0.5 percent electricity and 0.2 percent oil).

4. For hot water supply 47.4 percent of households used electricity, 33.5 percent solar, 16.2 percent wood, 13.4 percent gas and 1.8 percent oil; 84.5 percent of homes using solar heating for water also use some electricity for this purpose. In addition, 2.7 percent of all households used electricity and wood for hot water supply and 1 percent used gas and wood. No hot water supply was recorded for 21.0 percent of households. 43 percent of homes in the mountain areas had no hot water supply as compared to 28 percent in plains areas and 10.3 percent in towns.

Another survey, conducted by consultants to the Ministry of Commerce and Industry for the "Energy Planning Study" in July-August 1983, reveals that 90 percent, of the individual dwellings and 15 percent of the collective dwellings (flats) and 50 percent of hotels/hotel apartments are equipped with solar water heaters.

2.2 Progress of Solar Water Heater Industry

Solar water heaters, modelled on an imported design, were first produced in about 1960. Industry progress in the first six years was rather slow. This is attributed to the rather faulty initial design (leakages, low efficiency, etc.) and to their rather high cost. Due to developments in the construction of collectors which eliminated most technical problems, and the rationalization of production (so that costs, if not decreasing, at least remained constant), more and more units were installed, with the result that by mid 1974 about 24,000 units with a total collector area of 72,000 square meters were put into operation. This figure means that roughly 20 percent of

the population were satisfying their hot water needs through the use of solar water heaters at that time; with solar energy providing about 1 percent of the total energy requirements of Cyprus. It is difficult to give any figures for the contribution of solar energy to total energy consumption during the period 1974-76 because the national situation was thrown out of balance as a result of the Turkish invasion. The production of solar water heaters, however, was soon reactivated at a faster pace than before.

At present, there are about ten major and twenty minor manufacturers of solar water heaters in Cyprus, employing a total of about 400 workers and producing about 12,000 units per year, compared to 4,000 units per year prior to 1974. In 1983 solar water heating accounted for 3.5 percent to 4 percent of national energy consusmption.

2.3 Statistics of Solar Energy Utilization

2.3.1 Water Heating

The major conscious use of solar energy in Cyprus is for heating/preheating water, and in some rare cases the heated water is in turn used for space heating. A survey made by government consultants on the Energy Planning and Conservation Project has concluded that as of January 1, 1983 the percentage of buildings of the following categories equipped with solar water heating were as follows:

Individual Houses	90 percent
Flats	15 percent
Hotels and Hotel Apartments	50 percent

For the new buildings completed during 1983, the percentages were estimated by the consultants as:

Individual Houses	90 percent
Flats	25 percent
Hotels and Hotel Apartments	90 percent

It may be interesting to discuss briefly the above figures, especially those related to solar water heating in individual houses. Although the vast majority of them equipped with SWHs, some 10 percent are not. This small percentage represents:

(a) Old houses (which may not have a hot water system at all) whose design makes the installation of SWH prohibitively expensive.

(b) Houses in the high altitude region of the island where freezing frequently occurs.

(c) New luxury houses, equipped perhaps with central oil-fired central heating systems which also supply hot water.

The collector area of typical solar water heaters used for individual dwellings (house or flat) is 3 square meters; the consultants have estimated a collector area of 0.7 square meters per bed for hotel/hotel apartments.

From the above data as well as from available data related to number of existing and new dwellings, hotel rooms, etc., it is estimated that at present some 350,000 square meters of collector area is installed as shown on the following Table 2.1

Table 2.1

Estimated Collector Area in 1985 in M^2

Category	Area
Houses	300,000
Apartments	35,000
Hotels	15,000
	350,000

The yearly average solar radiation, incident on the collectors (inclination 40°) is 5.4 KWh/square meters day; typical values for the efficiency of the solar water heater and the utilization factor for hot water in dwellings are 0.3 and 0.6, respectively. Hence, the useful energy, collected by the solar water heaters is 5.4 x 0.3 x 0.6 x 365 KWh/square meters year; hence using Table 2.1 the energy saved due to the use of solar water heaters can be expressed as in Table 2.2

Table 2.2

Energy Saved by Use of Solar Water Heaters
(installed as of January 1, 1984

Buildings	Auxillary Energy	Energy Saved Per Year Million KWh	Energy Saved Per Year in Thousand Toe
Houses	Electricity*	105	36.1
Flats	Electricity*	12	4.1
Hotel/ Hotel Apts.	Diesel**	5	0.6
Total		132	40.8

*0.344 Toe/1000 KWh
**0.125 Toe/1000 KWh

The savings in oil caused by the use of solar water heaters is 40,800 tonnes/year, expressed as a percentage of the oil consumed annually viz. 1.075 million tonnes/year is 3.8 percent.

Other calculations, based on the results of the survey (section 2.1) carried out in 1979 and the statistics for production import and export of water heaters (Table 2.4) indicate that the percentage of national energy consumption met by solar water heating is 3.5 percent. The basis of this new figure is the production figures for all recent years, which do not take into account the production by unlisted producers of solar water heaters. The difference between the two figures can also be partly explained by the finite size of the samples. We may conclude this discussion by the statement that the percentage of the national energy consumption met by solar water heating is between 3.5 percent and 4 percent.

However, due to the mode in which the solar water heaters are used in Cyprus (such as switching on the electric heater when hot water is needed and not using a thermostat to switch on the electrical heater to keep the temperature of the water in the tank usable), a peak in demand of electrical power occurs in the winter evenings (particularly on cloudy days), when most Cypriots take a bath.

2.3.2 Use of Solar Energy in Multi-Storey Buildings

In Cyprus, usually, individual solar water heaters delivering hot water to different flats usually are located separately on the roof of the multi-storey building and hence economy of scale is not realized, and some heaters may be located in disadvantageous positions. The cost of plumbing, insulation, and lost energy is also relatively larger. Shade from neighbouring buildings can sometimes inhibit the use of solar water heaters, but the problem at the moment is not serious enough to warrant legislation.

It is evident from Section 2.3.1 that the use of solar water heaters in multi-storey buildings (flats) is not as widespread as that for houses. The reasons for this are many. First, the thermosyphon system generally used is suitable to serve the top two stories only. Second, multi-storey apartment buildings are usually constructed by developers who, amidst fierce competition, try their best to keep capital costs, and hence selling prices of flats to a minimum. Third, there are occasional problems with the rights of use of the roof, which is commonly owned by all flat owners in the building.

2.4 Technical Details

2.4.1 Flat Plate Collectors (for details see Appendix A)

Except for a very few imported collectors of the vacuum tube type, flat plate collectors are invariably used in all solar hot water systems in the country. The materials used in the construction of the collectors are as follows:

1.	Casing:	Galvanized Iron Sheets, Fiber Glass, Aluminum
2.	Insulation:	Fiber Glass, Polyurethane
3.	Risers and Heaters	Copper (rarely galvanized iron)
4.	Plate:	Copper, Aluminum, G.I. Sheet
5.	Glazing:	Clear Glass, Window Glass

6.	Paint on Plate:	Selective Paints, Nonselective Paints
7.	Gasket:	Rubber (developed in Cyprus)

The risers are bonded to the plate, using a variety of techniques resulting in poor to very good thermal contacts; roll bonding is not practiced. Many collectors use fins (most straight but in one case zigzag) to reduce convective losses and improve the effective absorption of light.

The designs range from poor to good; some designs start with a given thickness of insulation and compress it before use, a bad practice. The insulation between the plate and heaters and the casing is in many cases poor. In some designs the straight fins do not serve any useful purpose.

Since in domestic hot water systems, the water from the mains ent s the collector and gets recirculated before use, the scaling in areas whe- the water is hard is a serious problem; the scaling tends to reduce the performance with time (although there are no investigations being undertaken in this connection in Cyprus).

2.4.2 Domestic Hot Water System (for details see Appendix A)

The system consists of a cold water tank, a hot water tank, the collectors, and necessary plumbing; the movement of water between the tank and the collectors takes place by natural convection. The collector rea and tank capacity of a typical system are 3 square meters and 180 litres, respectively. There is no arrangement to inhibit the reverse flow during the night other than varying the difference of height between the tank and the collectors.

The tanks are mostly of the vertical type at a suitable height over the collectors, though recently horizontal tanks located just above the collectors are preferred; the latter variety however, suffers from increased reverse flow and lack of stratification (resulting in lower system efficiency).

Auxiliary energy to heat water, when solar energy is not enough, is supplied by a 3KW electric heater in the hot water tank.

2.4.3 Maintenance of Solar Water Heaters

Since almost all the solar water heaters are manufactured domestically (some assembled with imported serpentine collectors), the availability of service and spare parts is very satisfactory. Thanks to the training facilities in the country, the quality of technicians and mechanics is generally high; those working in the solar industry get further training, essentially on the job. Advanced training for technicians in the solar industry is provided by the Cyprus Productivity Centre, which collaborates with the Energy Service of the Ministry of Commerce and Industry.

Experience with installation and service by retailers has not been satisfactory; hence, presently almost all installations and service is managed by the manufacturers.

2.4.4 Efficiency of Collectors

The Energy Service of the Ministry of Commerce and Industry conducts the testing of collectors and provides curves for the dependence of thermal efficiency on $\Delta T/G$ where T is the difference between the mean temperatures of the fluid in the collector and the ambient in °C and G is the solar insolation in watt/square meters. The distribution of the efficiency n, for $T/G = 0.045$ square meters °C/Watts (corresponding to operation in typical Cypriot conditions) in a batch of 29 collectors, tested recently at the facility is shown in Table 2.3.

Table 2.3

Distribution of Efficiency of Solar Collectors in Cyprus ($\Delta T/G = 0.045$ m^2 °C/Watts)

Range	0.30-0.35	0.35-0.40	0.40-0.45	0.45-0.50	0.50-0.55	0.55-0.60
Number	2	9	5	8	4	1

The average value of the efficiency (for $\Delta T/G = 0.045$ square meters °C/Watts) is 0.43 for Cypriot collectors.

Thus one notices that there is considerable room for improvement of performance by careful choice of design, materials and manufacturing techniques.

2.5 Manufacture

Except for a very few vacuum tube collector based solar water heaters almost all solar water heaters are indigeneously manufactured; in less than 5 percent of the cases are the collectors of the SWHs imported. The statistics for the years 1980-83 are presented in Table 2.4.

Table 2.4

Statistics for Solar Water Heater Production in Cyprus

Year	Production of SWH ($3m^2$)	Import of Collectors+ (1.5 m^2)	Export of SWH
1979	7,484	187	205
1980	8,111	3,252	732
1981	9,258	926	114
1982	12,497	847	221
1983	9,778	1,239	132
1984 (Jan.-Nov.)	N/A	593	211

*incorporated in the solar water heaters, produced.

The importation of collectors fell during the period 1980 to 1982 due to the development of indigeneous technology: the increase in 1983 is due to the demand for more efficient products. The decline in exports from 1980 is due to a combination of factors (increased local demand and lower demand from western Asian* countries). It appears from informal sources that the domestic market saturated and the production for 1984 was almost the same as that in 1983. Hence improvement of product quality has been taken up with new urgency since quality improvement alone can create a large demand for replacements in the domestic market and a big export market.

2.6. Economics of Solar Water Heaters

In discussing the economics of solar water heaters one must take into consideration the capital costs of the various alternative systems, and the cost of useful energy in different hot water systems (based on calorific value of fuel, price of fuel, efficiency, etc.)

Table 2.5 below shows the capital costs for various alternative domestic hot water heating systems.

Table 2.5

Cost of Heating Systems

1.	Solar (auxiliary electric) Hot Water System		
	2 collectors (total area $3m^2$)	£130	($195)
	Hot Water Storage Tank with Electric Heater	65	(98)
	Tower and $1m^3$ cold water tank (needed due to intermittant water supply	70	(105)
	Plumbing, Installation, etc.	30	(45)
	Total	£295	($443)
2.	Electric Water Heater		
	Hot Water Storage Tank	£ 65	($ 98)
	Remaining part of system and installation	30	(45)
	Total	£ 95	($143)
3.	L.P.G. Water Heating System		
	Burner and Boiler	£ 80	($120)
	Installation/Plumbing	15	(23)
	Total	£ 95	($143)
4.	Gas/Oil Water Heating		
	For those having a gas/oil based space heating system the additional cost for hot water facility is as follows:		
	Storage Tank with Heat Exchanger	£ 95	($143)

*Most of the export was channelled through agents in Beirut, whose business was slow during this period; now manufacturers have established commercial links with agents in other countries.

It may be observed from Table 2.5 that the capital cost of a solar water heating system is approximately three times higher than the cost of the other systems (electric, LPG, gas oil). This, however, is somewhat misleading if one considers that for new houses most of its components (cold water tank, hot water tank, etc.) are already installed anyway. Thus, one may talk only about the additional cost of a solar system, which is considerably less.

One other point to be made is regarding the total cost of a solar water heater installation. Its price level ($443) is very low compared to that reported to prevail in other countries ($1000-$2000). Moreover, this total cost is within the financial capabilities of the population, representing (very roughly) less than one month's wages. In addition, when compared to the cost of a house, as well as various other loan facilities available (to be discussed later), the price of a SWH in Cyprus is within easy reach of the population.

The life of these systems may be assumed to be 15 years and the maintenance costs can be neglected. The interest rate in Cyprus (about 9 percent) over a period of 15 years corresponds to an annual cost of $12.41/year per $100 capital investment using the expression

$$A = \frac{C.r}{100} \quad 1-\left(1 + \frac{r}{100}\right)^{-n}$$

where A is the annual cost £/year,
C is the Capital cost £,
r is the rate of interest
and n is the period in years.

2.7. Cost of Useful Energy

The cost of useful energy delivered by different water heating systems is shown in Table 2.6; the data from which the cost has been calculated have also been summarized in the table.

From the Table it can be seen that solar water heaters are much preferable economically to electric water heating systems, which they have already replaced to a very large extent. The systems designs and components have to be carefully chosen to compete with gas oil (for those having central heating systems),

It is interesting to note from Table 2.6 that the least total energy cost is offered by LPG systems (largely due to the heavily subsidized retail price of the fuel). Nevertheless, their use is minimal largely due to the cumbersome method of supply (in cylinders of gross weight of approx. 20 Kg each) and perhaps also due to fears on the part of the public about their reliability and safety.

Another useful fact to be extracted from Table 2.6 is that when compared to electric systems a solar water heating system has a repayment period of 3-4 years, which is considered very satisfactory, bearing in mind that its useful life is over 15 years.

Table 2.6: Cost of Useful Energy in Different Water Heating Systems

uel	Caloric Value	Efficiency of Utilization	Fuel Cost	Fuel Cost Per MJ (10^{-3} $/MJ)	Capital Cost $	Annual Capital Cost $/Year	Annual Capital Cost per MJ 10^{3} $/MJ	Total Energy Per MJ 10^{-3} $
PG	50 MJ/Kg	0.75	$0.230/Kg	6.1	143	17.69*	2.7*	8.80
	Gas Oil	45.6 MJ/Kg	0.62	$0.255/Kr		9.0 *	143 **	17.69 .99
lectricity Resistance Heating)	1 KWh/KWh	0.98	$0.105/KWh	29.8	143	17.69*	2.7	32.50
resent Solar Water Heater ($3m^2$)	--	0.18	NIL	NIL	443	54.9	14.4***	14.4
refully esigned SWH	--	0.28 (0.7 x 0.4)	NIL	NIL	443	54.9	9.3	9.3

Corresponding to an output of 6570 MJ/year

Corresponding to an output of 6570 MJ/year for hot water and twice the amount for space heating.

* Based on a useful output of 3 x 5.4 x 0.3 x 6 x 365 KWh/year = 3931 MJ/yr (areas of pane in m^2 x output in KWh x efficiency x utilization factor x no. of days).

additional capital cost of solar/electric water heater over electric water ater is $300, which corresponds to an energy cost of $11.7 x 10^{-3}/MJ.

3. Government and Other Agencies Relevant to the Industry

3.1. Support and Incentives

3.1.1 Technical Support

Experts at the Ministry of Commerce and Industry have long been available to the solar industry for advice on improvement of components/systems and to the consumers (big or small) for advice on optimal use of solar energy. Since 1980 an outdoor testing rig has been set up to provide the efficiency versus $\Delta T/G$, curve for collectors, submitted by the manufacturers; G is the solar insolation in watts/square meters and ΔT is the difference between the mean fluid temperature and the ambient temperature in °C. The testing is carried out in accordance with Cyprus Standard 119:1980.

The Ministry of Commerce and Industry is presently processing the establishment of an Energy Service; the present Applied Renewable Energy Centre, set up for the implementation of a World Bank supported project, will serve as the renewable energy wing of the service. The subproject on solar energy which consists of adaptive research development, demonstration, dissemination, commercialization and technoeconomic evaluation, undertaken by the centre includes (for more details see Appendix B):

1. A network of solar/wind/meteorological parameter measuring stations - to provide a sound foundation for design of a solar/wind system.
2. Solar collectors and solar hot water systems
3. Passive Architecture - design of buildings to make optimum use of the sun for maximum comfort
4. Passive green houses
5. Solar crop drying
6. Feasibility study of use of solar ponds in Cyprus

3.1.2 Testing Facilities for Solar Collectors

When we started in 1979 at the Ministry of Commerce and Industry to deal with the technical aspects of the manufacture of solar collectors the absence of reliable data on their performance was a considerable hindrance. Thus it was decided to set up a testing facility in order to be able to measure the performance of solar collectors. The task was not an easy one. At the time there was not a universally accepted testing procedure and the funds available were not much. So it was decided to start with an outdoor testing facility which required only a minimum of capital expenditure.

This testing facility has since been used extensively for the following purposes:

1. To measure performance standards of the solar collectors manufactured in Cyprus.

2. To recommend to manufacturers and advise them on ways and means to improve product quality, on the basis of this testing.

3. To monitor the effectiveness of any changes made in the manufacture of solar collectors and to be able to calculate the relative costs and benefits of such changes, so that a decision may be made whether or not these changes are worth implementing.

4. To be able to give to designers of (especially large) systems reliable data on the performance of a particular collector so that they may proceed with the design of their systems on a correct basis.

5. To give performance certificates to those manufacturers who need them to support their export promotion activities.

6. To enable comparison in the performance of various types of collectors, both locally manufactured and imported, and on the basis of this comparison draft new policies, such as protection against imports, and revise technical and drafting standards.

The provision of this testing service, which is offered free to manufacturers has met with unequivocal success. There are times that we are literally inundated with requests for testing of collectors for any of the above purposes. The testing facility and standards were later adopted as Cyprus Standard 119: Testing procedures for solar collectors.

There are also plans to upgrade these facilities in order to conform to the latest international practice in this field.

3.1.3. Preparation of Standards for Solar Water Heaters

A standard is necessarily an attempt to achieve a compromise between different objectives, such as consumer protection, of local industry capabilities (manufacturers have a varying degree of design competence, manufacturing facilities, know-how, etc.), testing facilities available or which are reasonably expected to be set up, the various applications of the product, and other technical constraints that may exist, etc.

In addition standards in an area of rapid technical development should also allow flexibility in order to enable the exploitation of new technology.

Other questions to be addressed refer to whether a standard should be mandatory or optional, whether it is possible to have a standard for the system as a whole or individually for its constituent parts, etc.

All these issues are discussed in more detail below:

Standardization

The development of the standards is a collective effort for the satisfaction and benefit of all concerned. All interested parties take part in the technical committee that establishes the standards.

The committee encountered technical difficulties due to the fact that no foreign detailed standards exist which could be used as a model. Therefore the studies were based on the present manufacturing practice followed in Cyprus. One of the main problems was the development of criteria upon which the testing methods of system efficiency would be based. Following a detailed study of the problem and due to lack of a practically accepted methods of the system, it was decided that the efficiency of solar collectors presently in use would provide the main efficiency criteria. Thus the Cyprus standard CYS 119 method of testing the efficiency of plate solar collectors was prepared and published.

As a result, one of the basic prerequisites for the preparation of a standardised specification of solar water heaters was to enable to the consumer to make an informed choice for the purchase of solar heaters the collector efficiency. In other words, it enabled the consumer to buy a solar water heater from either the A, B, or C categories.

For two years, several tests were made by the Energy Service of the Ministry of Commerce and Industry on all types of collectors that are manufactured in Cyprus and on some imported types. Unfortunately, the results showed that a classification based on the method currently used is impossible. The efficiency curves did not show a marked difference to such a degree that would enable the classification into categories. In the case of two collectors for example, one made with copper serpentine and the other a galvanized collector, the difference was minimal. This does not mean that the two collectors have the same efficiency simply because they were both new; therefore, certain factors such as the development of scale formation on the inside of the tubes, do not affect the results in any way.

It was therefore decided that the standard should be prepared as one with minimum requirements regarding the collectors' specifications and the determination of its efficiency.

A standard of minimum requirements does not meet all of the objectives of the standardization project, but it does cover the basics. Nothing better could be achieved under the present circumstances; however, a standard of minimum requirements is ideal for meeting our needs.

3.2 Fiscal and Financial Support

3.2.1 Protection of Local Industries

The overall government policy is to give protection to local industries that have prospects of further development, but which require a period of protected adolescence before they can compete with foreign suppliers. The criteria for such protection are: quantity (whether production is sufficient

or not to satisfy local demand), quality (whether or not the product is of an acceptable standard) and price. Protection of local production may be covered either through the imposition of import duties or through the regulation of imports and the imposition of quotas.

In protecting the solar water heater industry, one is faced with the following problem: Too much protection would totally prohibit imports. It is my opinion that some imports are desirable in an area of rapid technical development . On the one hand it is a means of technology transfer; local manufacturers can see what are the latest technical trends and try to adopt and adapt these new products and methods. On the other hand, imports, especially if these are of higher quality and lower price than locally manufactured goods, introduce an element of competitiveness in the market creating an urge for local manufacturers to improve their production.

Bearing all these factors in mind, as well as other local conditions regarding the imposition of import duties (Parliamentary approval, etc.) the present situation is that imports of flat plate collectors are levied with duties ranging from 10 percent-15 percent (depending on the country of origin).

This measure was accompanied by the removal of the privilege of duty free importing of collectors by hotel establishments for their own use. After a recent change in the regulations, hotels now also have to pay the applicable duties described previously. Since the hotel sector presents considerable potential for the rise in purchasing of solar water heaters, it is expected that this measure will provide a further boost to local industries.

It may be mentioned here that for other renewable energy equipment which is not produced locally (such as photovoltaic cells, small wind generators, etc.) all import duties were removed and a number of other permits required for their use (production of electricity) were waived. Although their contribution to energy needs is still minute, government policy of renewable energy equipment in this sector encourages their use whereever possible. It also provides the opportunity to acquire experience, albeit to a limited extent, with such systems.

3.2.2. Import Duty Relief for Raw Materials, etc. Used in the Manufacture of Solar Collectors

Raw materials, components and other goods which are not produced locally and are used in manufacturing are usually admitted in Cyprus duty-free or at reduced rates of duty. Practically all materials used for the manufacture of solar water heaters have been gradually exempted from import duties.

3.2.3 Financing of Industries

Especially since the time of the Turkish invasion of 1974, a number of government-sponsored schemes for industrial financing were introduced. These schemes concern the provision of loans at the commercial interest rate of 9 percent to industries through the banks operating in Cyprus. Some of these

schemes are managed under a Government guarantee for the repayment of interest and principal. The purpose of these schemes was to revitalize industry in general. Although these schemes are addressed to all industries, it must be stated that two of the largest existing solar water heater manufacturers were financed under such schemes. The main criterion for financing is the commercial viability of the project.

In addition to the above it may be mentioned that financing of industries for the manufacture of energy saving equipment (including renewable energy products) is included under the special Fund for Financing Priority Projects. (This is a fund operated by the Central Bank of Cyprus and its purpose is to finance projects that fall within the priority sectors set by Government).

3.2.4. Tax Incentives

For the purpose of promoting investments in fixed assets (plant and machinery) in industry a number of tax incentives of a general nature are appliced to all industrial sectors. They are too numerous to describe in detail here but the major ones are: investment allowances (up to 45 percent) in addition to the normal annual wear and tear allowances, immediate depreciation, carrying forward of losses for an indefinite period, etc.

It will suffice to state that these incentives have proven to be very effective in promoting investment and that a number of solar water heater manufacturers, especially the larger ones, have taken advantage of their existence resulting in expanded production and modernized production methods.

It is also valid to state that the same incentives are applicable to businesses (hotels, industries ...) that install renewable energy equipment. However, there is not enough data to enable one to comment on their effectiveness for this purpose.

3.2.5. Government Purchases

It has been estimated that for the past seven years the government has purchased approximately 1500 solar water heaters per year. These are installed in the houses built by the government to house people displaced from their homes as a result of the Turkish invasion.

These purchases, however, although providing a good market for the manufacturers, are not part of a policy aimed at the promotion of solar energy utilization. They are considered rather as a standard installation procedure in building a house; everybody expects it to be there. In the first government housing projects built in 1975, solar water heaters were not installed. It is understood that this was decided due to the need to cut the cost of building each house to the absolute minimum, so that, within the limited funds, available, more houses could be built. The public outcry, however, (presumably due to the high operating costs of the electric systems installed) from occupants was such that the decision was immediately reversed and every housing unit built or subsidized by the Government was installed with a solar water heater.

The problems that have arisen from these government purchases are those usually associated with any construction contracts and will not be discussed in detail. It will suffice to say that they are concerned with whether they will be contracted together with the construction work or separately, the drawing up of specifications, and the responsibility of contractors and subcontractors, etc.

It is difficult to quantify the results of this program, but it is evident that a boost was given to the industry, resulting in increasing competition with reduced costs (or at least remain constant).

3.2.6. Financial Support for Purchasers of Solar Water Heaters

The only scheme available for financing the purchase of solar water heaters is one operated by a commercial bank. According to this scheme, a loan is granted to purchasers for the value of the installation (approx. C£300). The loan carries the current interest rate applicable in Cyprus (9 percent) and is repayable in two years. The scheme was introduced in September of 1981 and up to March 1985, some 7,000 units were financed, representing 20 percent of the market (assuming an annual average market of 10,000 units). The bulk of these installations were made in the early stages of the introduction of the scheme. This is attributed to the wide publicity that was given with launching of the scheme which was sustained for a number of months.

It is evident from the figures that the scheme was a successful one. The publicity that accompanied it was a major factor for this success. According to a representative of the bank operating the scheme, what people needed were guidance, enlightenment and (credit) facilities. All three elements were present in this scheme.

4. Conclusions

4.1. Reasons for Widespread Use of Solar Energy in Cyprus

A number of factors have contributed to the widescale use of solar energy in Cyprus; at present solar energy meets between 3.5 percent to 4 percent of the national energy consumption needs.

The first factor to be considered is the technical characteristics of the system adopted in Cyprus. It is a simple system in design and manufacture. Its uncomplicated nature makes it easy to manufacture, falling within the overall capabilities and capacity of the industrial sector, even in the early sixties when industry in Cyprus was at its infancy. It is also a system simple to install and maintain. The lack of any moving parts makes the system virtually trouble-free, providing many years of service without requiring any sophisticated maintenance work. Even when such work is necessary, such as replacing the electric element, this is within easy reach of the consumer. The system is also simple in terms of operation. For the major part of the year it just sits on top of the roof producing ample quantities of hot water without any effort or expenditure at all on the part of the consumer.

Another important characteristic of the system is that it falls within the life style and the needs of the people. Its widespread use coincided with the more general economic development of the country that occurred after independence and the boom in the improvement of the housing conditions in Cyprus. In addition, it may be argued that installation of such a system improves the quality of life of the people, having made available more hot water than they would otherwise ordinarily use for all sorts of domestic purposes (personal hygiene, washing, cleaning, etc.).

Of course all the above advantages of the system, as used in Cyprus, are coupled with its cost-effectiveness. Its original cost is within easy reach of the consumer (especially if it is installed in a new house during construction) and it can be repaid within a couple of years. The increasing cost of oil products and electricity along with a sunny climate have also tended to make solar water heating more competitive. In hotels the maximum demand occupancy in summer matches very well with the supply, solar radiation, to make the water heating systems more efficient and economic.

The most important factor, however, contributing to this phenomenon is the enterprising industry itself; the industry identified the prime application of solar water heaters and pushed the improvement of technology and promotion of products with vigour. The industry used correctly the general Government incentives that were available and exploited new opportunities that appeared on the horizon.

On the other hand, the government did not remain a silent observer during this period. Within the overall framework of government policies in the manufacturing sector, various incentives were fine tuned to provide even more impetus to the use of solar energy. In addition to the technical support given, consisting of testing of collectors, the government also provided advice to industry for improvement of products and to consumers for efficient utilization.

It is important to note that no direct subsidies have been given by the government and the growth of the solar energy in Cyprus is in conformance with natural laws of economics and hence reasonably stable.

All these measures have helped the promotion of solar energy; the technical support has been of increasing importance, becoming critical now, when further expansion of the market depends on quality and product diversification. To meet this challenge, the Government has with the support of World Bank undertaken a project of adaptive research, development, demonstration and technoeconomic evaluation in the field of renewable energy utilization; the solar energy aspects of the project have been highlighted in Appendix B.

4.2. Suggestions to Other Countries

A programme for wide scale application of solar energy should start with a realistic appraisal of the role that solar energy can play in meeting the national energy needs. The appraisal should identify applications that are technoeconomically desirable from the point of view of the individual and the nation. While the applications which are of advantage to the individuals

can be spread with an imaginative promotion programme, those of interest only from the national view point have to be subsidized.

The enterpreneurs have to be encouraged to get into the production of viable items but they have to be guided in the choice of technology; this has not happened in Cyprus, resulting in a wide range of quality of solar water heaters. Some testing facilities, even of an elementary nature are most helpful; they may at least initially be located at appropriate educational institutions.

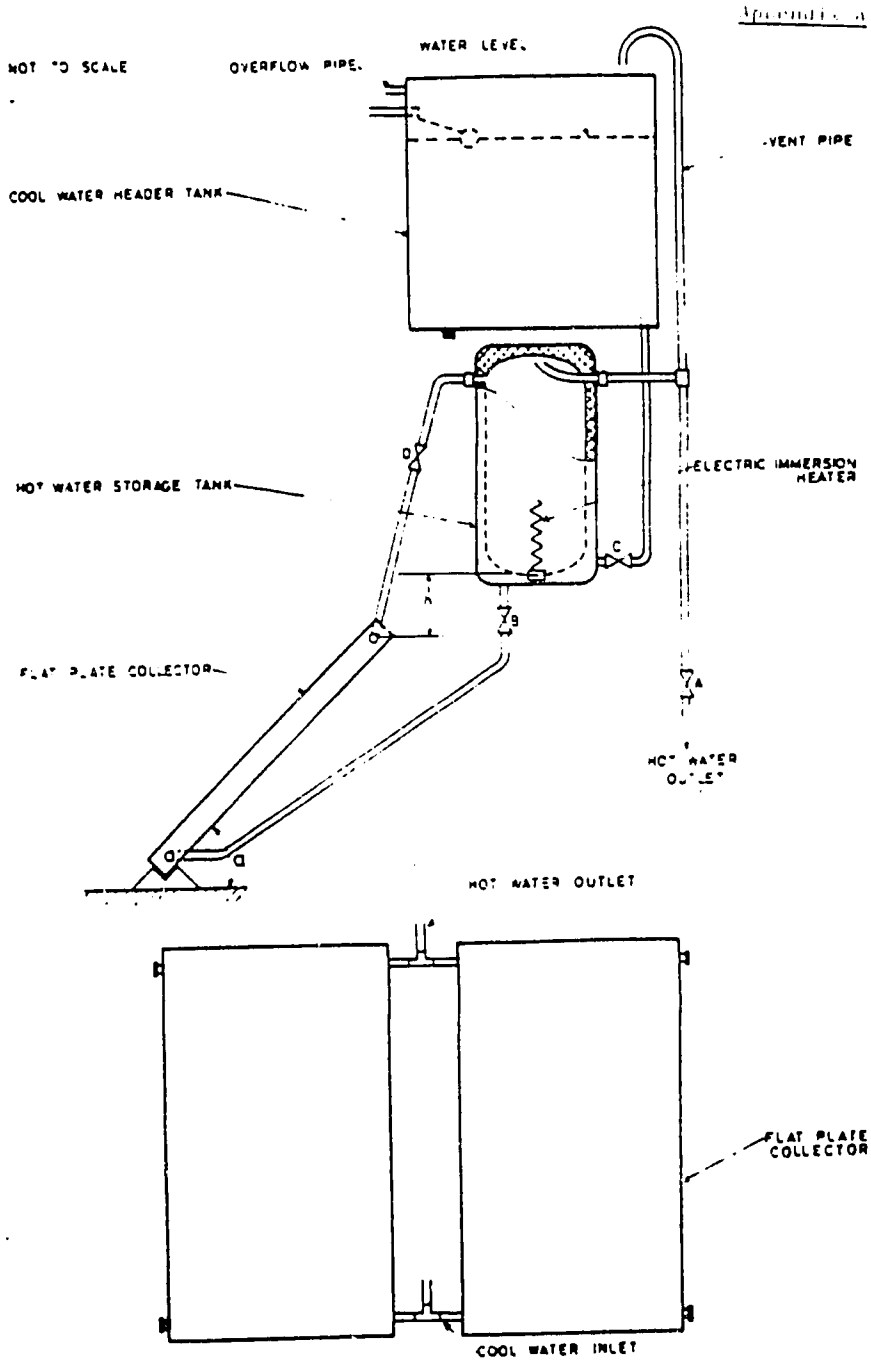
The incentives to be given to users and the industry have to be carefully examined in the context of the country concerned; any incentives given to the industry should be linked to quality.

Information on solar radiation and meteorological parameters in different zones of the country is necessary for the design of solar systems. Good designs and technological know how should be made available as freely as possible.

The main lesson to be learnt from Cyprus is that nothing succeeds like the exploitation of a properly identified application (of solar energy) by an enterprising industry and backed up by an understanding government.

Appendix A

Schematic Diagram of Solar Water Heater Assembly



Schematic diagram of assembly of solar water heater.

Appendix B

ENERGY PLANNING AND CONSERVATION PROJECT
GOVERNMENT OF CYPURS

Background Information

The government of Cyprus has with the support of the World Bank undertaken a project on Energy Planning and Conservation. The project is designed to assist the country in the development of a national energy plan and the development of renewable energy and energy conservation programs. The project consists of the following parts:

A. Energy Planning

Energy planning capability will be developed; the existing data on energy will be collected and analyzed to prepare a detailed medium term energy master plan and a long term energy plan. The plans will indicate the measures to be taken by the government, including pricing for the implementation of the plans.

B. Renewable Energy

1. After an assessment of the economic potential of the available renewable technologies in Cyprus is completed, priorities for development will be suggested. This work will form the basis of the renewable energy component of the energy planning program (A).

2. A national solar and wind resource measuring network will be developed and a program to analyze the data and present it in the most useful form to the users will be implemented. The present work in this field will be integrated into the project.

3. Ten existing windmills will be reactivated and five new contemporary ones will be installed for pumping water; one windmill may also be used for producing electrical power. The performance of the wind mills will be evaluated; this knowledge along with the wind data, collected and analyzed by the measuring network will be used to observe the prospects of wind energy utilization.

4. The manure of an existing hog farm will be used in pilot and demonstration scale plants (to be set up under the program) for production of biogas. Plant performance and gas usage will be explored to assess the technical and economic feasibility of biogas technology.

5. Under the jurisdiction of the Ministry of Commerce and Industry an "Applied Renewable Energy Centre (AREC)" will be set up with competent staff from Cyprus and abroad. The centre will serve as the focal point of the renewable energy effort in the country, be responsible for the implementation of the renewable energy program (Part B) of the project, and develop a capability for initiating and coordinating applied research and development in renewable energy.

6. The solar component of the renewable energy effort consists of the following subprojects.

   a. Indoor and outdoor test facilities, commensurate with contemporary international practice will be set up and used to certify locally made solar water collectors. Facilities will also be set up for testing of complete hot water systems; in case of inadequate performance of some systems, remedial action will also be suggested.

   b. Pilot and demonstration projects for using solar energy to heat water in commercial and public buildings and industry will be undertaken, monitored and evaluated.

   c. Studies on passive solar design of buildings and other conservation measures will be undertaken to reduce the heating and cooling loads. The architects and interested engineers will be made aware of the state of the art.

   d. Pilot and demonstration projects for crop drying using solar energy will be undertaken; raisins appear to be a good product to start with. Passive solar green house will also be designed and set up.

   e. Assessment of the technical and economic feasibility of solar ponds, keeping in view the presence of natural salt lakes in Cyprus, will be undertaken.

C. Energy Audits

The energy audit capabilities of the Ministry of Commerce and Industry staff will be strengthened by intensive field training of staff and provision of additional equipment.

D. Energy Conservation (by the Electricity Authority of Cyprus)

EAC will be assisted in increased energy conservation through:

1. On the basis of appropriate studies, developing and providing and installing the necessary equipment for:

   (a) a management and dispatch program; and

   (b) an energy conservation scheme for the mini-power station.

2. Carrying out a feasibility study of the standby and other generation equipment.

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