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Application of Solar Energy in Dwellings

A technical and economical analysis for the European Community

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Summary:

In the present study the technical possibilies and economical limitations of solar heating systems for the application in swimming-pools, hot water preparation, space heating and air conditioning were investigated. This analysis was performed for dwellings with special consideration of the climatic differences in each E.C. country. The computer program, which was used for solar system calculations, and all mathematical models for technical and economical analysis are explained.

In the technical and economical analysis the most suitable solar system sizes for each E.C. country was determined. Four types of solar collectors were investigated. The single glass selective collector proved to be the most cost effective collector in all the above applications, provided for that the additional cost for the selective coating is not more than 20 DM/m^2.

From the results of the analysis certain recommendations were derived, which can improve the rapid implementation of solar heating systems into the market.

Zusammenfassung:

Die vorliegende Studie untersucht die technischen Möglichkeiten und wirtschaftlichen Grenzen von solaren Heizungssystemen für Schwimmbäder, Brauchwasserbereitung, Raumheizung und Raumklimatisierung. Diese Untersuchungen wurden für den Wohnbereich unter besonderer Berücksichtigung der klimatischen Unterschiede in den einzelnen EG-Ländern durchgeführt. Das für die Berechnungen benutzte Computerprogramm und alle Rechenmodelle für die techn. und ökonomische Analyse werden beschrieben.

Bei der techn.-ökonomischen Analyse wurden lokale Unterschiede in der günstigsten Dimensionierung von Solaranlagen festgestellt.

Von den vier untersuchten Kollektortypen ist der Einscheibenkollektor mit selektivem Absorber der in allen Anwendungsfällen Günstigste, wenn die Mehrkosten für die selektive Beschichtung unter 20 DM/m^2 liegen.

Aus den Analysenergebnissen wurden Empfehlungen abgeleitet, die eine rasche und reibungslose Markteinführung von Solarheizungssystemen begünstigen.

Abbreviations

B	annual oil demand for conventional heating
C.E.R.	cost effectiveness ratio
C.O.P	coefficient of performance
c_p	specific heat
d_h	hydraulic diameter of flow paths
e_D	specific roof plating costs
E.C.	European Community
E_D	savings of conventional roof structure
E_1	heating cost savings in the first year of solar heating system operation
F_K	collector area
g	specific oil price
k_A	specific cost of pumps, valves, tubing, etc.
k_{in}	hourly wage of installers
k_k	specific cost of collectors
k_{st1}	specific cost of supporting structure and sealing of a collector area
k_{st2}	specific cost of peripheral roof sealing
K_A	total cost for pumps, valves, tubing, etc.
K_{Ao}	basic cost for pumps, valves, tubing, etc.
K_{inst}	personnel cost for installation
K_K	collector cost
K_R	control cost
K_{sp}	solar energy storage tank cost
K_{st}	total cost of collector supports and sealing

l	tube length
n	pay back time for investment cost
Nu_{d_n}	$= \frac{\alpha\, d_h}{\lambda}$ Nusselt number = nondimensional heat transfer coefficient
P.E.R.	reciprocal thermal efficiency (performance energy ratio)
P_r	$= \frac{\rho \nu c_p}{\lambda}$ Prandtl number = ratio of molecular diffusivities of momentum with respect to heat
Q_o	total cost
R_e	$= \frac{w \cdot d_h}{\nu}$ Reynolds number = ratio of inertial to viscous forces
S_{eff}	specific insolation
T	temperature in general
T_∞	ambient temperature
T_{Abs}	average temperature of the collector absorber plate
U	heat transfer coefficient of insulations
$\dot{V}$, $\dot{V}_o$	hourly volume flow rate
V_{sp}	heat storage tank size
w	flow velocity
x	specific installation time per collector
α	heat transfer coefficient in Nusselt number, absorption coefficient of absorber coatings
γ	azimuthal deviation from the south
ΔB	annual oil savings by solar energy utilisation
Δp	pressure loss due to flow resistance
ϵ	emittance of absorber coatings
λ	thermal conductivity, coefficient of friction in pressure loss calculations
ν	kinematic viscosity
ρ	density of working fluid

1. INTRODUCTION

During the oil crisis in 1973/74 the Western European countries were the ones which suffered the most from their dependence on oil imports.

Table 1 shows the oil demand for each E. C. country. It is clear that the more industrialized countries have the largest oil consumption (i. e. Germany, Great Britain, France). The predicted average national oil demand will increase in each country by approximately 21 % over the next ten years up to about 660 million tons of oil.

Table 2 shows the attained and planned goals of national oil production efforts. It is clear that the North Sea oil bonanza has become an important factor for Great Britains' industries and trade balance. This new found oil is however just a temporary alleviation of the problem. The longer term energy needs will unfortunately not be satisfied from oil in the North Sea.

Although the international oil market has been relatively stable for the time being, the threat of another oil embargo due to the political instability in the Middle-East remains a possibility. Western Europe, four years after the oil embargo is still economically at the mercy of OPEC.

Due to their different fuel resources the countries of the European Community looked for different alternatives to satisfy their individual energy needs.

On the European Continent the use of conventional energy sources such as coal and water power could be increased, but economical limitations due to expensive mining and transport costs force us to prefer other alternatives with respect to a long-term energy solution.

TABLE 1: OIL DEMAND ^{x} AND EQUIVALENT THERMAL ENERGY $^{+}$

E.C.COUNTRY	1976 M TOE	1976 TWH	1980 M TOE	1980 TWH	1985 M TOE	1985 TWH
BELGIUM	26.30	285.4	30.0	325.5	33.6	364.6
DENMARK	16.73	181.5	18.84	204.4	13.6	147.6
GERMANY	140.4	1523.3	155.0	1681.8	162.0	1757.7
FRANCE	119.3	1294.4	134.5	1459.3	127.0	1378.0
IRELAND	5.214	56.6	6.128	66.5	9.862	107.0
ITALY	97.8	1061.1	117.5	1274.9	134.9	1463.7
LUXEMBOURG	1.45	15.7	2.0	21.7	2.5	27.1
NETHERLANDS	38.3	415.6	45.6	494.8	63.0	683.6
GREAT BRITAIN	97.0	1052.5	90.0	976.5	112.0	1215.2
E.C. TOTAL	542.5	5886.1	599.6	6505.4	658.5	7144.5

TABLE 2: NATIONAL OIL PRODUCTION (REF. 1)

E.C.COUNTRY	1976 M TOE	1980 M TOE	1985 M TOE
BELGIUM	-	-	-
DENMARK	0,177	0,60	0,5
GERMANY	5,6	5,0	5,0
FRANCE	1,9	1,4	0,9
IRELAND	-	-	-
ITALY	1,1	3,0	3,0
LUXEMBOURG	-	-	-
NETHERLANDS	1,6	1,5	1,5
GREAT BRITAIN	12,0	105,0	125,0
E.C. TOTAL	22,4	116,5	135,9

^{x} M TOE = MILLION TON OIL EQUIVALENT

$^{+}$ TWH = TERA WATT HOURS = 10^{12} WH = 10^{9} KWH

1 TWH = 10,85 M TOE

Table 3 shows the E. C. energy scenario. The largest fraction of the primary energy contribution is provided by oil, this fraction can hardly decrease in the next 10 years. That means that approximately one half of the total energy demand in the countries of the E. C. is based on oil, 80 to 100 % of which has to be imported.

In the discussion of solutions of the energy supply problems one must determine the nature and distribution of the secondary energy demand. The utilisation of solar energy is favourably suitable for low-temperature level applications, that means heat consumption at temperatures less than 200°C. Investigations performed by IIASA (see Ref. 7) show, that the largest consumers of low-temperature-level heat are residential and commercial users.

Table 4 shows the partitioning of secondary energy in West Germany in 1970. More than 45 % of the annual total secondary energy demand in West Germany is provided for by low-temperature-level heat.

All these figures point to large scale implementation of solar thermal energy systems for space heating and cooling, hot water heating, and swimming-pool heating.

One must naturally ask ones self, is there enough solar energy available in the E. C. countries to theoretically cover a significant fraction of the energy needs. The answer to this question is yes. If one takes into account not only direct insolation but also diffuse radiation there is more usable solar energy than one would expect. Table 5 shows the average solar radiation (direct plus diffuse) falling on a horizontal square meter of surface area for each of the countries in the E. C. If one multiplies this figure by the area of each of the countries one can see that there is enough energy in the form of solar radiation falling on any country in the E. C. in one week to cover the energy needs for that country for an entire year (see table 6).

TABLE 3: PRIMARY ENERGY STRUCTURE IN THE COUNTRIES OF THE E. C. PERCENTAGE OF TOTAL ENERGY DEMAND (REF. 5)

PRIMARY ENERGY	1973	1976	1985
COAL	22.6	22.5	17.2
OIL (PETROL)	61.4	55.3	51.3
NATURAL GAS	11.6	16.9	17.7
NUCLEAR ENERGY	1.4	2.3	10.8
WATER POWER	3.0	3.0	3.0
TOTAL	100	100	100

TABLE 4: FINAL ENERGY USE IN WEST GERMANY 1970 (REF. 7) IN PERCENT (100 % = 159 MILLION TOE)

CONSUMER	INDUSTRIAL	RESIDENTIAL AND COMMERCIAL	TRANSPORTATION
ELECTRICITY	6.4	4.6	0.4
HIGH-TEMPERATURE-LEVEL (MORE THAN 200°C)	24	-	17.6
LOW-TEMPERATURE-LEVEL (LESS THAN 200°C)	9.5	37.4	-
TOTAL	40	42	18

TABLE 5: COLUMN 1 SHOWS THE CALCULATED YEARLY AVERAGE AMOUNT OF SOLAR ENERGY (DIRECT AND DIFFUSE) INCIDENT ON A HORIZONTAL SQUARE METER OF LAND FOR THE COUNTRIES IN THE E.C. +

COUNTRY	SOLAR INSOLATION KWH / M^2 YEAR	AREA x KM^2
BELGIUM	949	30 514
DENMARK	906	43 069
GERMANY xx	922	248 577
FRANCE xx	1136	543 998
IRELAND xx	804	70 280
ITALY xx	1201	301 230
LUXEMBOURG	936	2 586
NETHERLANDS	886	33 716
GREAT BRITAIN xx	929	224 019
E.C. TOTAL		1 497 989

+ THESE FIGURES ARE BASED ON CALCULATIONS WITH METEOROLOGICAL DATA THAT HAVE BEEN STATISTICALLY AVERAGED FOR AT LEAST A FIVE YEAR PERIOD

x $1\ KM^2 = 10^6\ M^2$

xx INSOLATION WAS CALCULATED FOR CENTRAL PART OF THE COUNTRY

TABLE 6: COLUMN 2 SHOWS THE EQUIVALENT TOTAL THERMAL ENERGY DEMAND FOR THE YEAR 1976. COLUMN 3 SHOWS THE TOTAL AVERAGE SOLAR ENERGY INCIDENT UPON AN ENTIRE COUNTRY IN ONE DAY

COUNTRY	ENERGY DEMAND IN M TOE/YEAR	EQUIVALENT THERMAL ENERGY DEMAND TWH/YEAR+	SOLAR ENERGY FALLING ON ENTIRE COUNTRY TWH / DAY
BELGIUM	46.290	502.2	79.4
DENMARK	20.068	217.7	106.8
GERMANY	261.2	2834.0	628.0
FRANCE	180.5	1958.0	1693.7
IRELAND	6.996	75.9	154.8
ITALY	141.6	1536.0	990.8
LUXEMBOURG	4.64	50.3	6.6
NETHERLANDS	75.7	821.3	81.8
GREAT BRITAIN	216.0	2344.0	570.0
E. C. TOTAL	952.9	10339.4	4311.9

+ 1 TWH = 10^{12} WH = 10^{9} KWH

It is abvious that the entire surface area of a country cannot be completely covered with solar collectors. The figures in column 3 table 6 give one an idea as to the magnitude of the energy that is theoretically available from solar energy. It is important to note that a large fraction of the total radiation falling on the E. C. is in the form of diffuse radiation (up to 60 % for West Germany in the winter time). Since focusing collectors cannot effectively collect the diffuse component of the radiation one should restrict oneself to simple flat plate collectors.

The present study tries to answer the most important questions related to the technical and economical application problems in each country of the European Community, such as:

- In which countries of the E.C. can solar energy be economically implemented

- The effect of different weather conditions on solar energy applications and heating demands in the E. C.

- How efficient do solar energy system components have to be for economical applications?

- What do the different types of collectors have to offer for the various countries in the E. C.

- Which increase in oil costs is necessary for economical applications of solar energy systems?

- How much oil can one save for the countries in the E. C. by using solar energy?

Moreover the pertinent characteristic parameters of solar energy system design and amortisation calculations are varied and investigated.

All economical considerations are related to the most important-critical fossil fuel, heating oil, whose scarcity was the initial reason for world wide research and development of new energy sources such as solar energy. Therefore on other alternative auxiliary heating fuels, such as natural gas or electricity, were investigated. One should note that at present 24 % of all the electricity in the E.C. is derived from iol.

It was not possible to consider local and national differences in material and manpower costs. A realistic cost calculation was made by the use of reliable data from solar energy system manufacturing and installation costs in West Germany. All price calculations were performed with regard to mass production. In calculations with current marketing prices of low quantity produced solar heating or cooling systems there is no chance for economical application in the next ten years.

The fabrication and integration of solar energy heating systems in dwellings are assumed to be quite similar in all countries of the E.C. These assumptions are quite accurate considering the uniform level of technology available in the E.C.

2. Computer simulation for Solar Heating and Cooling in the E.C.

2.1 Details of the model

A computer simulation model for solar heating and cooling in the E. C. was developed. The flow chart of the programs for space heating, hot water heating, swimming-pool heating and air conditioning are shown in Figs. 1 and 2. The model of the house consists of four walls, a floor and a roof. The roof consists of two surfaces each of which are inclined with respect to the horizontal at some prespecified tilt angle.

The house is assumed to be at some fixed desired house temperature T. The ambient air temperature for a given area in a pre-specified country in the E. C. is assumed constant for each month. The basis of the model is a monthly energy balance to determine both the heating and cooling loads of the house. The following effects are considered in determining the energy balance:

- U-value losses (or gains) between the house at temperature T and the environment at temperature T-ambient

- The amount of energy that the sun delivers when shining upon the walls and through the windows

- The extent of the hot water demand

- The heat given off by the human body

- The heat given off by electrical devices in the house

In the case of indoor swimming pools the following effects are also considered in determining the monthly energy balance:

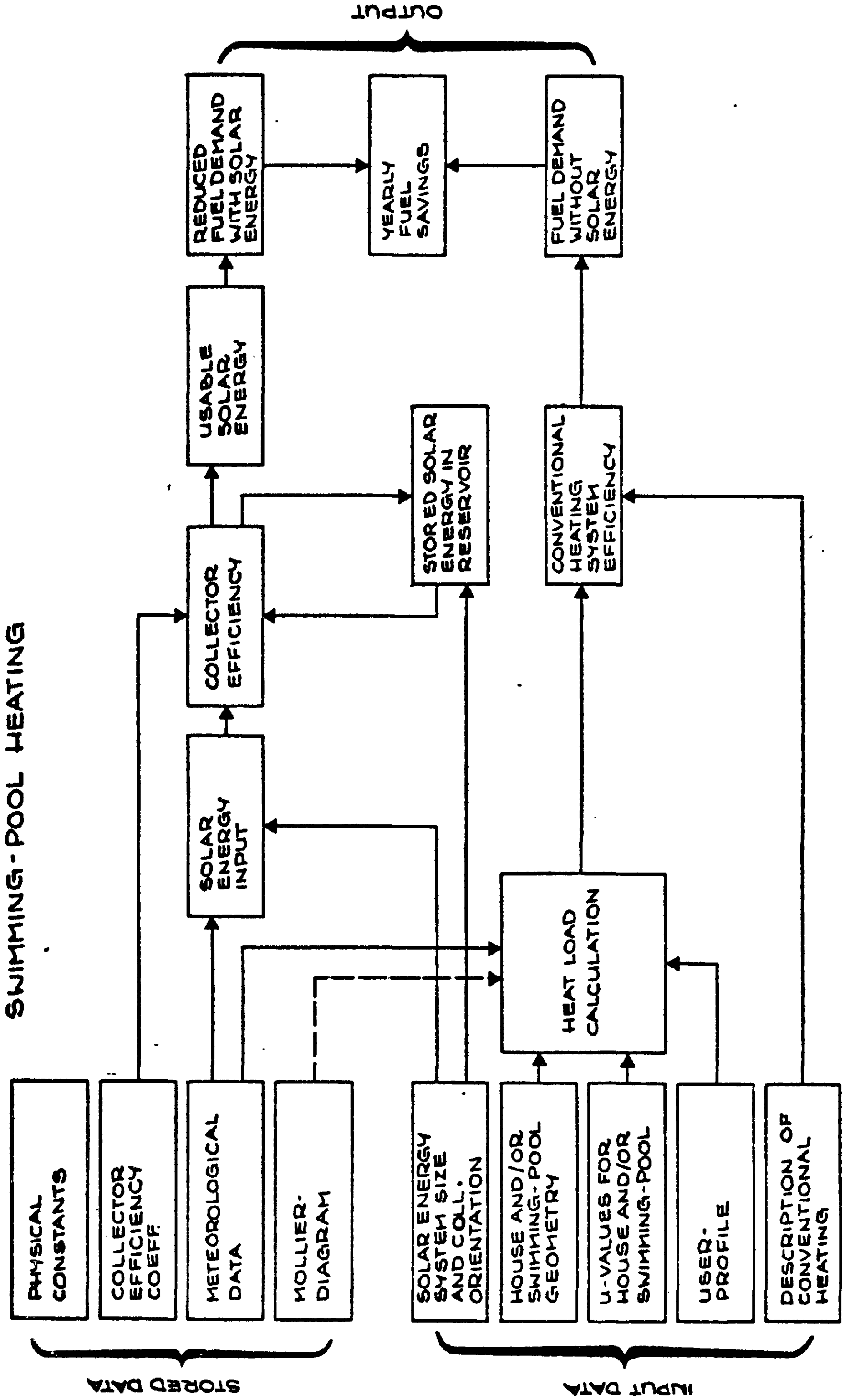


Fig. 1 BLOCK DIAGRAM OF MBB's SOLAR ENERGY SIMULATION PROGRAM FOR SPACE HEATING, HOT WATER AND SWIMMING-POOL HEATING

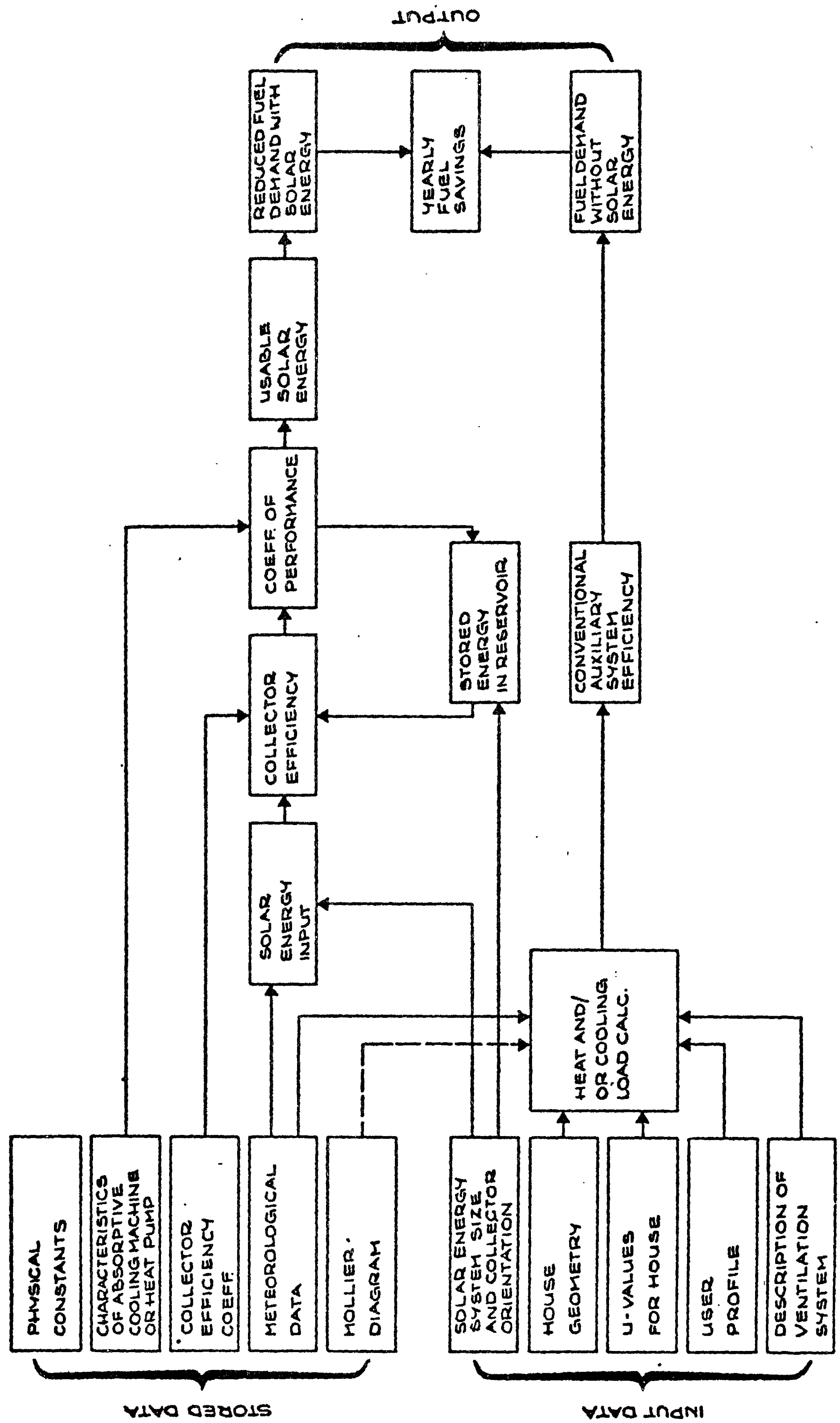


Fig. 2 BLOCK DIAGRAM OF MBB's SOLAR ENERGY SIMULATION PROGRAM FOR AIR-CONDITIONING AND HEAT PUMP APPLICATIONS

- Evaporation of the water to the surroundings
- The heating of the fresh air entering the swimming area
- The heating up of the fresh water to replace the older water

The extent of the energy losses due to evaporation of the water and the heating of the fresh air entering the swimming area are calculated with the aid of a Mollier diagram that is built into the simulation program.

For each month the program calculates an energy balance which enables one to determine the heating or cooling load of the house. It is important to note that the model that is described above is applicable to not only small residential houses but also larger buildings as well.

2.2 Necessary data for the analysis

The following pieces of information are needed in the simulation:

- The monthly average outside air temperatures
- The height above sea level
- The monthly average hours of relative sun shine
- The latitude
- The type of solar collector used
- The U-values of the walls
- The U-values of the windows
- House and/or swimming pool geometry including tilt angle of roof and the window area of each of the four walls

- The length - width - and height of the house
- The number of occupants of the house
- The type of auxiliary heating fuel (oil, electricity, gas)
- The type and age of the auxiliary heating system
- collector area
- storage tank volume

The monthly average outside air temperatures and the monthly average hours of relative sunshine were gathered for each of the countries in the E. C. . The data that was gathered represent long term averages for periods of up to 30 years. The data was compiled at the German weather service in Munich. In countries where the outside air temperatures and hours of relative sunshine varied significantly within a particular country, it was necessary to break up the countries into finer segments. This was the case for Great Britain, France, Ireland, Italy and West Germany. The above countries were than divided into three segments, northern, central and southern. All of the above meteorological data was stored in a separate data file for each of the countries in the E. C.. The program simulations were performed on an IBM/ 370 computer at MBB in Munich.

The details of the calculation of solar insolation from the hours of relative sunshine are given in references (1 and 2). The monthly average collector efficiency is also calculated. It depends on the solar intensity, the collector inlet temperature and the outside air temperature. Another computer program generates 10 coefficients that are dependent on the physical properties of the collector (see 3.1.1). With the above information it is possible to accurately calculate the average monthly collector efficiency.

The results of the computer simulation have been in excellent agreement with the experimental results of installed MBB solar houses in West Germany.

3. TECHNICAL ASPECTS OF SOLAR ENERGY UTILIZATION

3.1 Solar Energy System Lay-outs

3.11 Properties of Various Types of Flat Plate Collectors

In this study four basic types of flat plate collectors were considered:

- Single glass cover, black absorber	$\alpha = .96$	$\varepsilon = .86$
- Double glass cover, black absorber	$\alpha = .96$	$\varepsilon = .86$
- Single glass cover, selective absorber	$\alpha = .92$	$\varepsilon = .10$
- Double glass cover, selective absorber	$\alpha = .92$	$\varepsilon = .10$

Two of the most important properties of flat plate collectors are the absorption and emission coefficients of the absorber plate. In the case of the selective absorbers one can technologically attain an absorption coefficient alpha = .92 and an emissivity epsilon = .10 . For black flat-plate non-selective absorbers values for alpha and epsilon were .96 and .86 respectively. It should be pointed out that in the case of selective absorbers it is technically feasible under "laboratory conditions" to produce selective coatings with alpha = .98 and epsilon = .05. The problems with these coatings are that they are not yet reproduceable in mass produced quantities and also the life expectancy of the coatings cannot always be guaranteed.

Table 7 shows the pertinent physical parameters of flat plate collectors that are now, or will soon be available on the market. It should be noted that the single glass evacuated (to reduce convection and conduction losses) flat plate collector is still in a testing phase and will probably not be available on the European Market before 1979. This collector does not have a cylindrical housing.It is a flat plate collector with supports running along the plate itself.

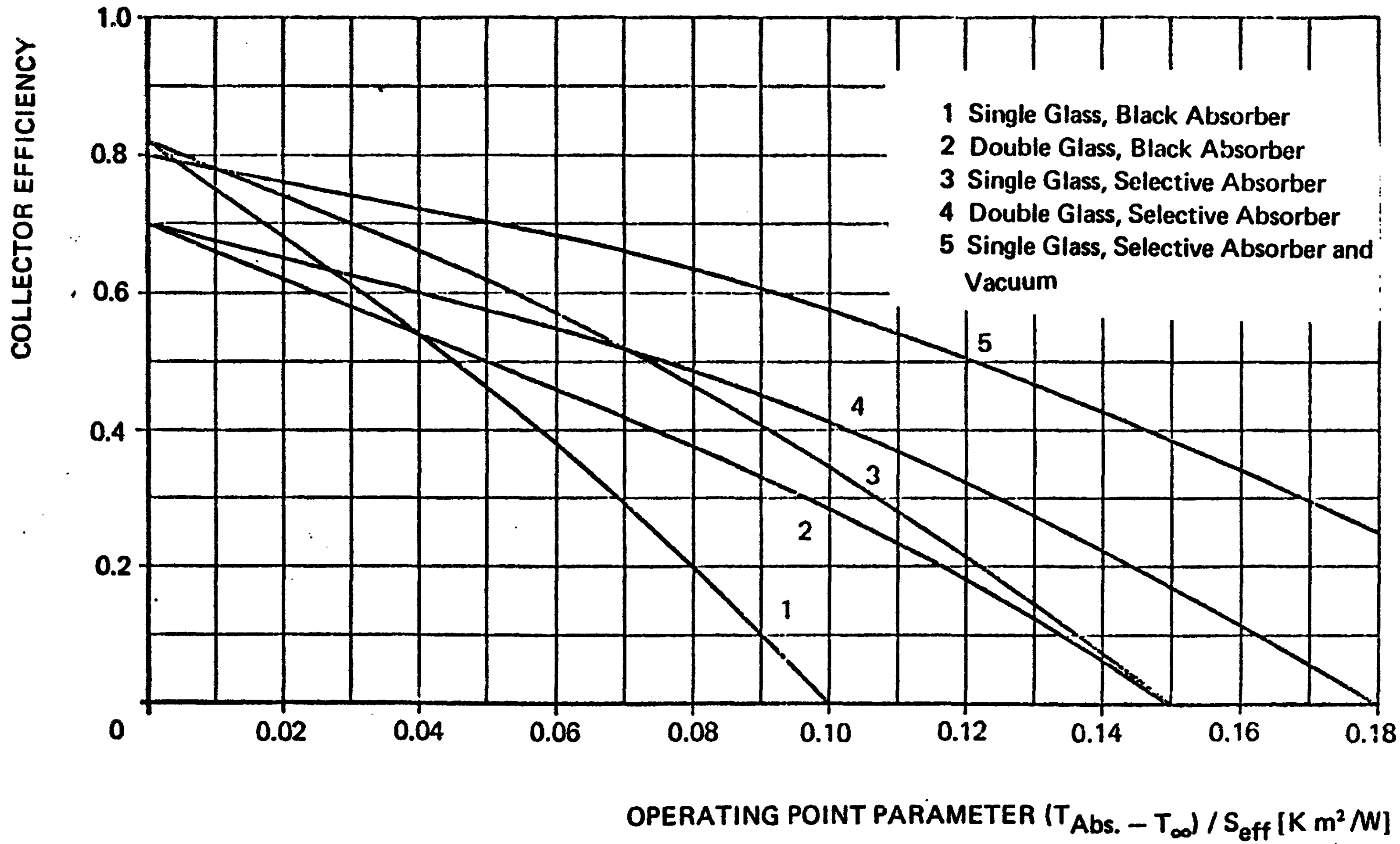
TABLE 7 PERTINENT PHYSICAL PARAMTERS FOR A SPECIFIC TYPE OF FLAT PLATE COLLECTOR

TYPE	ABSORPTION COEFF. EMISSION COEFF.	EFFECTIVE TRANSMISSION ABSORPTION PRODUCT	TOP LOSS COEFF. U IN $\frac{W}{M^2 K^o}$	MIN. INSOLATION FOR x COLLECTORS TO OPERATE IN W / M2
SINGLE GLASS BLACK ABSORBER	α = .96 ε = .86	.82	7	340
DOUBLE GLASS BLACK ABSORBER	α = .96 ε = .86	.70	4	230
SINGLE GLASS SELECTIVE ABSORBER	α = .92 ε = .10	.82	4	195
DOUBLE GLASS SELECTIVE ABSORBER	α = .92 ε = .10	.70	2.5	145
SINGLE GLASS + SELECTIVE ABSORBER AND EVACUATED	α = .92 ε = .10	++ .80	1.5	75

x AMBIENT TEMPERATURE = 10°C , COLLECTOR INLET TEMPERATURE = 50°C
+ THE EVACUATED COLLECTOR IS STILL IN AN EXPERIMENTAL STAGE
++ THICKER GLASS COVER ACCOUNTS FOR LARGER OPTICAL LOSSES

Fig. 3 shows the characteristic curves of the collector efficiency as a function of the well known operating point parameter for the five collectors described in table 7. It is interesting to note that the single glass selective absorber (3) is superior over the entire curve to the double glass black absorber (2). It is also important to note in Fig. 3 that there is a large region where the single glass selective absorber is superior to that of the double glass selective absorber. It is clear that this is physically possible since the optical losses in the single glass collector are less than in the double glass collector. The most important criteria in determining which collector is best for which application is the cost of the collectors in relation to the fuel saved. A more detailed discussion for specific applications and the economics associated with each application are discussed in chapters 3 and 4.

Fig. 3 Characteristic curve of collector efficiency as a function of the operating parameter for 5 different flat plate collectors (see Ref.5)



3.12 Appropriate Heat Storage

There are several reasons why one needs an appropriate heat storage system when using solar collectors. First of all, the energy delivered to the collectors from the sun often doesn't coincide with the demand. After the sun has set there is often a heat demand especially in the winter time. Secondly there may be successive days of bad weather when there is virtually no usable solar energy being delivered.

At the present there is no economical application of long term storage for a period of about half a year. This is unfortunate since a large fraction of the energy that is incident on the earth is in the summer months when there is virtually no space heating load. One therfore often encounters situations where there is an excess of energy available in the summer months. This energy could be used to heat swimming pools or in some cases one could use this "excess energy" to provide for solar cooling via an absorptive cooling cycle.

Many investigations involving the different types of heat storage were performed in both Europe and the U.S.A. The results of these investigations will be summarized and evaluated.

The main heat storage types are:

- Hot water storage
- latent heat of fusion storage
- aquifer storage ponds
- chemical storage using eutectic mixtures
- pebble bed storage
- heat storage in solid materials such as porous stone.

Latent heat of fusion storage can reduce the storage volume as compared to water storage by about 50%, but technological problems such as chemical separation of salt solution, corrosion effects, and difficult heat input and output, rule out a commercial implementation at the present time. Similar problems prevent the present application of chemical storage using eutectic mixtures.

Aquifer storage is an expensive solution due to the large volume of earth removal that is necessary. It is only in large community heating needs where it is economically applicable. Aquifer heat storage systems operate at low-storage temperatures up to 40°C due to biological conversion effects and increased thermal losses at the large storage walls. Pebble bed storage is usually associated with air as a fluid medium. One has the distinct disadvantage of large volumes and the inability to heat hot water using this type of storage. Heat storage in solid material requires high inlet temperatures up to 500°C, which can only be provided for by highly efficient concentrating type collectors. To avoid high thermal losses and evaporation of the working fluids. Solar energy heating in dwellings usually operate at a maximum heating inlet temperature of 80°C.

Today the application of hot water storage tanks is the most effective, safe and reliable storage available, because the storage fluid properties are well known and the tank construction uses standard technology. The optimum tank size depends on the collector area and the heating load. For space heating and hot water preparation the following "rules of thumb" can be applied:

- Solar energy systems with double glass, black absorber collectors:

  1 m^3 storage tank per 10 m^2 of collector area

- solar energy systems with single glass, selective absorber collectors:

  1 m^3 storage tank per 8 m^2 of collector area

For solar cooling cycles the optimum storage tank size varies with the generator inlet temperature and the cooling load of the air conditioned building. No general value can be stated (see chapter 3.24).

The suitable tank construction materials depend on the tank size and maximum storage temperature. Plastic tanks are applicable for small size storage volume up to 1 m^3 and maximum temperatures up to 60°C.

Steel tanks are suitable for storage volumes between .2 to 20 m^3 and temperatures up to 100°C. In the case of solar cooling the desired water storage temperatures sometimes go up to 120°C at which case one is forced to use pressurized storage tanks preferably of steel. For newly built houses with a large heat demand one would recommend concrete tanks integrated with the foundation. Such tanks should be insulated from the inside to retard heat loss and humidity diffusion as is often done in the case of swimming pools. Concrete tanks become economically interesting for storage volumes larger than 10 m^3 and temperatures up to 100°C. Concrete storage tanks are normally non-pressurised.

The insulation efficiency is a function of the properties and thickness of the insulation material fixed around the tank structure. Experiments have proven that 10 to 15 cm of polyurethane-foam are sufficient. In order to save money double insulation layers are possible, using the more heat resistant material in direct contact with the hot side of the tank. The essential criteria for tank insulation selection are:

- thermal conductivity less than 0.04 W/m K
- long-term thermal durability at a maximum temperature of 95°C
- low absorption of humidity
- chemical and biological resistance against the surroundings

For the computer calculations performed for specific applications of solar energy in chapter 3.2 the assumption was made that heat storage occured without heat loss through the insulation layer. A parametric investigation of tank insulation effectiveness showed that this assumption is valid since that heat loss through the tanks insulation is not lost but contributes to the energy balance of the house. This would not be the case if the storage tank were outside the house. All investigated solar heating and cooling systems are assumed to operate with closed collector loops and hot water storage.

3.13 Controls

When working with a fluid storage medium and a specified collector loop it is essential that some control mechanism be implemented between the collector loop and the storage tank. The simplest and most efficient way of achieving this is to put a temperature sensor in both the collector and in the storage tank. One then demands that the circulating fluid circulate only when the temperature of the collector is higher than the storage tank temperature. One usually requires that the temperature difference between the collector and the storage tank be a few degrees centigrade before the pump sets the working fluid circulating. This requirement is necessary since the fluid that enters the heat exchanger in the storage tank must be at a higher temperature than the water in the storage tank. With most heat exchangers a 5°C temperature difference is required before any energy can be transferred to the storage tank. In the controls it is also necessary to guard against evaporation of the working fluid medium. This is a distinct possibility in the summer months. The best way to prevent the working fluid from going above 100°C is simply to install a valve in the storage tank which will allow the water to evaporate when the water temperature in the storage tank reaches the vicinity of 100°C. One must note that it would not be advisable to completely stop the working fluids from circulating at this point, since the collector plate may reach stagnation temperatures of up to 200°C. The internal increase of pressure in the absorberplate and rapid temperature changes are detrimental to the life expectancy of the collectors.

One must also implement some control mechanism between the storage tank and the heating load. The control mechanism is simple and is to some degree dependent on the type of conventional heating that is used. In any case a specified heating inlet temperature is required. If the water in the storage tank is below the specified heating inlet temperature the heat distribution net is heated directly by the conventional heater to the desired temperature. In this case the solar system is by passed. To avoid excess heating inlet temperatures in the heat distribution net a buffer solar heat storage tank has to be provided for. This way the thermal cycles of the collector loop has no serious influence on the thermostatically operated heat output from the solar energy system.

In the case of solar cooling (air-conditioning) the controls will be different than for space heating. In this study the solar cooling simulation was performed for an absorptive cooling machine. Absorptive cooling machines have a threshold generator inlet temperature in the vicinity of 75°C. If the water temperature inside the storage tank is below this threshold temperature, and there is not enough solar energy available, one would then have to conventionally heat the storage tank.

The most important control parameter in the air conditioning of a building is the desired room temperature. If the room temperature rises above a specified level the ambient temperature is the criteria for the control mode. Generally one can turn on the air-conditioner until the desired room temperature is reached. If the ambient temperature is less than the room temperature it is more economical to circulate air from the environment into the room. The hardware necessary for the above control logic is readily available.

During the night a heated building loses some of its heat by reradiation and convection. This was also built into the climatisation model. Climatisation control is very sensitive with respect to building heat capacity and desired room temperature. Therfore a critical analysis of the control assumptions should be carried through in the proposed solar cooling cycle study to be sponsored by the E.C.

One must not forget the controls that have to be implemented in emergency situations such as electric power failure and other crash case conditions which could take place during vacation periods. One should note that in the evaluation of the economics of solar energy implementation that the pay-back-times are of the order of ten years. For this reason solar energy heating and/or cooling systems must be safe and reliable enough to reach such long-term operation capability. A small number of solar energy system manufactures have recognized this and offer complete systems with built in safety devices.

3.14 Heat Transport and Working Fluid

The selection of heat transport and working fluids has two essential technical aspects:

- optimum thermal properties for heat transport and heat transfer
- optimum chemical properties with respect to corrosion effects, chemical resistance, and material compatibility

At the present one can not optimize both of the above at the same time. Furthermore the fluid cost has to be considered. The realized solution has to be a compromise between technical and economical aspects.

The thermal properties of selected working fluids at 100°C are shown and compared with those of water in table 8.
The Prandtl-numbers for the different fluids are as much as 28 times that of water. The heat capacity and the thermal conductivity for the different fluids are reduced by as much as 5o% and 17% respectively as compared to that of water.

TABLE 8 THERMAL PROPERTIES OF TYPICAL WORKING FLUIDS FOR SOLAR COLLECTOR LOOPS (SELECTION), REF. 5

MANUFACTURER	HOECHST	RHÔNA-POULENC	HULS AG	SHELL	-
WORKING FLUID (TRADE-NAME)	52% BY VOL ANTIFROGEN-N	ADX 10 GILOTHERM	MARLOTHERM S	THERMIA 11	WATER
HEAT CAPACITY kJ/kgK	3,54	2,17	2,11	2,14	4,22
VISCOSITY 10^{-6} m^2/s	0,70	1,2	3,0	1,5	0,294
THERMAL CONDUCTIVITY W/mK	0,384	0,120	0,123	0,125	0,682
DENSITY g/cm^3	1,020	0,802	0,970	0,840	0,958
PRANDTL-NUMBER -	6,58	17,4	49,9	21.6	1.75

At first the influence on the characteristic heat transfer was investigated. The average fluid temperature was assumed to be 100°C. The advantage of using synthetic fluid mediums are that they don't evaporate at 100°C. In certain situations higher collector inlet temperatures are desirable such as in absorptive cooling loops with highly efficient collectors, where collector inlet temperatures up to 200°C can be reached.

The basic off-design parameters for the absorber plate were based on those of a typical roll-bond aluminum absorber plate:

- hydraulic diameter 6 mm
- average flow velocity 0.1 m/s
- total collector volume flow rate 305 ltrs./m^2h
- 30 channels
- characteristic length of absorber plate channels 1 m

Parametric variations were performed for:

- constant hydraulic diameter, see Fig. 4
- constant fluid velocity, see Fig. 5
- constant total volume flow in the collector, see Fig.6

In these diagrams the usable collector heat is represented by the average heat transfer coefficient, between the wall of the absorber tubes and the working fluid. Fig. 4 shows that an increasing fluid velocity is the most effective means of reaching the same heat transfer coefficient for the synthetic working fluids as compared to water. That means that synthetic working fluids must generally be circulated with higher velocities than water in order to reach turbulent heat transfer. The reduction of the hydraulic diameter of the absorber flow channels has less influence on the heat transfer except in the case of Antifrogen-N. When considering the heat transfer parameters the pressure losses caused by mass flow friction have to be considered as well. This pressure loss is a function of the volume flow $\dot{V}$ hydraulic diameter d_h, tube length 1, and coefficient of friction λ as follows:

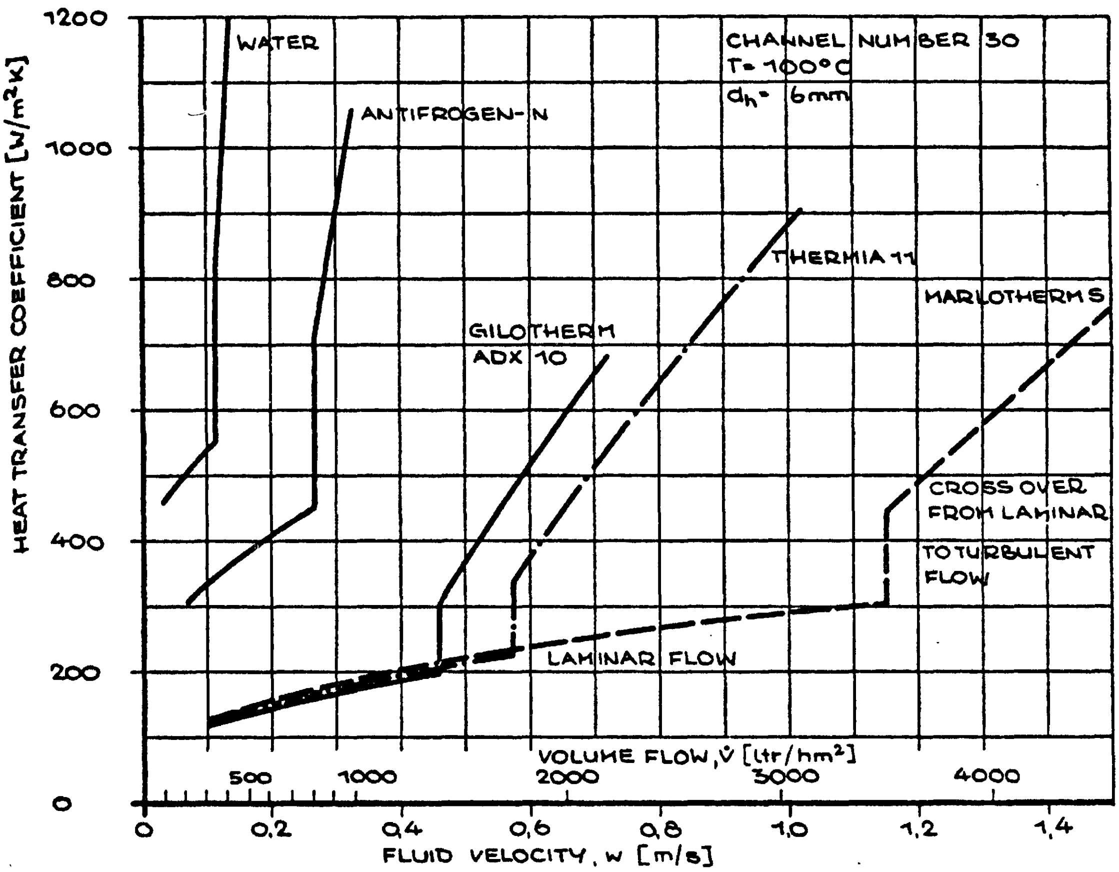


Fig. 4 HEAT TRANSFER AS A FUNCTION OF SINGLE CHANNEL FLUID VELOCITY AND TOTAL ABSORBER PLATE VOLUME FLOW, RESPECTIVELY, FOR DIFFERENT WORKING FLUIDS.
CONSTANT HYDRAULIC DIAMETER ASSUMED.

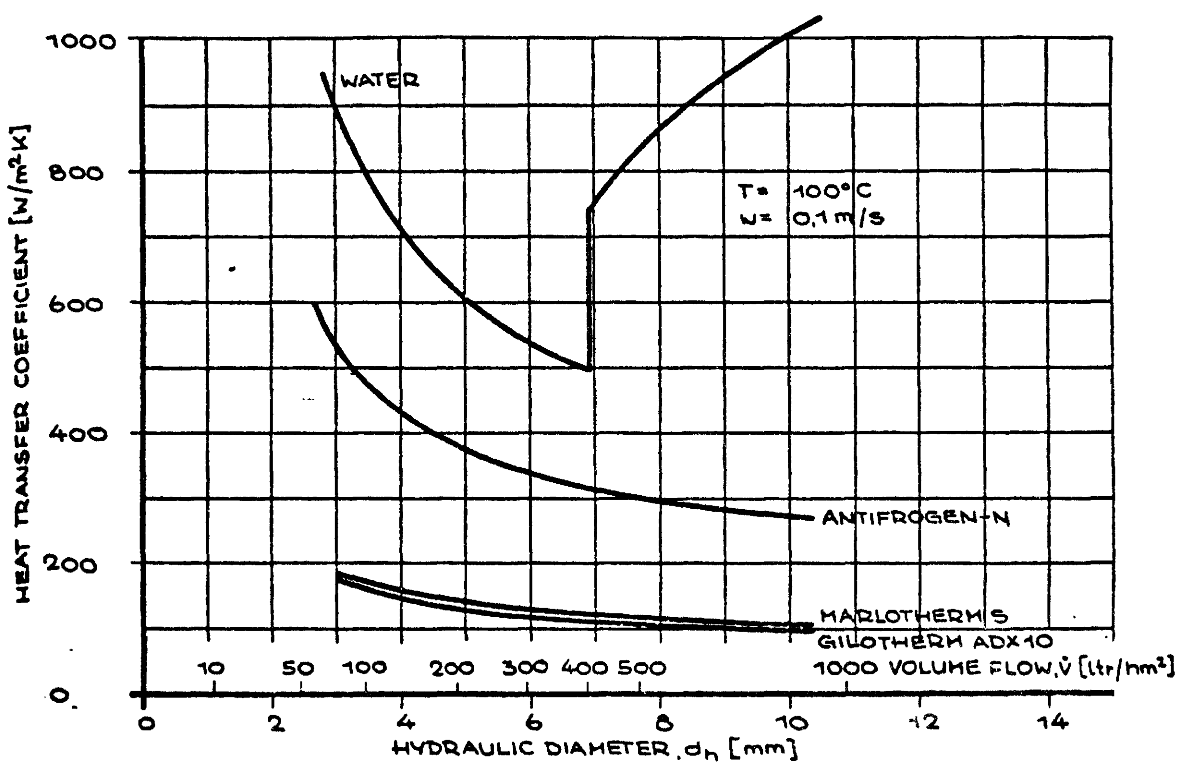
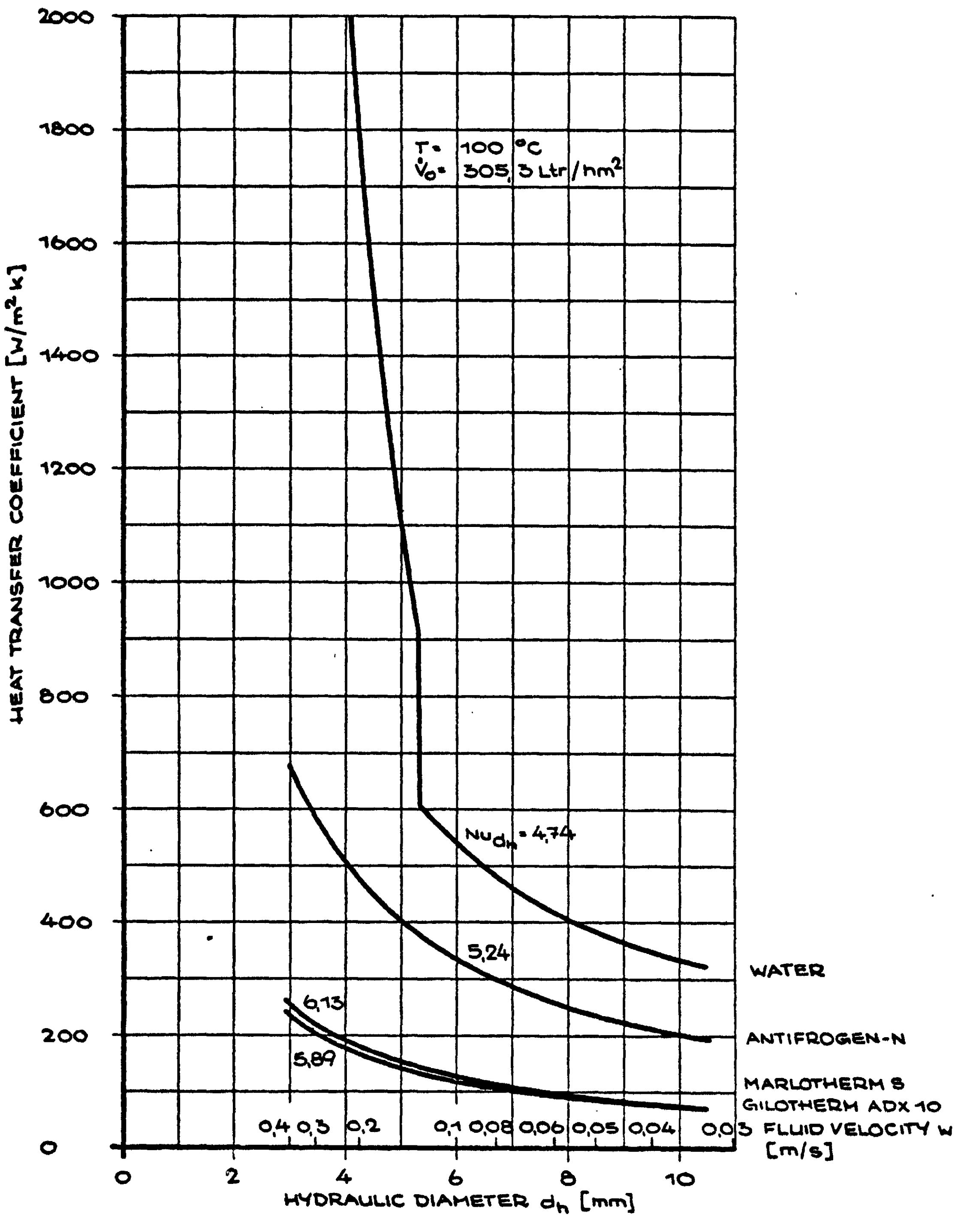


Fig. 5 HEAT TRANSFER AS A FUNCTION OF SINGLE CHANNEL HYDRAULIC DIAMETER AND TOTAL ABSORBER PLATE VOLUME FLOW, RESPECTIVELY FOR DIFFERENT WORKING FLUIDS.
CONSTANT FLUID VELOCITY ASSUMED.

Fig. 6 HEAT TRANSFER AS A FUNCTION OF SINGLE CHANNEL HYDRAULIC DIAMETER AND FLUID VELOCITY, RESPECTIVELY FOR DIFFERENT WORKING FLUIDS.
CONSTANT TOTAL COLLECTOR VOLUME FLOW ASSUMED.



$$\frac{\Delta p}{\rho} = \frac{8}{\pi^2} \lambda \dot{V}^2 \frac{l}{d_h^5}$$

or as a function of the flow velocity w

$$\frac{\Delta p}{\rho} = \lambda \frac{l}{d_h} \frac{w^2}{2} .$$

In both equations the coefficient of friction is a function of the Reynolds-number:

$$\lambda = \frac{64}{Re} \quad \text{for } Re < 2300 \text{ (laminar flow)}$$

$$\lambda = \frac{0,3164}{\sqrt[4]{Re}} \quad \text{for } Re \geq 2300 \text{ (turbulent flow)}$$

If the heat transfer coefficient is to be comparable for all of the above working fluids, one can calculate that the Reynolds-number must increase up to 10 times that of water. One can calculate from the above equations that because the working fluids except for water operate mostly with turbulent flow, the coefficient of friction decreases by only 56 %. Therefore a factor of ten increase in fluid velocity corresponds to about a 56 times higher pressure loss, provided that no additional change in the flow geometry has occurred.

Using Antifrogen-N a reduction of the hydraulic diameter with constant fluid velocity or constant volume flow leads to laminar flow of the order of the heat transfer coefficient of water (see Figs. 5 and 6).

For constant velocity the pressure loss varies proportinal to $1/d^2_h$. Compared with water the pressure loss increases to four times its original value if the diameter is halved. For constant volume flow the pressure loss varies proportional to $1/d^4_h$. If the diameter is chosen to result in an equal heat transfer the pressure loss increases to more than seven times its original value as compared to water.

These results show that the implementation of working fluids other than water has to be made with caution. For Antifrogen-N the best method of attaining a heat transfer equal to that of water is the reduction of the hydraulic diameter with constant flow velocity. All the other newly introduced synthetic or organic working fluids must be operated in the turbulent flow range by a large increase of fluid velocity if optimum heat transfer is preferred as opposed to pressure losses. In any case the circulating pump of such collector loops must be stronger than hot water pumps. It should be pointed out that the use of synthetic fluids or thermal oil introduces some new problems such as chemical resistance of the working fluid against oxidation, chemical resistance of the sealing materials against corrosive fluids, poisonous fluids, etc. These problems have not been completely solved up until now. The tendency to more effective solar energy components and systems will require the solution of these technological problem.

3.15 Realization of Different Collector Loops

As previoulsly mentioned in sec. 3.12 some means of heat storage is necessary when working with solar collectors in the E.C. One must design storage tanks so that they can store energy long enough to overcome bad weather conditions of up to a maximum of 8 days. Simple collector loops without storage tanks can be used only in countries with high solar insolation and a small heating demand. This is often the case for hot-water preparation and swimming-pool heating in the mediterranean countries.

The connection of the collector area with a storage tank either directly (open loop) or indirectly via a heat exchanger can be easily implemented without any excessive heat loss through the heat exchanger (see Fig.7)

The application of open collector loops introduce problems such as pressure build up due to the hydrostatical height of the collector installation in the storage tank, and also chemical corrosion. Since the working and storage fluids are identical in this case, additional costs due to extra anticorrosion and anti-freezing additives must also be provided for in the storage tank. To counter the hydrostatical pressure one has to employ expensive pressurized storage tanks. It is important to note that synthetic working fluids can be up to 2000 times more expensive than tap water. In particular large solar energy systems often require storage tank sizes in the order of 10 m^3.- This would lead to additional costs for such large volumes of specially treated storage mediums. These disadvantages clearly point to the implementation of closed collector loops with heat exchangers which can be optimized with respect to installation size and chemical compatibility with the working and storage fluid. One can then neglect the slight disadvantage of heat losses (up to $5^{o}K$) via the heat exchanger.

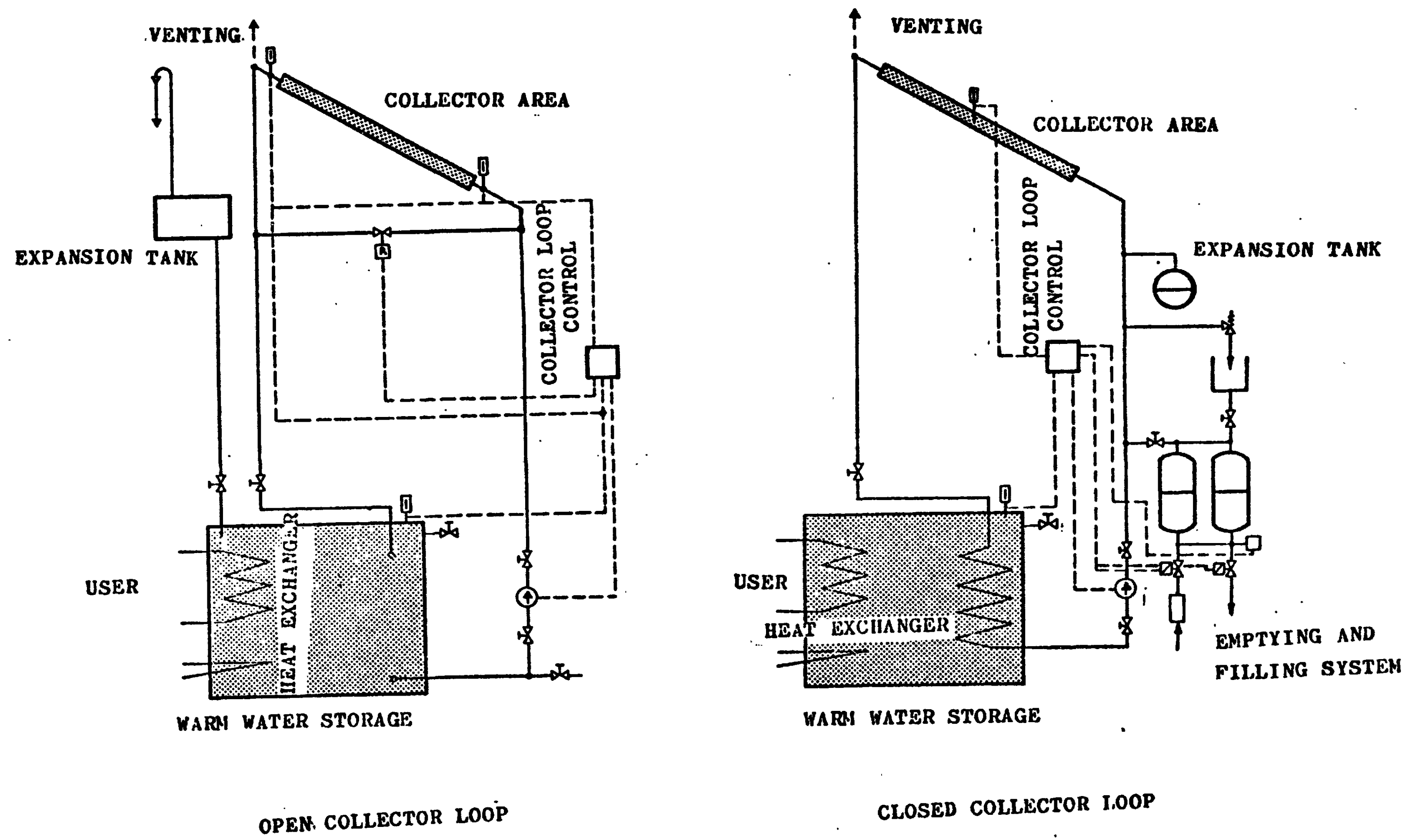


Fig. 7 Comparison of open and closed collector loops with possible solution for control and safety devices (Ref.5)

Simple collector loops which operate with the thermosiphon principle (see Fig. 8) are not suitable for applications in Middle-Europe. The high degree of cloudiness require a precisely controlled adaption of the operating mode to the weather conditions.

Thermosiphon systems were therefore not considered in the technical and economic calculations (see sec. 3.2 and ch. 4).

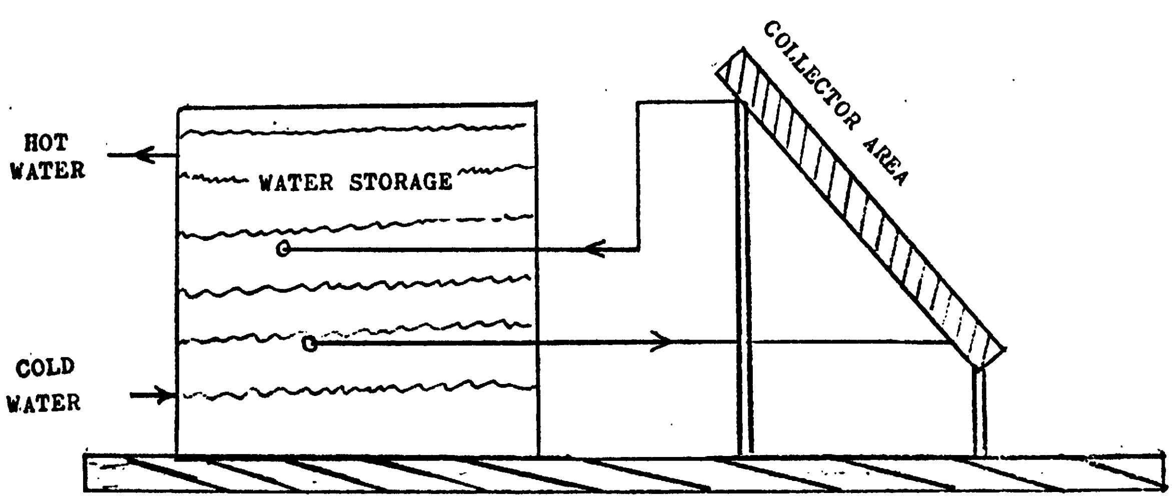


Fig. 8 THERMOSIPHON PRINCIPLE

3.2 Specific Applications of Solar Energy

3. 21 Hot Water Preparation

The most widely used application of solar energy to this date is the hot-water preparation for dwellings. The Thermosiphon technique Ref. 2 has been successfully used in Israel for over 10 years. The reasons why solar energy is so suitable for hot water preparation are the following:

- A relatively small collector area is necessary to cover a large fraction of the hot-water need.
- The conventional heating systems have a very low efficiency during the summer months when the space heating load is zero. What often happens is that the entire conventional heating system has to be turned on just to heat up 20 liters of hot-water. This would not occur with a properly dimensioned solar energy system, where one can usually count on 100% coverage of the hot-water demand during the summer months for a single family house with four occupants and 6 m^2 of collector area.

A schematic of a typical commercial solar energy system lay-out for hot-water preparation is shown in Fig. 9.

In the investigation of the applications of solar Energy for hot water preparation in the E.C. the following input information was assumed:

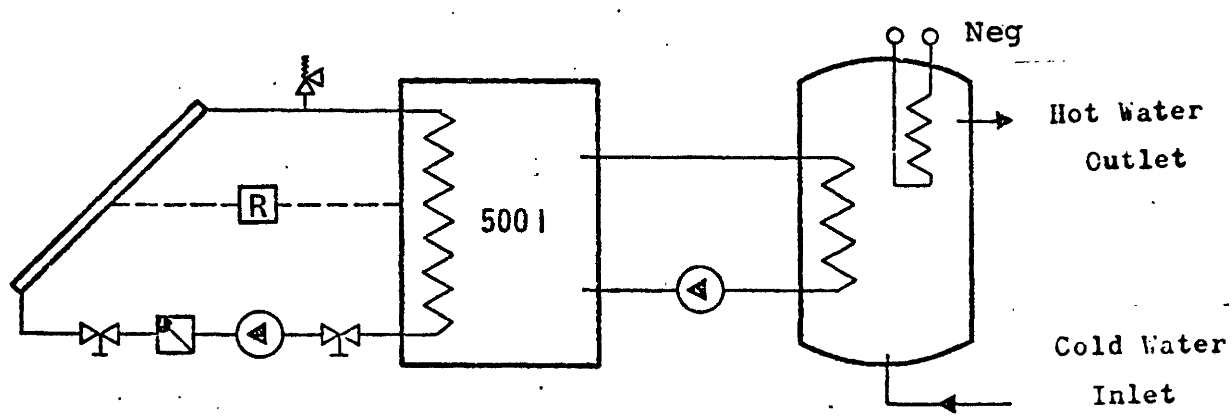


Fig. 9 A schematic of a typical commercial solar energy system lay-out for hot-water preparation.

- Application for a single house-hold with four occupants
- A hot-water need of 260 liters/day
- Water is heated from 10°C to 50°C
- 6 m^2 of collector area
- tilt angle of collectors with horizontal, 35°C
- collectors point directly due south
- storage tank volume .5 m^3
- Solar energy system lay-out as in Fig. 9
- conventional heating fuel is oil
- conventional heating system has boiler integrated with furnace
- ambient wind velocity 3 m/s

Fig. 10 shows a comparison of fuel savings for various collector types and E.C. countries using solar energy for hot water preparation. The ordinate shows the fraction of fuel saved in relation to the fuel required for hot water preparation only, to the conventional hot water heating need. The assumptions in the calculations are those that were discussed above. It is interesting to note that in each country the collector with a single glass selective absorber brings the highest fuel savings. One should note that in general the absolute fuel savings are larger for southern E.C. countries. However the relative fuel savings are also a function of the furnace efficiency, which decreases with decreasing energy demand (for both heating and hot water). One therefore should not be surpriced in Fig. 10 that the relative fuel savings do not vary drastically for countries with similar weather patterns.

Fig. 11 shows the fraction of fuel saved as a function of collector area for solar hot water heating for collectors with a single glass selective absorber and a double glass black absorber. It is interesting to note that for southern Italy the curve starts sloping downward when the collector area increases above 7 m^2. This is due to the fact that the storage volume of .5 m^3 is too small to accommodate all of the energy input from the collectors. This can often happen in sunny climates where the solar insolation is so intense that an appropriately designed system should be carefully calculated before implementation.

Fig.10 COMPARISON OF FUEL SAVINGS FOR VARIOUS COLLECTOR TYPES AND E.C. COUNTRIES USING SOLAR ENERGY FOR HOT WATER HEATING ONLY

BASIS:
6 m^2 COLLECTOR AREA
0,5 m^3 HEAT STORAGE TANK
35° INCLINATION
0° AZIMUTHAL DEVIATION
50°C HOT WATER TEMPERATURE
260 l/d HOT WATER DEMAND
3 m/s WIND VELOCITY

1 SINGLE GLASS, SELECTIVE ABSORBER
2 DOUBLE GLASS, SELECTIVE ABSORBER
3 SINGLE GLASS, BLACK ABSORBER
4 DOUBLE GLASS, BLACK ABSORBER

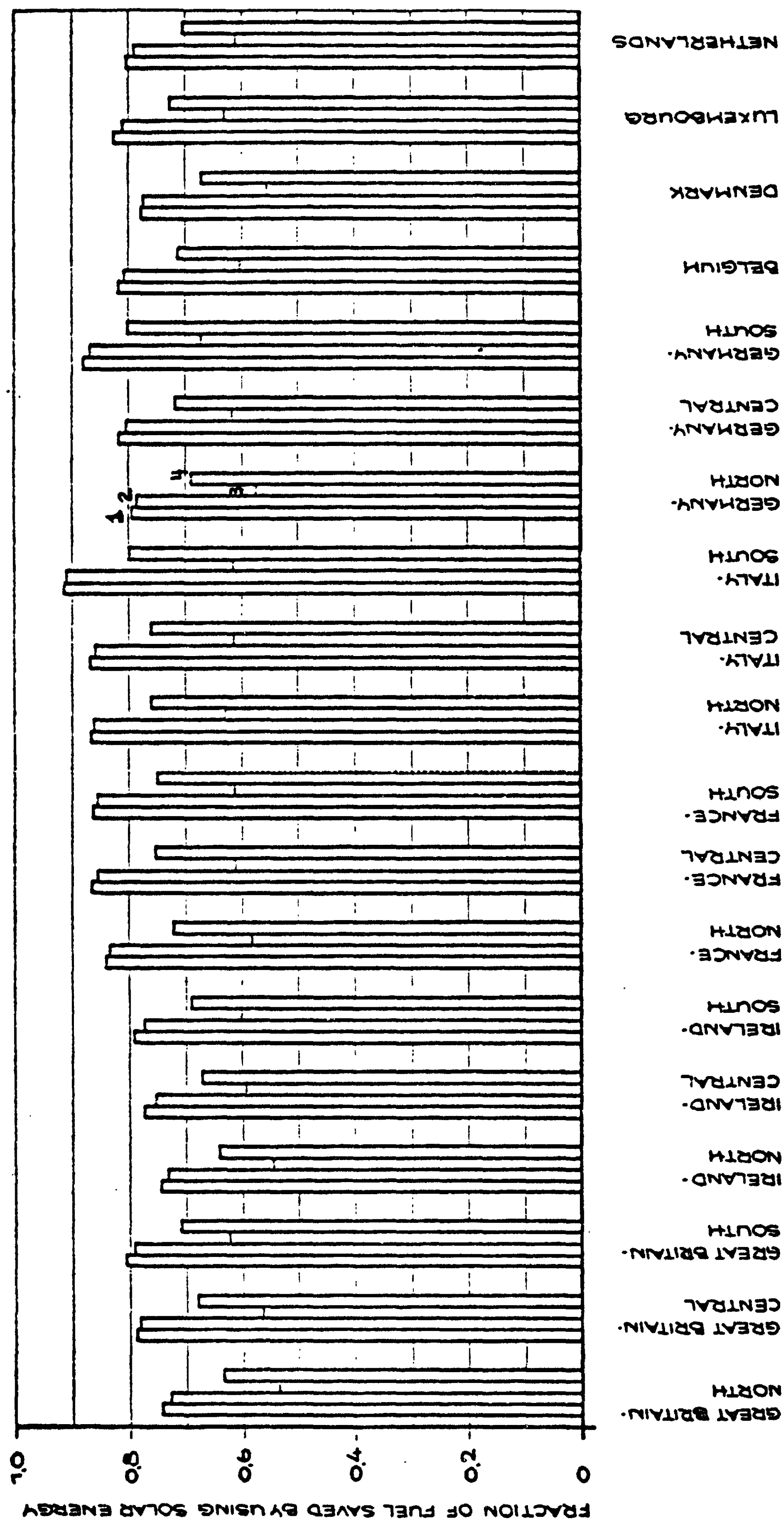
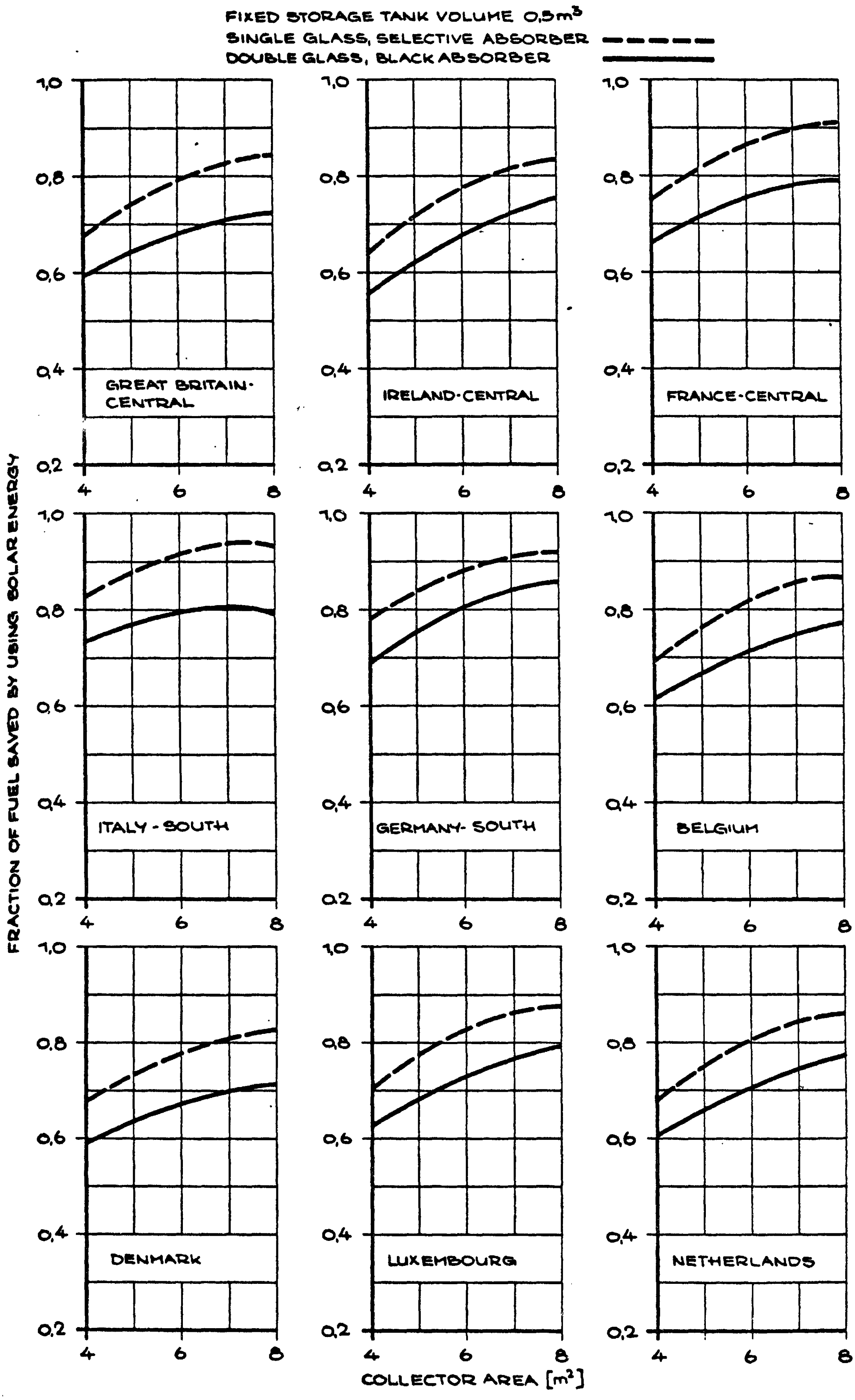


Fig. 11 FRACTION OF FUEL SAVED AS A FUNCTION OF EFFECTIVE COLLECTOR AREA FOR SOLAR HOT WATER HEATING



3.22 Space Heating and Hot Water Preparation

A schematic of a typical commercial solar energy system lay out for space heating and hot water preparation is shown in Fig. 12 A significant portion of the space heating and hot water load can be covered using solar energy if we correspondingly increase the size of the collector area.

In the investigation of the applications of solar energy for space heating and hot water preparation one adopted a so called "standard house".

The following input information was assumed: (Standard House)

- Single family House with four occupants
- Detatched House
- Desired year round room temperature 21°C
- Hot water need 65 liters/day per person
- Water heated from 10°C to 50°C
- The U-values of the floor, walls, and roof were taken to be .75 $\frac{W}{m^2K}$
- The U-value of the windows was 2.8 $\frac{W}{m^2K}$
- The window areas for the south, east, west and north walls were 5, 2, 2 and 2 square meters respectively
- The length, width, and height of the house were 12, 10, and 6.5 meters respectively
- Tilt angle of the roof with respect to the horizontal was 35°
- Roof faced directly south
- Conventional fuel-oil
- Heating distributed via Radiators
- Conventional heating system has boiler integrated with furnace
- Collector Area - 50 m^2
- Water storage tank volume - 5 m^3
- Ambient wind velocity 3 m/s

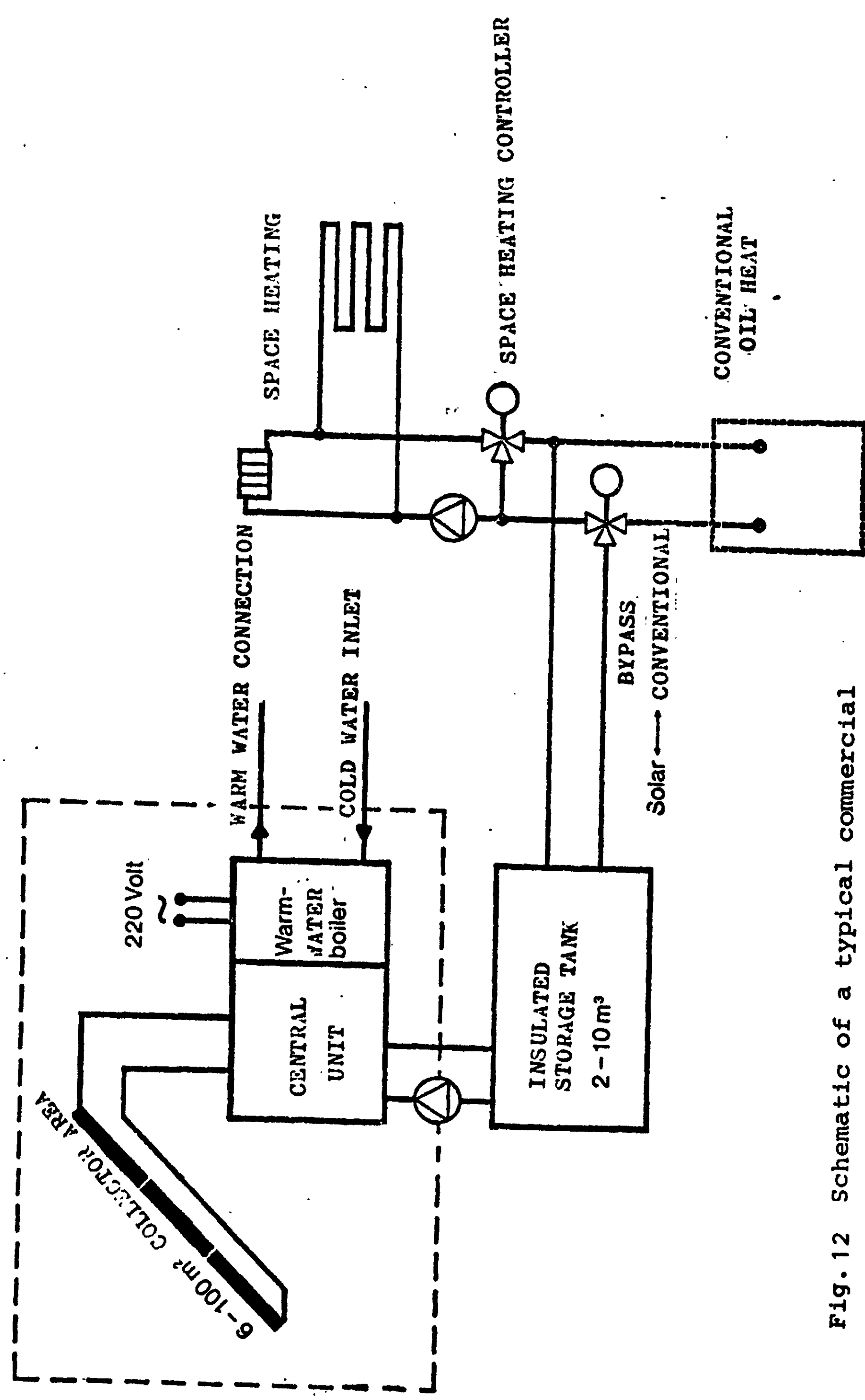


Fig. 12 Schematic of a typical commercial solar energy system lay out for space heating and hot water preparation.

Fig. 13 shows a comparison of fuel savings for various collector types and E. C. countries using solar energy for space heating and hot water preparation. The ordinate shows the fraction of fuel saved in relation of the fuel required for space heating and hot water to the conventional heating need. It is interesting to note that the fraction of fuel saved hovers around 50% for most of the countries in the E. C. The differences for the various collector types can readily be seen. The reason why the fraction of fuel saved in southern Italy is so large is due to the very small space heating load in the winter in southern Italy.

Detailed results of the simulation for all of the countries in the European Community in the case of space heating and hot water heating are shown in appendix A.

The heating system inlet temperature which is to a certain extent determined by the heating distribution network in the house, can effect the collector efficiency. The general rule of thumb is that the lower the heating system inlet temperature, the higher the collector efficiency. Floor heating usually involves maximum heating inlet temperatures around 40°C, where as radiator heating usually involves heating inlet temperatures around 60°C. The effect of the heating system inlet temperature on the fraction of fuel saved in the case of space heating and hot water preparation for all of the countries in the E. C. are shown both for the single glass selective absorber and the double glass black absorber in Fig. 14.

Fig.15 shows the fraction of fuel saved as a function of collector area for space heating and hot water preparation for a single glass selective absorber and a double glass black absorber. The only parameter that was varied from those fixed in the standard house was the collector area. For a summary of results see sec. 5.1.

Fig. 13 COMPARISON OF FUEL SAVINGS FOR VARIOUS COLLECTOR TYPES AND E.C. COUNTRIES USING SOLAR ENERGY FOR SPACE HEATING AND HOT WATER HEATING

BASIS:
- 50 m² COLLECTOR AREA
- 5 m³ HEAT STORAGE TANK
- 35° INCLINATION
- 0° AZIMUTHAL DEVIATION
- 0,75 W/m²K U-VALUE
- 60° C MAX. HEATING INLET TEMP.
- 4 PERSONS
- 3 m/s WIND VELOCITY
- STANDARD HOUSE

1. SINGLE GLASS, SELECTIVE ABSORBER
2. DOUBLE GLASS, SELECTIVE ABSORBER
3. SINGLE GLASS, BLACK ABSORBER
4. DOUBLE GLASS, BLACK ABSORBER

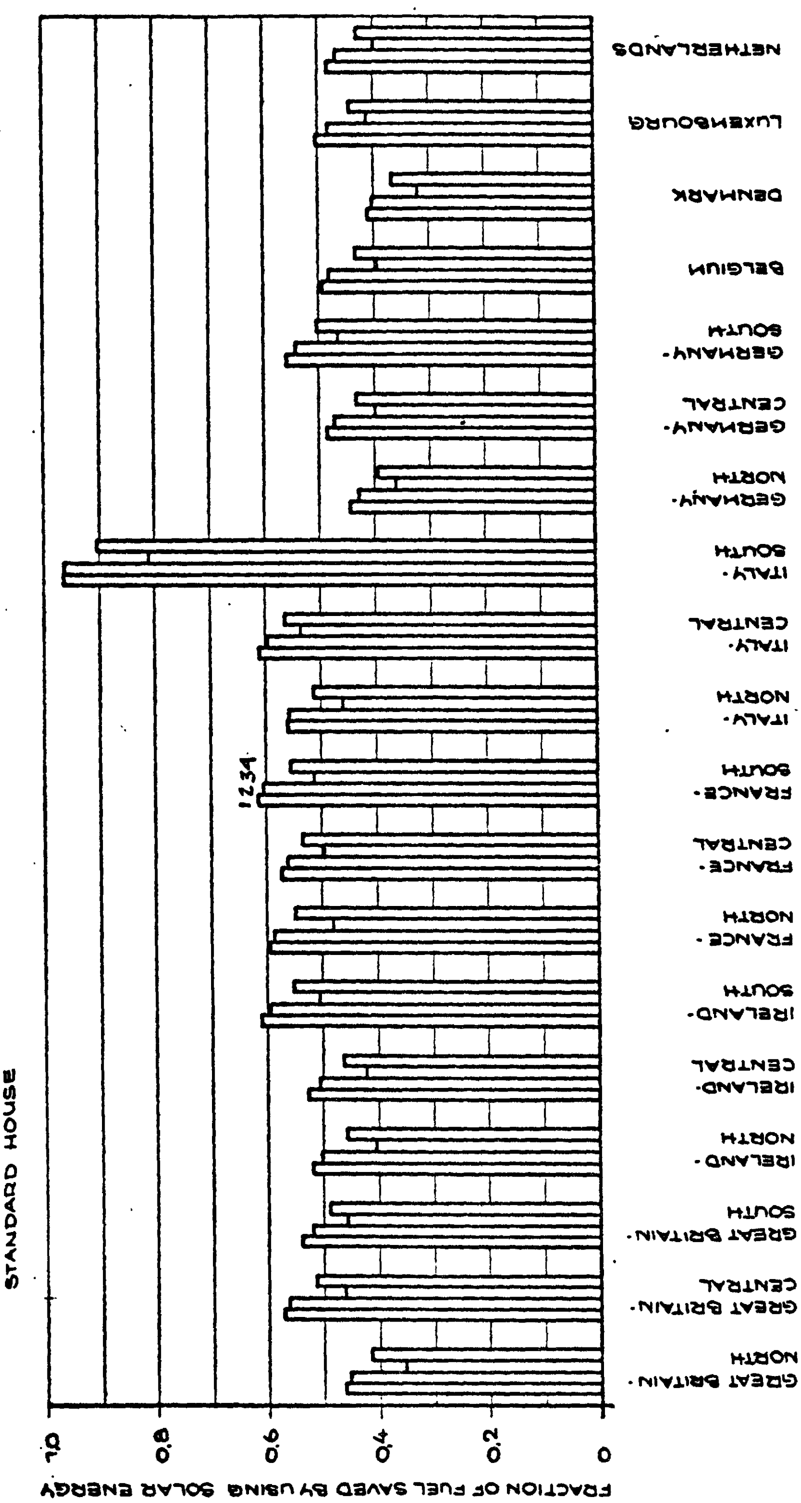


Fig. 14 FRACTION OF FUEL SAVED AS A FUNCTION OF MAXIMUM HEATING SYSTEM INLET TEMPERATURE (FOR SPACE-HEATING AND HOT WATER)

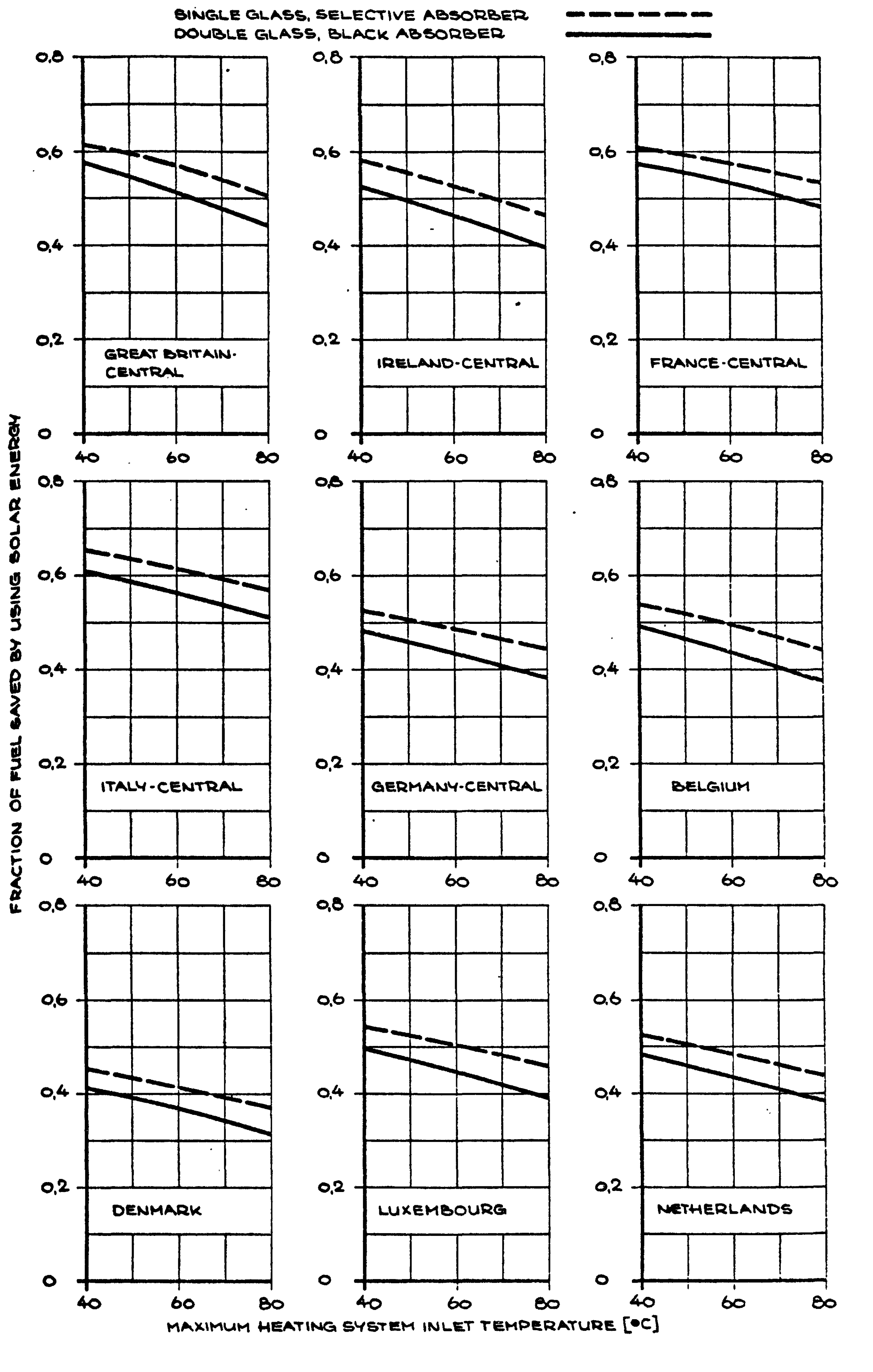
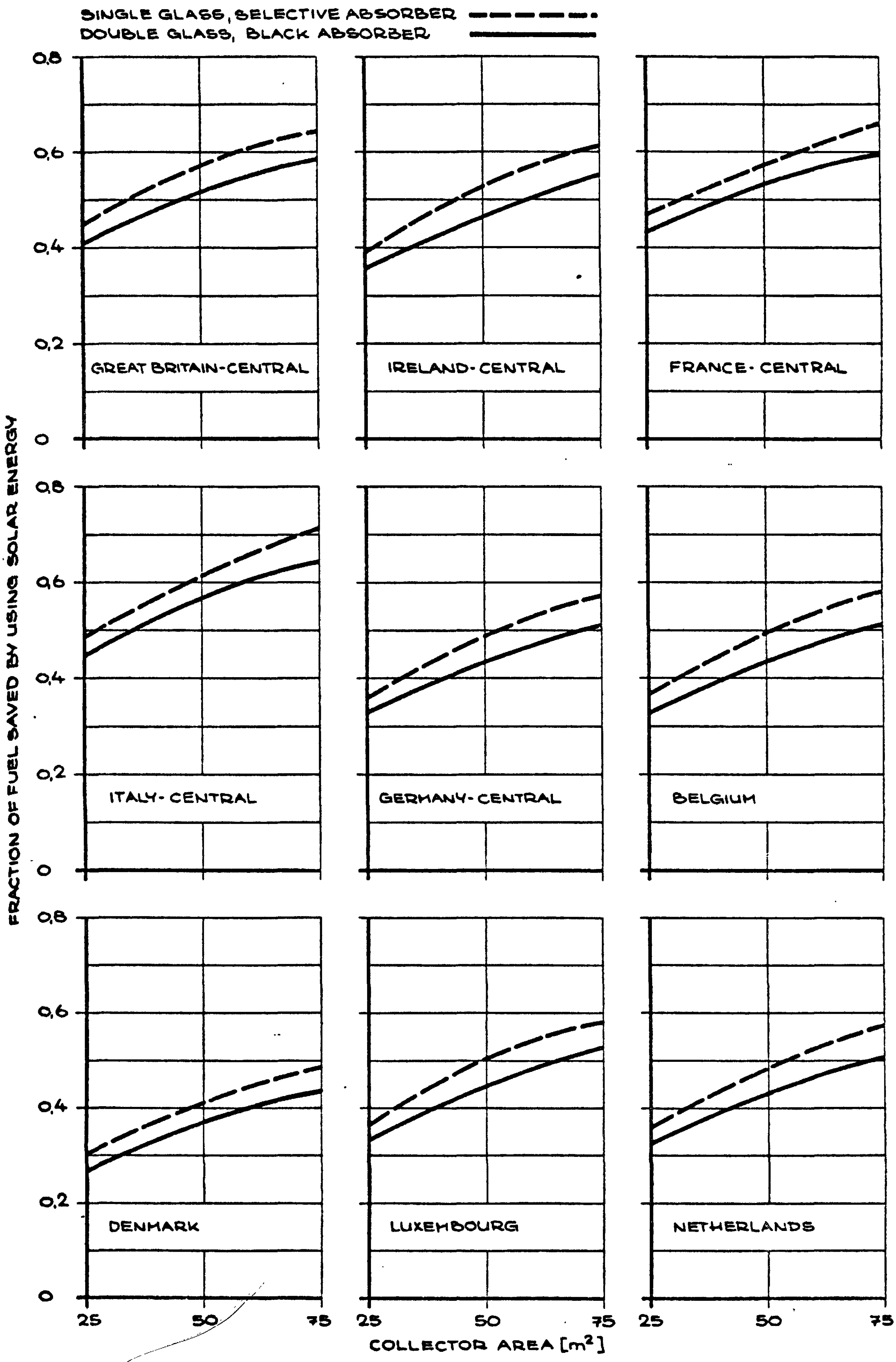


Fig.15 FRACTION OF FUEL SAVED AS A FUNCTION OF COLLECTOR AREA FOR $5 m^3$ STORAGE TANK (FOR SPACE-HEATING AND HOT WATER)



3.23 Outdoor swimming pool heating

One of the interesting applications of solar energy is in the case of outdoor swimming pool heating. Fig. 16 is an example of a schematic for a simple outdoor solar swimming pool heating system with a closed collector loop and a synthetic working medium. A computer simulation of the application of solar energy to small outdoor swimming pools was performed for all of the countries in the E. C. The basic parameters that were fixed were as follows:

(standard outdoor swimming pool)

- Heating season from April to September
- 40 m^2 of swimming pool surface area
- 50 m^3 of water in swimming pool
- Water temperature remained fixed at 24° C
- Average number of hours for bathing per day was 5 hours
- Swimming pool was covered with a plastic foil when not in use
- U-value of plastic foil cover was 4.5 W/m^2
- Average number of bathers per day was 4
- Average ambient wind velocity was 1.5 m/s
- Conventional heating fuel was oil

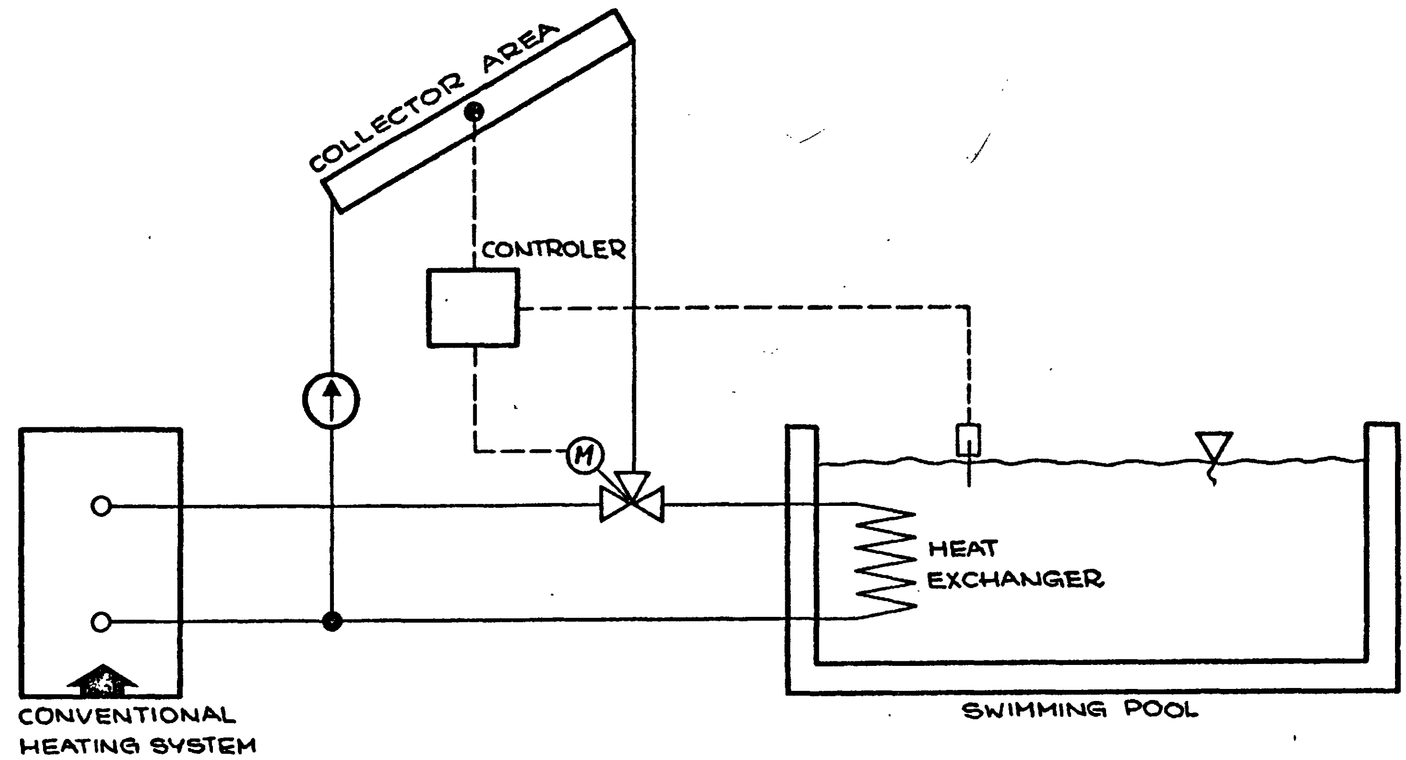


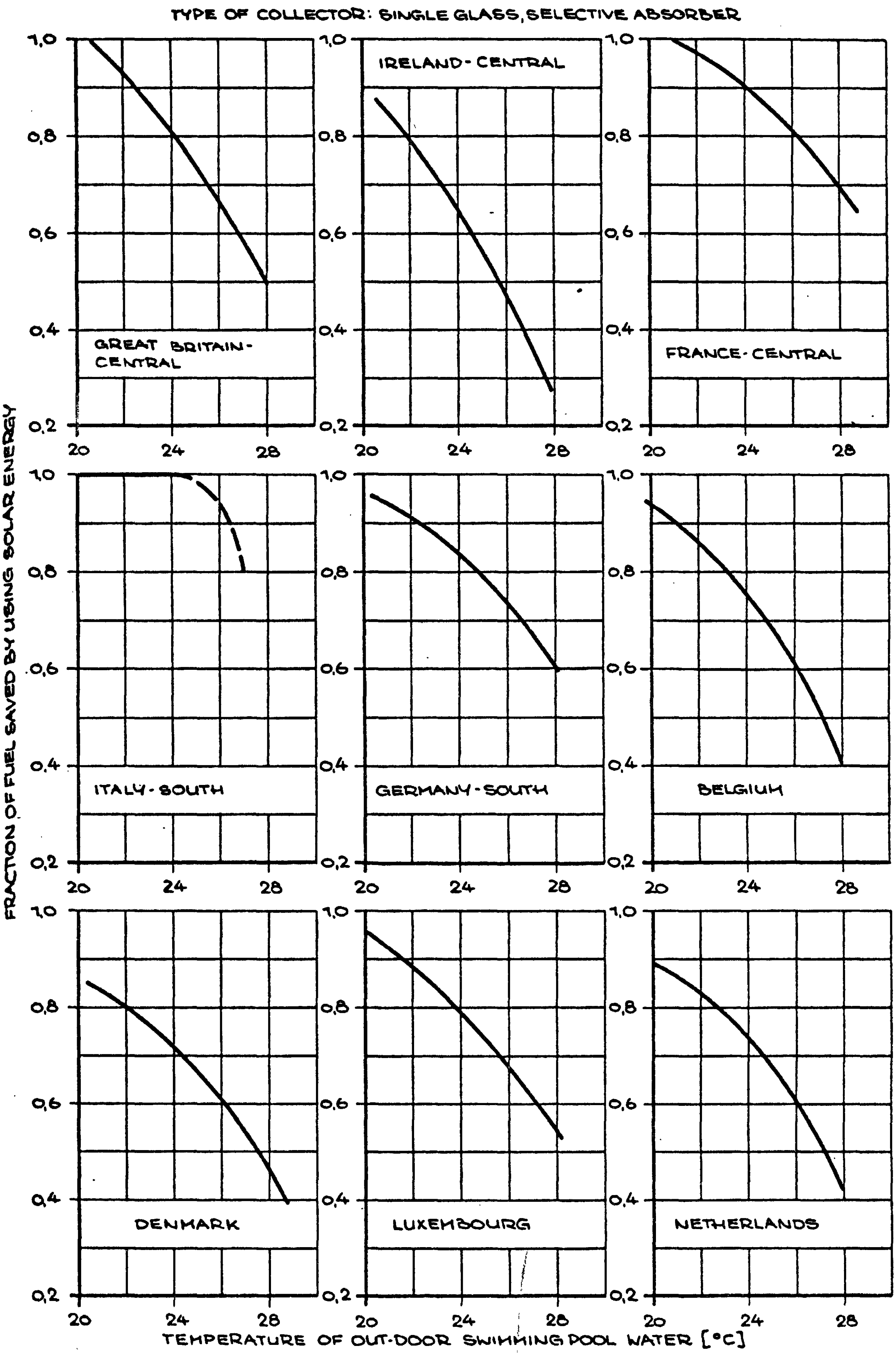
Fig. 16 EXAMPLE OF A SCHEMATIC FOR A SIMPLE OUTDOOR SOLAR SWIMMING POOL HEATING SYSTEM WITH A CLOSED COLLECTOR LOOP AND A SYNTHETIC WORKING MEDIUM.

- Single glass cover selective absorber
- 20 m^2 of collector area
- Storage tank volume was 50 m^3 (see Fig.16)
- Tilt angle of collectors was 40°
- Collectors pointed due south

It is important to note that the heating load for outdoor swimming pools is very strongly dependent upon whether or not the pool is covered when not in use. The heating load is also very dependent upon both the relative wind velocity and the desired swimming pool temperature. This is due to the fact that the major heat loss in outdoor swimming pools is due to the evaporation of the swimming pool water. The rate of evaporation strongly depends upon the temperature of the water, the temperature and humidity content of the ambient air, and the relative ambient wind velocities. By placing a plastic cover on the swimming pool, when not in use, one can strongly suppress the heat losses due to evaporation.

Fig. 17 shows the fraction of the fuel saved as a function of the desired water temperature for various countries in the E. C. The variables that were fixed in the simulation were those discussed above in the case of the "standard outdoor swimming pool". Detailed results of the simulation of the standard outdoor swimming pool for Belgium are given in appendix B.

Fig. 17 FRACTION OF FUEL SAVED AS A FUNCTION OF WATER TEMPERATURE OF A SOLAR HEATED SWIMMING POOL



3.24 Cooling

An absorptive cooling machine which is directly heated is the most appropriate cooling machine to couple with a solar collector loop. The cooling power and the type of absorptive medium in water determines the necessary generator inlet temperature. The generator inlet temperature range is from 75°C to 150°C. For average heating temperatures above 95°C the solar buffer storage tank has to be pressurized if water is used as the storage medium (see sec. 3.12). Fig. 18 shows the schematic for a typical single step absorption cooling machine and its connection to a highly efficient collector loop. The complicated internal thermodynamic cycles of the two phase mixtures $LiBr/H_2O$ or NH_3/H_2O are not discussed in this study. To understand the operation of such machines it is important to know their operating characteristics. Fig.19 shows (for a $LiBr/H_2O$ Arkla-solaire WF36 machine) the coefficient of performance (COP) as a function of the generator inlet temperature and the cooling water temperature in the condenser. The cooling water circulates in the recooling cycle. Fig.20 shows the absolute cooling power as a function of the variables in the previous figure.

The (COP) is defined as the ratio of the heat extracted from the air-conditioned area to the generator heating load. As can be seen in Fig.19 the most efficient region for operating the absorption machine is for a generator inlet temperature between 85 - 90°C.

One should note that the recooling cycle temperatures become more critical with increasing average outside air temperatures (i.e. applications in southern and tropical climates). Problems also arise in countries where either the available water temperature is above 32°C, or the water is so scarce that it is only used for drinking water or irrigation. If one uses evaporative cooling methods in the cooling tower the effectiveness of the cooling water in the recooling cycle can be improved. One can also use radiative cooling in the shaded region of the installed collector area in which case there is no cooling water lost due to evaporation or open convection.

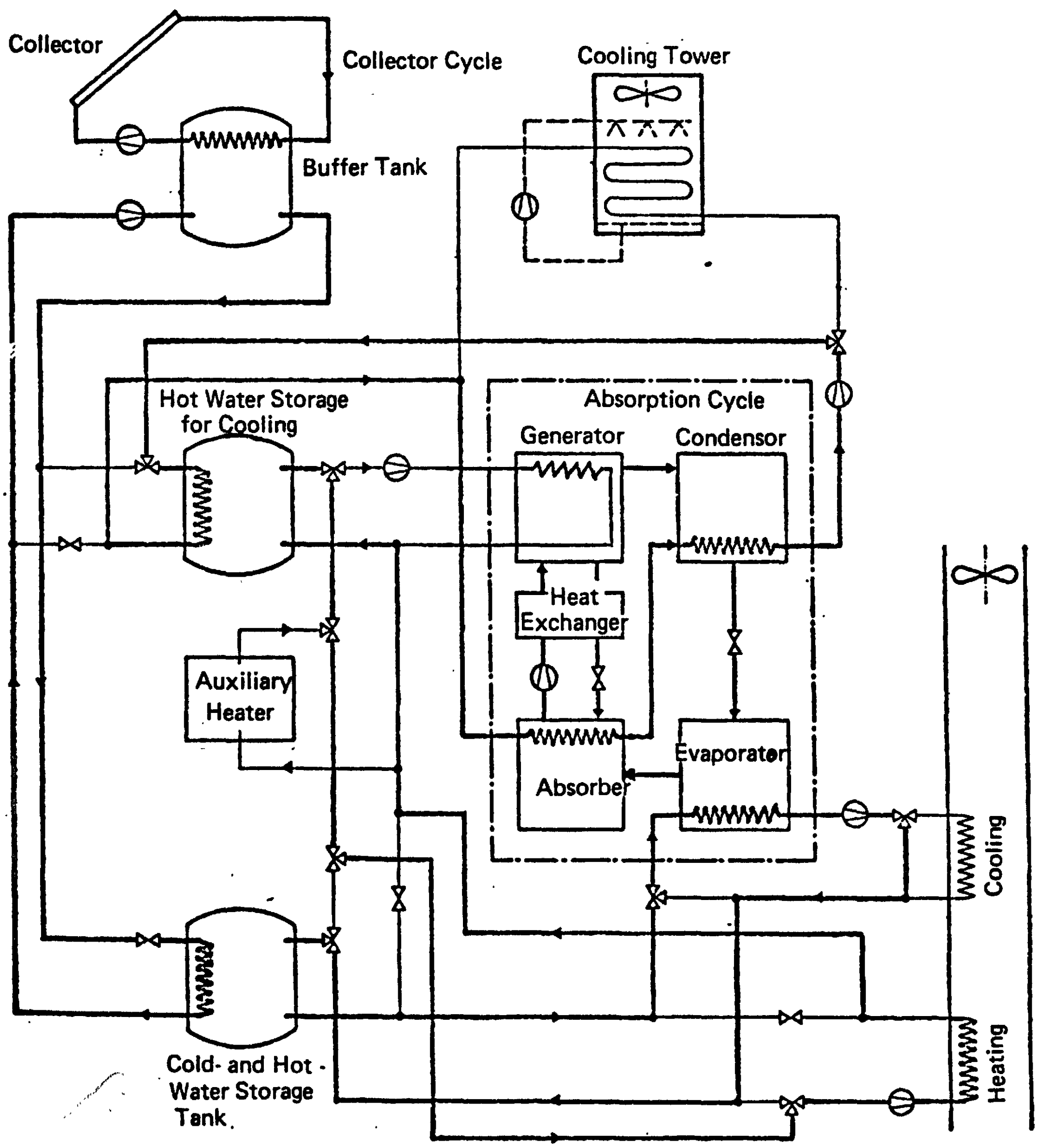


Fig. 18 Principle of Solar Thermal and Absorption Cycles for a Combined Heating and Cooling System

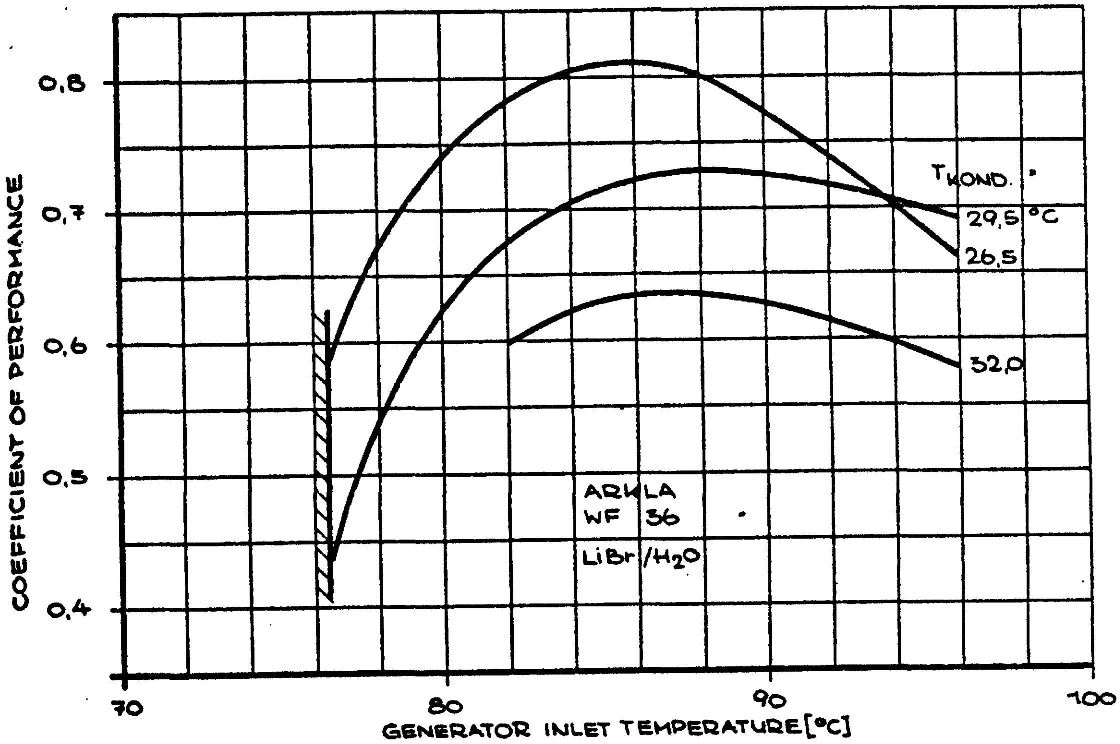


Fig. 19 COP as a function of the generator inlet temperature and the cooling water temperature in the condenser.

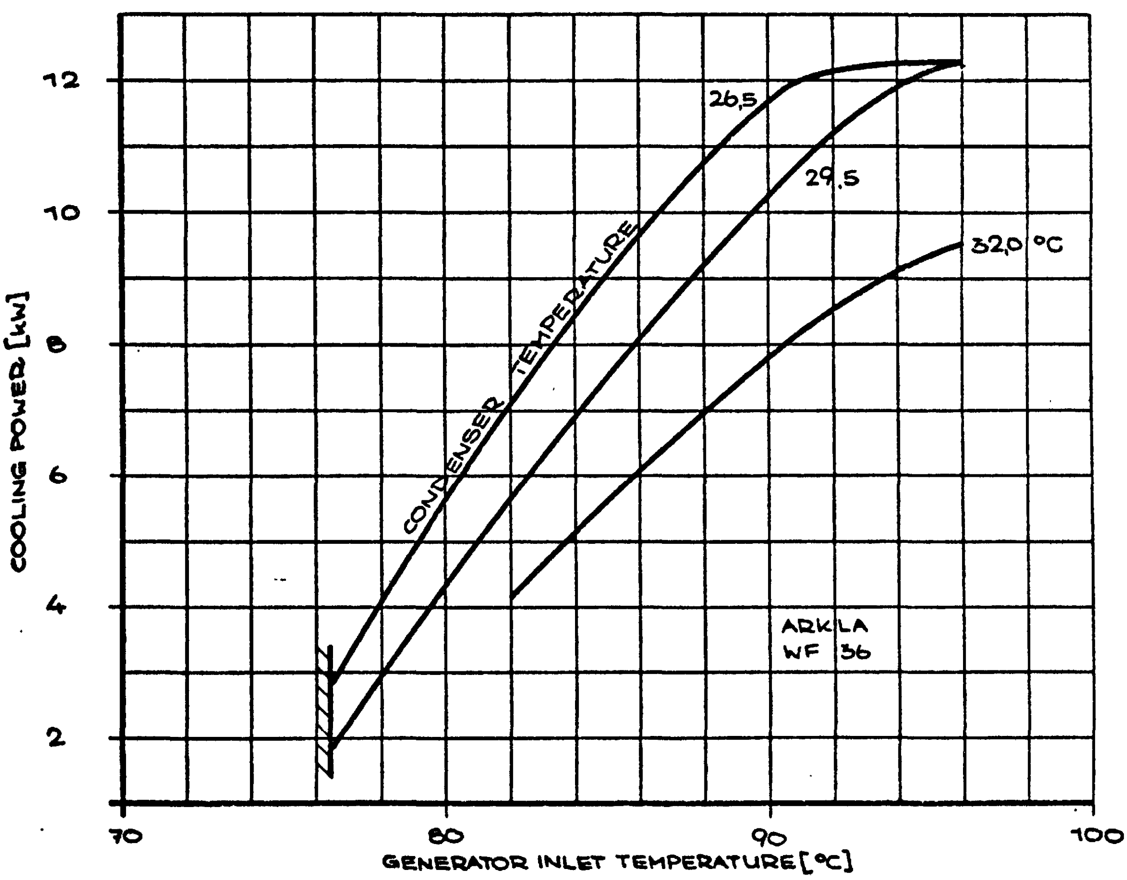


Fig. 20 Absolute cooling power as a function of the generator inlet temperature and the cooling water temperature in the condenser.

In the study a "black-box" method was adopted for the analysis of a typical solar cooling cycle as shown in Figs. 21 and 22. The boundary for the energy balance was the surface (walls, roof, and foundation) of the "Standard House" as described in sec. 3.22. In the analysis of the thermal behavior of the house, the air-conditioning needs, and the cooling system, the following effects over and above those of the standard house were considered:

- solar heating (space heating and/or hot water preparation) and cooling whenever a heating or cooling load existed. As determind from a monthly energy balance on the house (see sec. 2.1)
- thermal heat capacity of the house
- controls for heating and air conditioning as described in sec. 3.13
- storage tank temperature (from solar collector loop) equal to generator inlet temperature
- single glass, selective absorber
- minimum generator inlet temperature 85^{o}C
- condenser temperature from the recooling cycle depends on ambient air temperature
- cooling machine characteristics as described in Figs.19 and 20
- 50 m^2 collector area with single glass cover and selective absorber
- 5 m^3 heat storage tank with direct auxiliary oil heating

An example (for southern France) of the annual computer simulation calculation results for the above application which was performed for all E.C. countries, is given in appendex C. One should note that this calculation was performed with a desired house temperature of 21^{o}C. A comparison of this result with the reference simulation for solar space heating and hot water preparation (see appendix A for southern France, single glass selective absorber) shows the additional theoretical oil demand during the summer months June to September of about 514 liters/year assuming that the cooling machine were conventionally driven by oil. A comparison of the results for

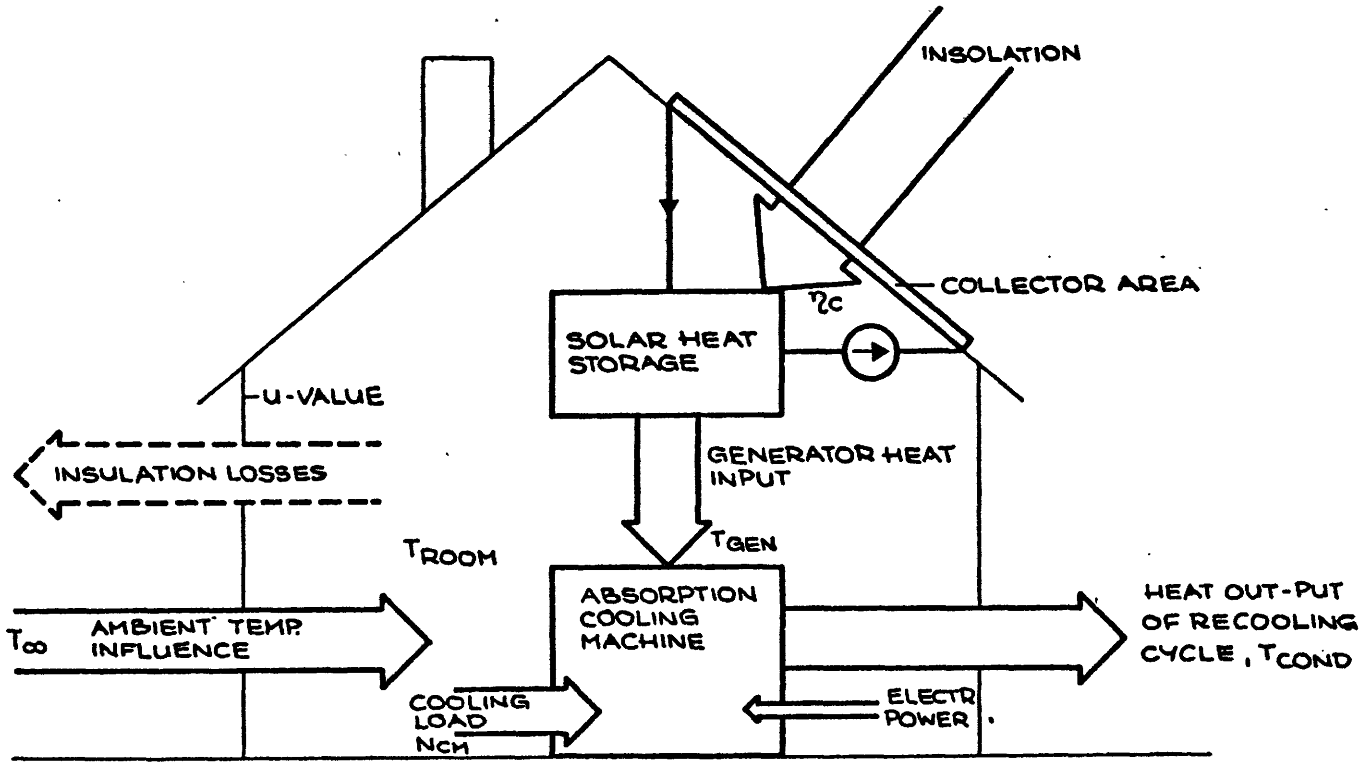


Fig.21 BLACK-BOX-METHOD USED FOR AN ENERGY BALANCE OF A HOUSE CONTAINING A SOLAR HEATED ABSORPTION COOLING SYSTEM FOR AIR CONDITIONING.

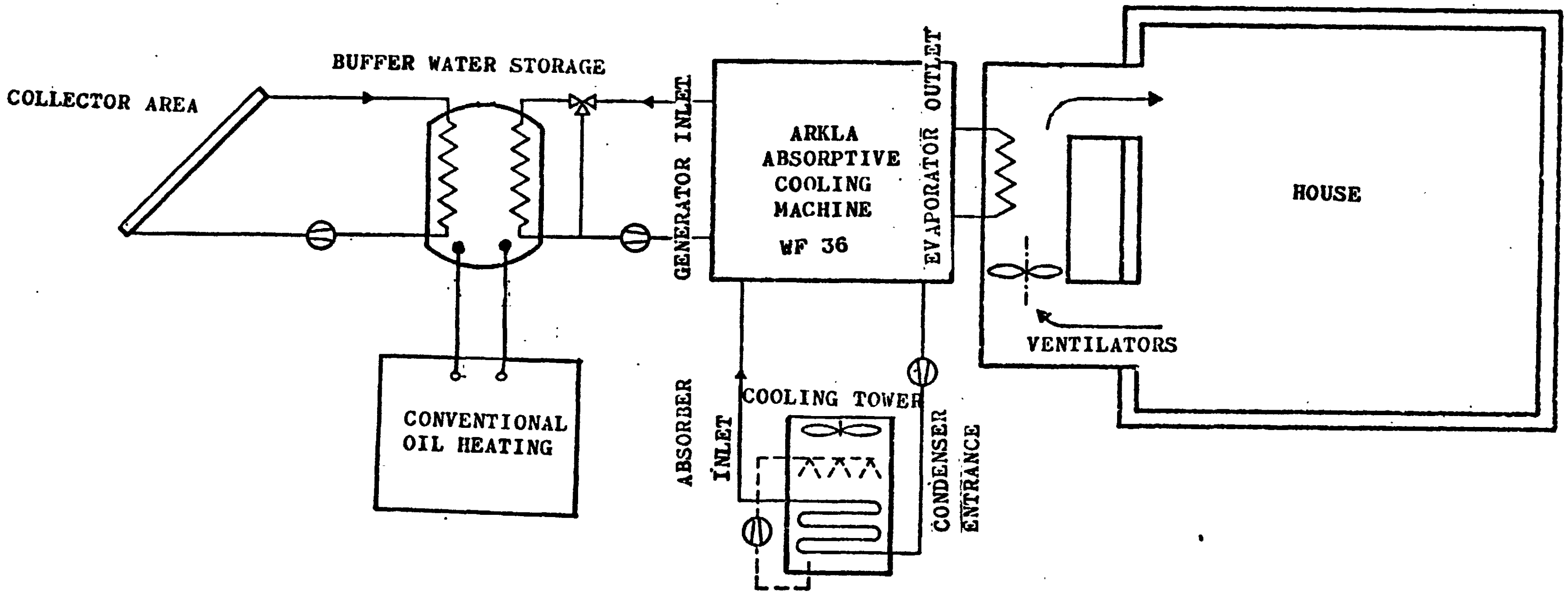


Fig. 22 A "Black-Box" schematic of solar cooling system

the annual oil savings with and without solar air-conditioning shows that the total cooling load can be satisfied from the "excess energy" stored in the storage tank. Although the total theoretical oil demand increases from 3108 liters/year to 3622 liters/year due to the cooling load, the relative annual oil savings increases from 61.7% to 67.2%. In the second part of the tabulated results given in appendix C, some characteristic operation parameters of the cooling cycle appear. One of the parameters that appear is the average number of hours per day that the cooling cycle operates (DT). The calculated values of 1.4 to 5.7 h/day indicate a suitable adaption of the cooling power range to the cooling load of the "standard house" in southern France. One should note that the collector area was not optimized. One could however optimize the solar system size with respect to an economical application of a combined solar heating and cooling cycle.

Table 9 summarizes the essential results of the simulation calculations for all of the climatic regions in the E.C. From the table one can see three country groupings for the application of solar cooling cycles:

1) In Great Britain, Ireland,Belgium, Denmark and the Netherlands there is no economical application of solar cooling due to the negligible cooling load.

2) In Germany and Luxembourg solar cooling is feasible due to a reasonable cooling load during three months of the year. The maximum average daily operating time of the cooling machine is about 3 hours.

3) In France and Italy solar cooling is suitable if the complete solar cooling and heating system is properly dimensioned. For applications in Italy the cooling power (10.6 KW) of the cooling machine under investigation seems to be under demensioned. The average calculated operating times of 10 - 18 h/day

Table 9 Results of Annual Simulation for Heating and Cooling of the Standard House in different EC Countries

COUNTRY	ADDITIONAL OIL DEMAND FOR COOLING (ltrs/year)	TOTAL OIL DEMAND (ltrs/year)	TOTAL ANNUAL OIL SAVINGS (%)	MONTHS OF COOLING LOAD	MAXIMUM DAILY AVERAGE OPERATION TIME (h)
GREAT BRITAIN					
- North	0	4368	46.3	0	0
- Central	163	3512	59.2	2	2.5
- South	198	4017	56.1	2	3.0
IRELAND					
- North	0	3820	51.9	0	0
- Central	0	3839	52.7	0	0
- South	0	3329	61.1	0	0
FRANCE					
- North	194	3659	61.7	2	3.0
- Central	424	3988	61.8	4	4.7
- South	514	3622	67.2	4	5.7
ITALY					
- North	797	4284	64.2	5	11.9
- Central	787	3974	69.0	5	9.9
- South	1216	3377	97.9	6	18.3
GERMANY					
- North	182	4661	46.6	2	2.9
- Central	253	4511	51.5	3	3.1
- South	302	4506	59.0	3	3.8
BELGIUM	0	4277	49.4	0	0
DENMARK	166	4794	43.2	2	2.7
LUXEMBOURG	267	4423	53.3	3	3.4
NETHERLANDS	156	4333	50.5	2	2.4

are unusually high and would lead to premature demise of the machine. In France and Italy the annual cooling load period lasts from 4 to 6 months. Therefore the additional capital investments (for the cooling cycle) may be worth while.

The results of the computer simulation clearly confirm the suitable application of solar cooling cycles in southern and tropical climatic zones.

The optimization of system size and operating parameters of solar cooling cycles which were not performed in this study could be investigated in a future study.

3.25 Influence of collector tilt angle and azimuth on fuel savings

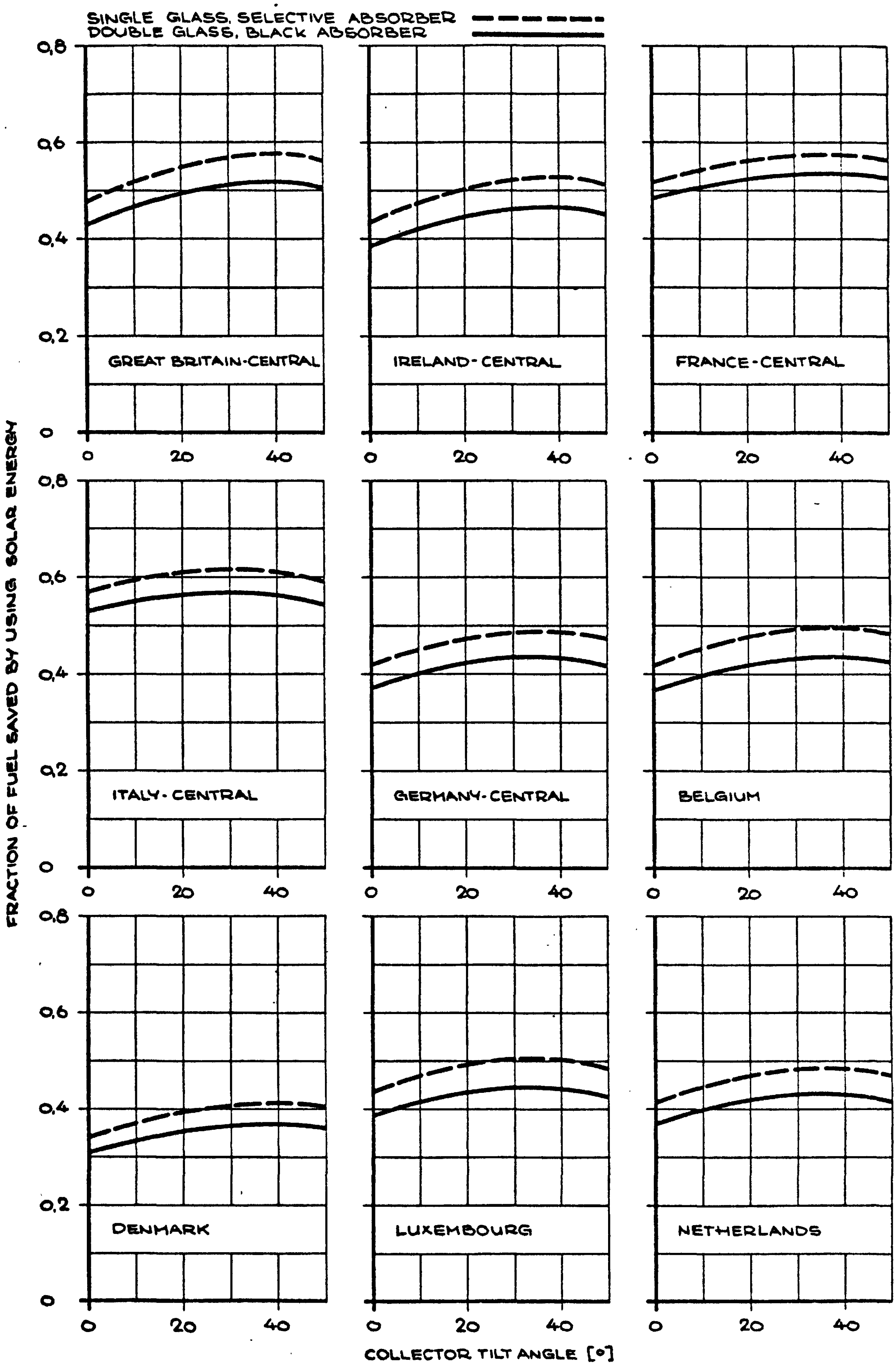
The amount of energy incident on a collector surface depends on many parameters, one of which is the tilt angle of the collector with respect to the horizontal. It is a well known fact that the suns trajectory in the sky is different for each day of the year. The suns trajectory in the sky appears much higher in the summer time than in winter time. It is therefore clear that the tilt angle of the collector with respect to the horizontal is an important parameter in determining the amount of solar energy incident upon a collector. Most collectors are mounted on the roof of the house. It is then the tilt angle of the roof that determines the tilt angle of the collector. One very important fact that is often neglected in the determination of the ideal tilt angle of the collector is the extent of the diffuse component of solar radiation. The larger the diffuse component the smaller the gain in insolation from the tilt. In our computer simulation this fact was considered in determining the optimum tilt angle of the roof. in the application to space heating and hot water preparation. *

Fig. 23 shows the fraction of fuel saved as a function of collector tilt angle for space heating and hot water for both the single glass selective absorber and the double glass black absorber for the countries in the E. C. The input parameters to the computer simulation program were those that were defined for the standard house in section 3.22. The only parameter that was varied was the tilt angle of the roof. The maxima in the curves in Fig. 23 indicate the optimum tilt angle for each country.

The insolation incident on a collector depends not only on the tilt angle of the collector but also to a certain extent on the orientation of the collector surface. Since the sun rises in the east and sets in the west, the ideal orientation of the collector is to have the collector face due south. As is often the case most existing houses don't

*Please note that for a given house that the tilt angle of the roof also effects the size of the roof and thereby the heat load, In all calculations we assumed that the roof volume is part of the living area.

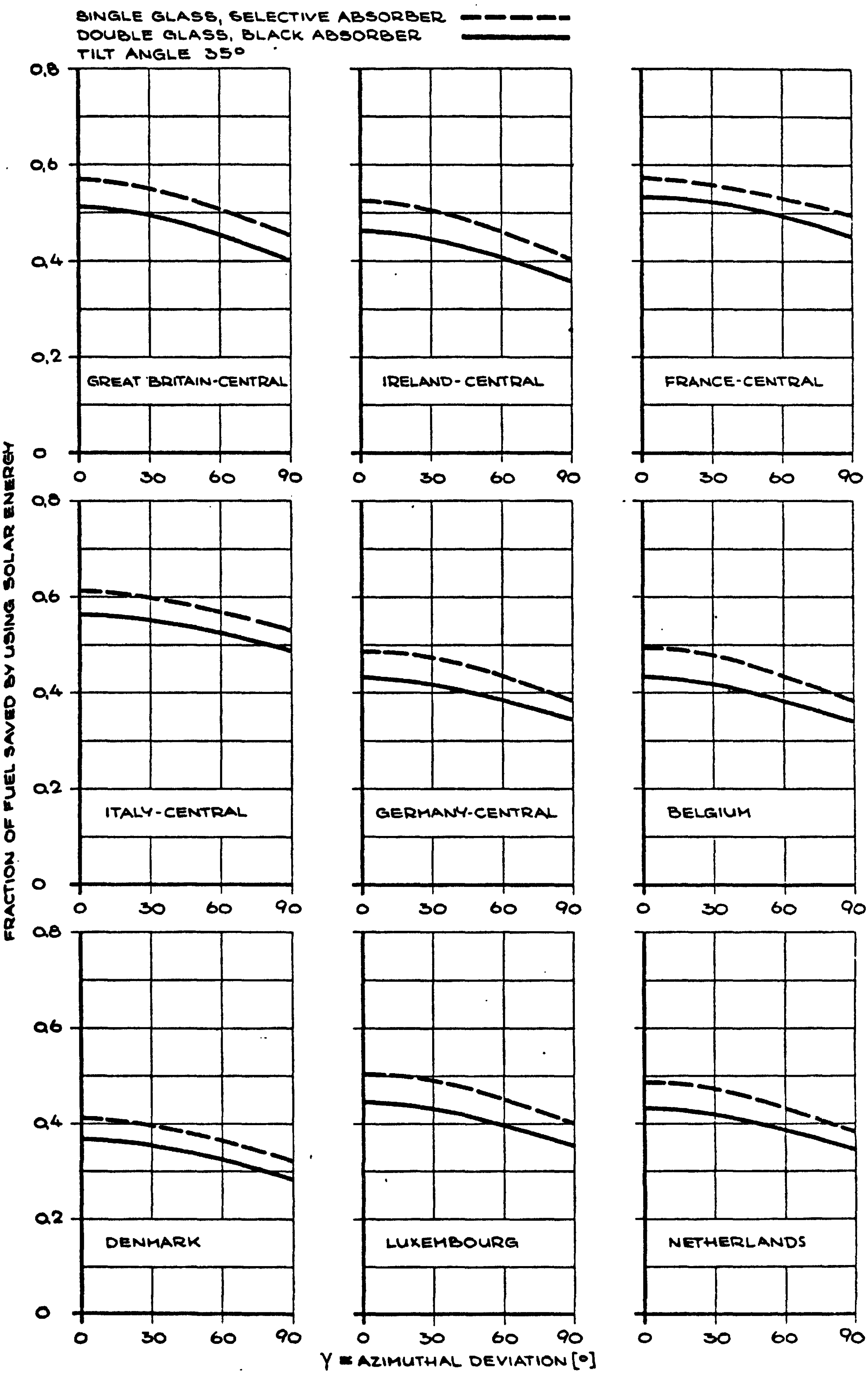
Fig. 23 FRACTION OF FUEL SAVED AS A FUNCTION OF COLLECTOR TILT ANGLE (FOR SPACE-HEATING AND HOT WATER)



have the normal to the roof facing due south. To investigate the effect of the azimuthal deviation (i. e. $\gamma = 0$ means collectors face due south, $\gamma = 90^{o}$ means collectors face due east) on the fraction of fuel saved for each of the countries in the E. C. a computer simulation was performed. The input paramters to the computer simulation program were those that were defined for the standard house. The only parameter that was varied was the azimuthal deviation from the south.

Fig. 24 shows the fraction of fuel saved (for space heating and hot water) as a function of azimuthal deviation from the south for both the single glass selective absorber and the double glass black absorber for each of the countries in the E. C. assuming a tilt angle of 35^{o}.

Fig. 24 FRACTION OF FUEL SAVED AS A FUNCTION OF AZIMUTHAL DEVIATION FROM THE SOUTH (FOR SPACE-HEATING AND HOT WATER)



3.26 Influence of House insulation on Energy and fuel Demand

The single most important parameter in determining the heat load of a house is the U-value of the insulation. The smaller the U-value the smaller the heat load. A computer simulation was performed to investigate the dependence of the heat load and the fuel demand as a function of the insulation of the house. As a basis for the simulation the standard house described in sec. 3.22 was used. The only input parameters that were varied were the U-values of the walls, roof, and floor. To simplify the analysis of the results the insulation of the house was varied as follows:

Well insulated house U-value of walls, roof, and floor = .5 $\frac{W}{m^2K}$

Moderately insulated house
U-value of walls, roof, and floor = .75 $\frac{W}{m^2K}$

Poorly insulated house
U-value of walls, roof, and floor = 1.0 $\frac{W}{m^2K}$

In all three cases the U-value of the windows was taken to be 2.8 $\frac{W}{m^2K}$.

Fig. 25 shows a comparison of the annual heat load for various E. C. countries and average U-values (for space heating and hot water). Fig. 26 shows a comparison of the annual oil demand for the standard house in various E. C. countries and for the three different values of the insulation. It is interesting to note that the difference in the oil demand between the poorly insulated house and the well insulated house is almost a factor of two in countries where there is a large heat load. One cannot emphasize enough the importance of a well insulated house in the energy saving schemes that are available to the

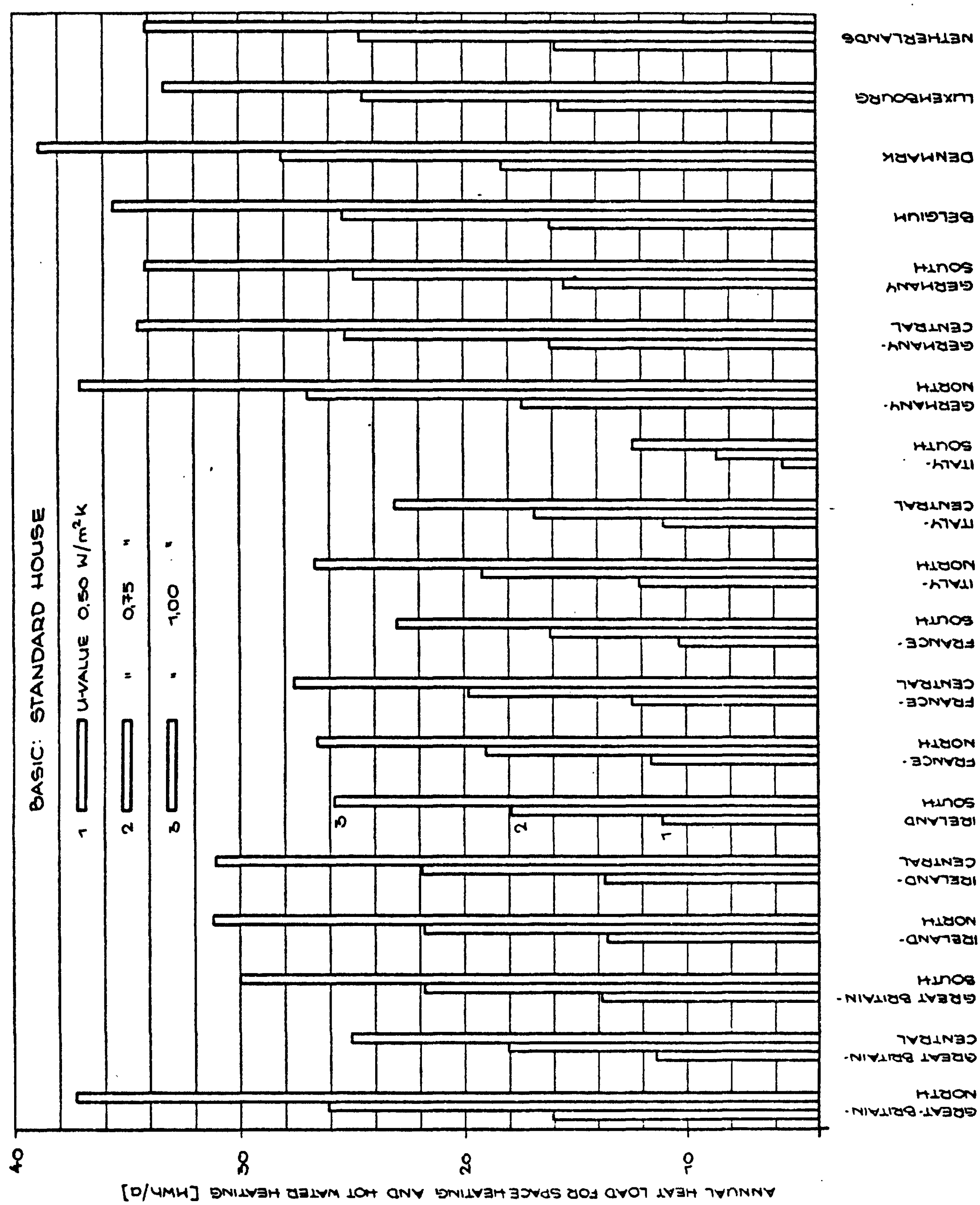


Fig. 25 COMPARISON OF ANNUAL HEAT LOAD FOR VARIOUS E.C. COUNTRIES AND AVERAGE U-VALUES (FOR SPACE-HEATING And Hot Water)

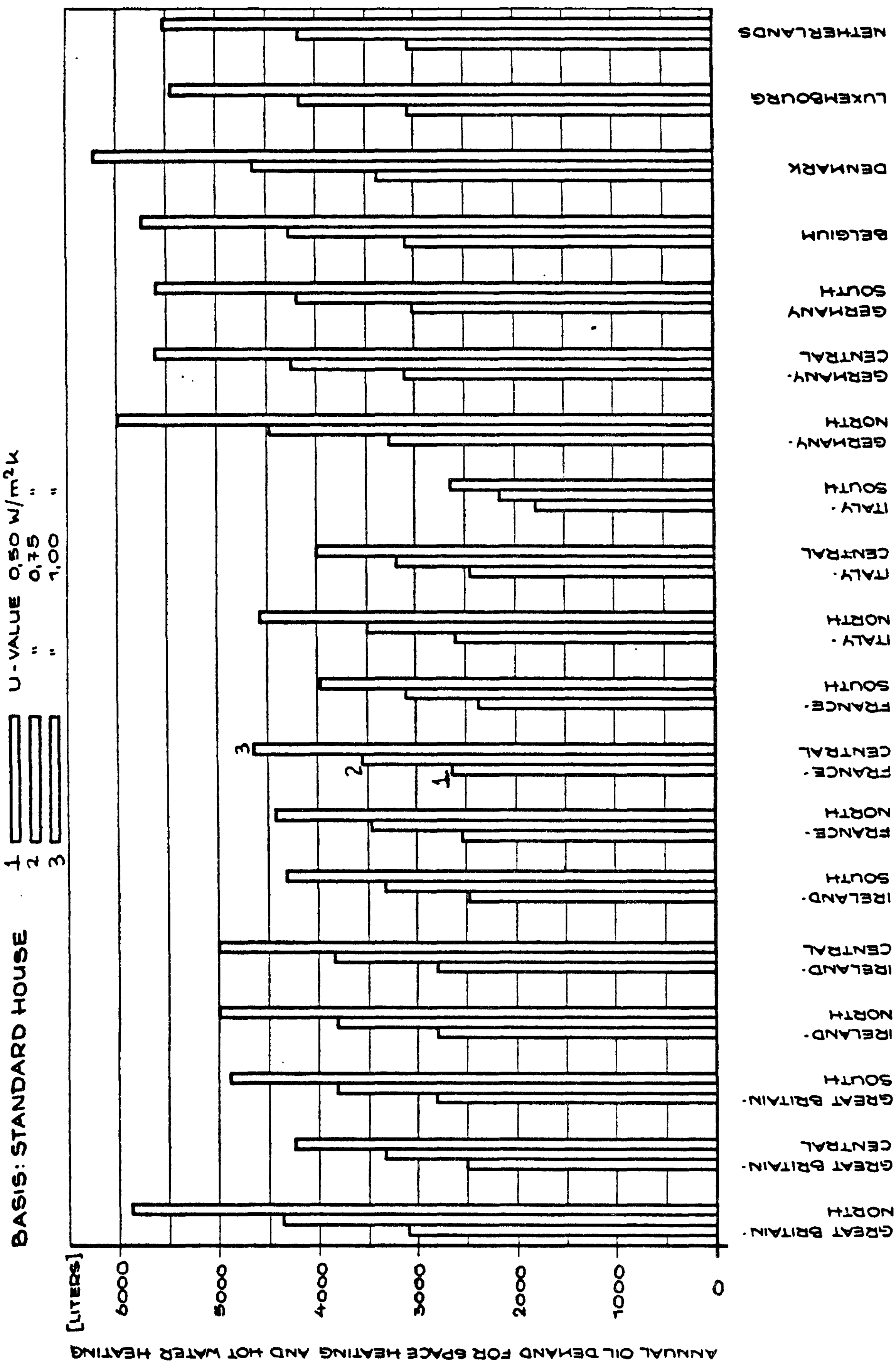


Fig. 26 COMPARISON OF ANNUAL OIL DEMAND FOR VARIOUS E.C. COUNTRIES AND AVERAGE U-VALUES (FOR SPACE-HEATING AND HOT WATER)

average home owner. Indeed many governments have realized this and are just now beginning to promote tax-incentives, and new building code requirements, with a big emphasis on properly insulating a home.

In the comparison of Figs. 25 and 26 one should note that the fuel demand does not depend linearly on the load. This is due to the dependece of the furnace efficiency on the heating load.

3.3 Combination of Solar Energy and Heat Pumps

The concept and technical application of heat pumps date back to before world war II. Heat pumps have now become popular in connection with the research and development of solar thermal heating systems.The philosophical concept of the heat pump as an indirect user of solar energy will not be discussed. Under the assumption that heat pumps can be used as an auxiliary heating system to solar heating systems one has to analyze the effectiveness as well as the total investment costs. There have been several investigations in this field (see Ref. 3 and 4). For this reason only the essential facts relating the combination of heat pumps and solar heating systems will be summarized.

From a purely physical viewpoint heat pumps are used to transfer energy from a colder body to a warmer body. If a water to water heat pump is connected between a solar storage volume of a collector cycle and a heat load, then this technique is referred to as the "cold storage" method. This technique is partially justified because it results in a decrease of the collector inlet temperature and there by an increase of the collector efficiency. Other investigations have shown that this gain in collector efficiency doesn't justify the additional personell and material costs.

The conventional application of heat pumps is more suitable technically and economically. In the conventional application heat is transferred from the ambient air or water (ground water, nearby rivers, or soil moisture) to the heat load in the house. There exist however some disadvantages which hinder it's implementation into the market, for example:

- Lower limit (3°C) on ambient air temperature when using an air to water heat pump. If the lower limit were reached, one would have to electrically heat the evaporator. This would clearly be uneconomical.

- In times of high electricity demand one is often prohibited from plugging in an extra electrical load. This may occur in cold winter months at the time when the heat pump could be technically more efficient than solar heating systems.

- Investment costs are of the same order of magnitude as those of solar heating systems with comparable output. The investment costs include among others: Inlet vent installation (noise suppressors) when using air to water heat pump, or well digging in the case of water to water heat pumps, or large evaporator tubes which have to be laid in the case of soil moisture to water heat pumps. Furthermore one needs control devices for operating the heat pump.

- High operating costs despite reciprocal thermal efficiencies (P.E.R.) of 1.8 - 2.8 (average annual values). The high operating costs are due to the high costs of electricity. In most countries one has to pay a minimum electrical rate which depends on the maximum power need. This minimum cost is naturally higher with the implementation of a heat pump. Where as in the case of solar energy there are very little additional electricity costs.

Considering these disadvantages (with few exceptions) the electrically driven heat pump is not a desirable alternative as compared to other solutions to the energy problem.

The following alternatives are more economically suitable:

- Natural gas driven compression heat pump implementation, as soon as the noise and short life expectancy have been solved.

- Natural or liquid gas directly heated absorption heat pump implementation as soon as the high initial investment costs can be strongly reduced (ref. 4).

In general one can determine that the combined or separate application of heat pumps and solar heating systems are suitable when the following conditions are met:

- Very high annual heat load with inappropriate house orientation and/or roof geometry with respect to the installation of solar collectors.

- House is located near a river which has been thermally polluted.

- Heating of large public buildings in urban environments.

The price determined by the heat - pump manufacturers, and the price strategy of the electrical suppliers will decide whether or not the electrically driven heat pump will absorb a considerable portion of the energy demand market. Over and above the economics to the private consumer one should not forget the negative effect of the implementation of electrically driven heat pumps on the economics of the country.
One should note that electricity has the highest potential application value of all the secondary energy sources.
It should therefore be used when no primary energy source exists (i. e. for lighting, tele-communications etc.).
Furthermore the technological effort starting with manufacturing, until it is set into operation is much higher for heat pumps than for solar heating systems.

4. ECONOMICAL CONSIDERATIONS+

4.1 Essential Economic Variables

4.11 Capital Investment and Tax Incentives

For an appropriate economical analysis one should compare the gain and savings respectively with initial investment costs and all operating costs. One should not forget the cost of borrowing money which often occurs for large investments. Furthermore one has to consider the cost increase of the product with time (due to inflation) and the cost increase of the base model on which the entire economic comparison is based. In this study the basis for the economic analysis was the oil price as a function of time.

In the economical analysis for solar heating systems in conjunction with auxiliary oil heating the following assumptions were made:

- Annual interest rate 8 %
- Annual cost increase of heating oil and solar energy system 9 % (inflation effect included)
- Annual service costs 1 % of initial investment

From the above, the effective interest rate is about 1 %, this figure is in good agreement with the actual capital market conditions. The effect of deviations of the above numbers on the economical analysis is most sensitive to variations in the annual service cost. Therefore solar heating systems must be both reliable and virtually service free.

The economics of a solar heating system can be significantly improved by governmental subsidies and/or tax incentives to alleviate the large initial investment costs (see following section).

+) In the economical analysis which follows all calculations are performed assuming that the currency in question is in Deutsche Marks (DM). One should note that at present 1 DM = .39 units of account.

4.12 Amortisation and Cost Effectiveness

Amortisation time is defined as the time necessary to retrieve the initial investment and any additional capital costs. If the life expectancy of the system is greater than the amortisation time, then the system is considered profitable. The amortisation time n, is a monotonic function of the cost to effectiveness ratio (C.E.R.) = Q_o/E_1. Based on the assumptions in the preceeding section the following linear approximation for n is valid when Q_o/E_1 is between 5 and 15:

$$n = 1.21\ Q_o/E_1 - 0.61 \quad \text{(years)}$$

In this equation Q_o is the total investment including installation costs, and E_1 is the heating cost savings in the first year of operation.

The C.E.R. contains all costs for components and personnel costs up until the system is set into operation, and furthermore the total annual effectiveness to the owner is also included. On the other hand if one were to solely restrict oneself to either a collector price, or collector efficiency, or yearly energy savings, or thermodynamic system efficiency, the economic analysis would be wrong.

To attain amortisation times of ten years the C.E.R. must be 8.8, for amortisation times of 15 years the C.E.R. must be 12.9. The reciprocal of the C.E.R. is E_1/Q_o and is called the effectiveness to cost ratio. A governmental subsidy of 20 % of the initial investment cost Q_o, of a solar heating system would reduce the amortisation time to about .24 Q_o/E_1+. Under these circumstances a Q_o/E_1 between 8.8 to 17. will lead to a reduction of the amortisation time of between 2 and 4 years. One should note that such a subsidy will be instituted in 1978 by the Federal Government in West Germany. It is obvious that the life-expectancy of the solar energy system should be at least as long as the amortisation time for any economic

+ see above equation

analysis. This requirement can only be satisfied with a reliable and fully technologically developed solar system. At the present, all serious economic considerations of solar systems lead to a minimum amortisation time of ten years. The target expectancy is therefore a minimum of 15 years.

4.2 Present Aspects of Economical Solar Energy Utilisation

4.21 Cost Analysis of Solar Heating Systems

For all components for a complete solar heating system the present costs were determined. These costs were extrapolated assuming an annual mass production per manufacturer of 5o ooo m^2 of colletors, this corresponds approximately to 2ooo integrated solar heating systems. These production rates corresponds to the predicted production rate per manufacturer in middle Europe for the next 5 years. Smaller solar energy system size will be implemented in the mediteranean countries where the primary application is for solar hot water preparation.

In the total system cost calculation the follwowing mathematical model was assumed (see Ref. 5):

$Q_O = K_K + K_{sp} + K_A + K_{st} + K_R - E_D + K_{inst}$ (Final retail Price)

- Collector cost $K_K = k_k \cdot F_K$
- Thermal storage cost K_{sp}
- Cost for pump, valves, and tubing etc. $K_A = \frac{2}{3} (K_{A\ddot{o}} + k_A \cdot F_K)$
- Cost of collector supports and sealing
  $K_{st} = 0{,}63\ k_{st1} \cdot F_K + 2 \cdot k_{st2} \sqrt{1{,}26 \cdot F_K}$
- control costs K_R
- savings of conventional roof structure $E_D = e_D \cdot 1{,}26 \cdot F_K$
- personnel cost for installation $K_{inst} = \frac{1}{2} K_A + K_{st} + X \cdot k_{in} \cdot F_K$

The specific costs were evaluated from several solar heating system installations already installed in Germany:

k_K	= 300 DM/m^2	for Single Glass Collector with selective absorber as well as for double glass collector with black absorber
k_A	= 46 DM/m^2	for solar heating and hot water preparation
	= 94 DM/m^2	for solar hot water preparation
k_{st1}	= 0	for newly built houses without flat roof
k_{in}	= 24 DM/h	hourly wage of installers
X	= 0.2 h/m^2	specific installation time per collector
e_D	= 38 DM/m^2	specific roof costs
k_{st2}	= 52 DM/m	specific cost of peripheral roof sealing
K_{sp}	= 5160 DM	for 5 m^3 heat storage tank
	1500 DM	for 0..5 m^3 heat storage tank
K_{Ao}	= 3862 DM	for solar heating and hot water preparation
	2190 DM	for solar hot water preparation
K_R	= 600 DM	cost for controls

The solar system size is given by the collector area F_K and the solar buffer storage tank size V_{sp}.

4.22 Influence of System Size on Cost Effectiveness

Economical investigations were performed for solar hot water preparation and for space heating and hot water preparation. These investigations correspond to the calculation of the annual oil savings performed in sec. 3.2. For the graphical presentation the necessary initial oil price was calculated such that the capital investment for a solar heating system will have a pay back time of 15 years. This evaluation technique was chosen because the C.E.R. value alone is more difficult to physically visualize. The necessary initial oil price g, was calculated from the following equation:

$$g = \frac{Q_o}{(Q_o/E_1)_n \quad (\Delta B/B)_{corr} \cdot B} \quad \text{(DM/Ltr.)}$$

where Q_o = is calculated as in sec 4.21

$$Q_o = 351.4\ F_K + 233.8\sqrt{F_K} + 4290\ \text{DM}$$

(for solar hot water preparation)

and $$Q_o = 303.8\ F_K + 233.8\sqrt{F_K} + 9622\ \text{DM}$$

(for solar space heating and hot water preparation)

B = absolute annual oil demand without solar heating, which was taken from the computer calculation out-put.

The relative annual oil savings $\frac{\Delta B}{B}$ as a function of collector area for the two above mentioned applications was taken from Fig. 27 and 28 respectively. In the calculation of $(\frac{\Delta B}{B})_{corr.}$ from the two figures one must also add. to $\frac{\Delta B}{B}$ the passive energy saving effect from the improvement of the roof insulation due to the collector installation.

As explained in 4.12 the C.E.R. was set to 12.9 which corresponds to a pay back time of 15 years.

As already mentioned in sec. 4.21 it was assumed that the single glass selective absorber and the double glass black absorber had the same final retail price (300 DM/m^2). This assumption is valid since the inner construction of the single glass collector can be considerably cheaper than that of the double glass collector. This difference in price can account for the cost of the selective coating.

Fig. 27 shows the specific minimum oil cost for a pay-back time of 15 years as a function of collector area for solar hot water heating. The buffer storage tank size was assumed to be constant at .5 m^3. It is interesting to note that there are minima in the curves and that the minima appear for different collector area for different E.C. Countries and that the minima are different for the two collector types investigated. From Fig. 27 the following conclusions can be drawn:

Fig. 27 MINIMUM OIL COST FOR 15 YEARS PAY-BACK TIME AS A FUNCTION OF COLLECTOR AREA. (SOLAR HOT WATER HEATING)

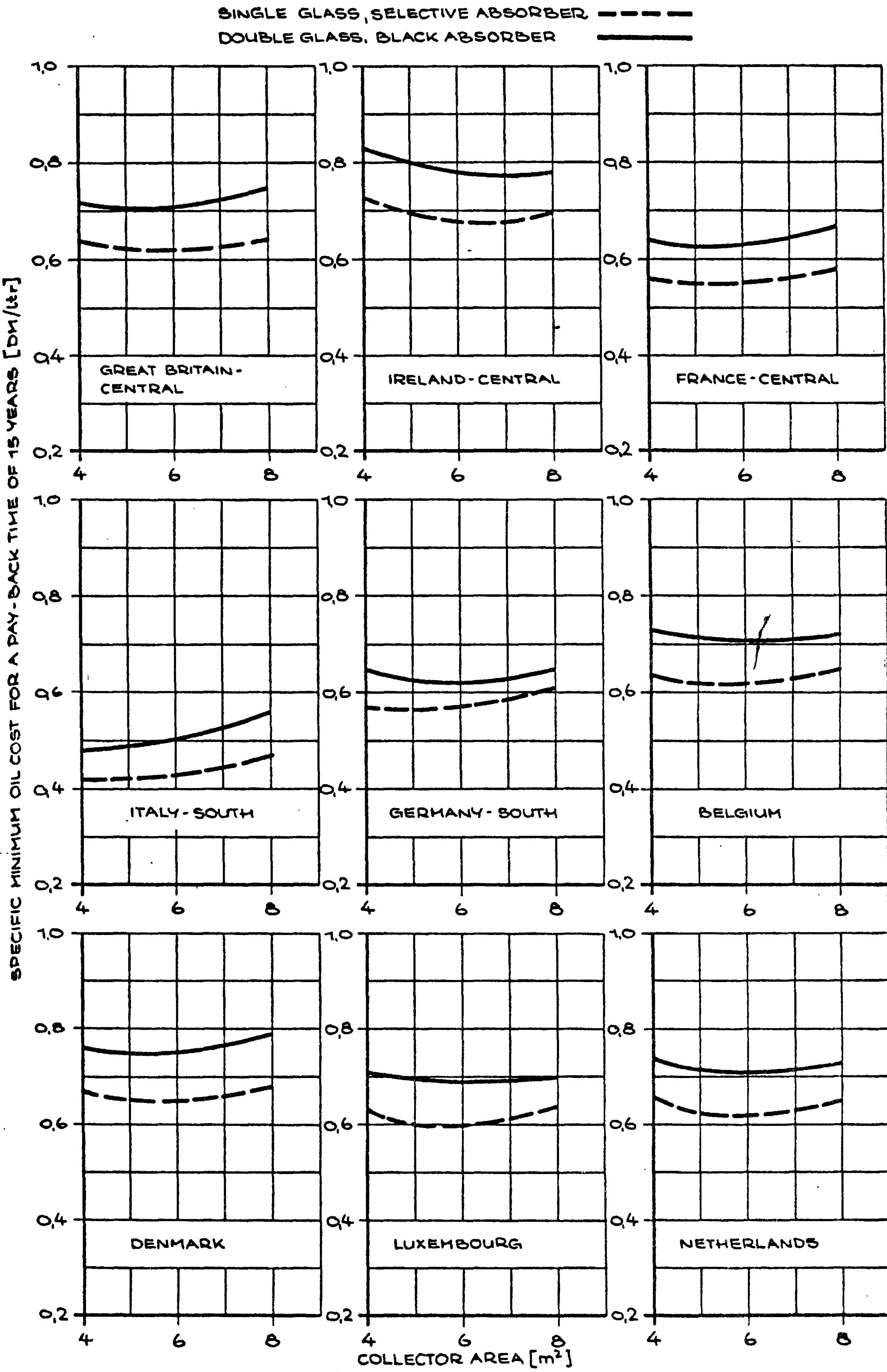
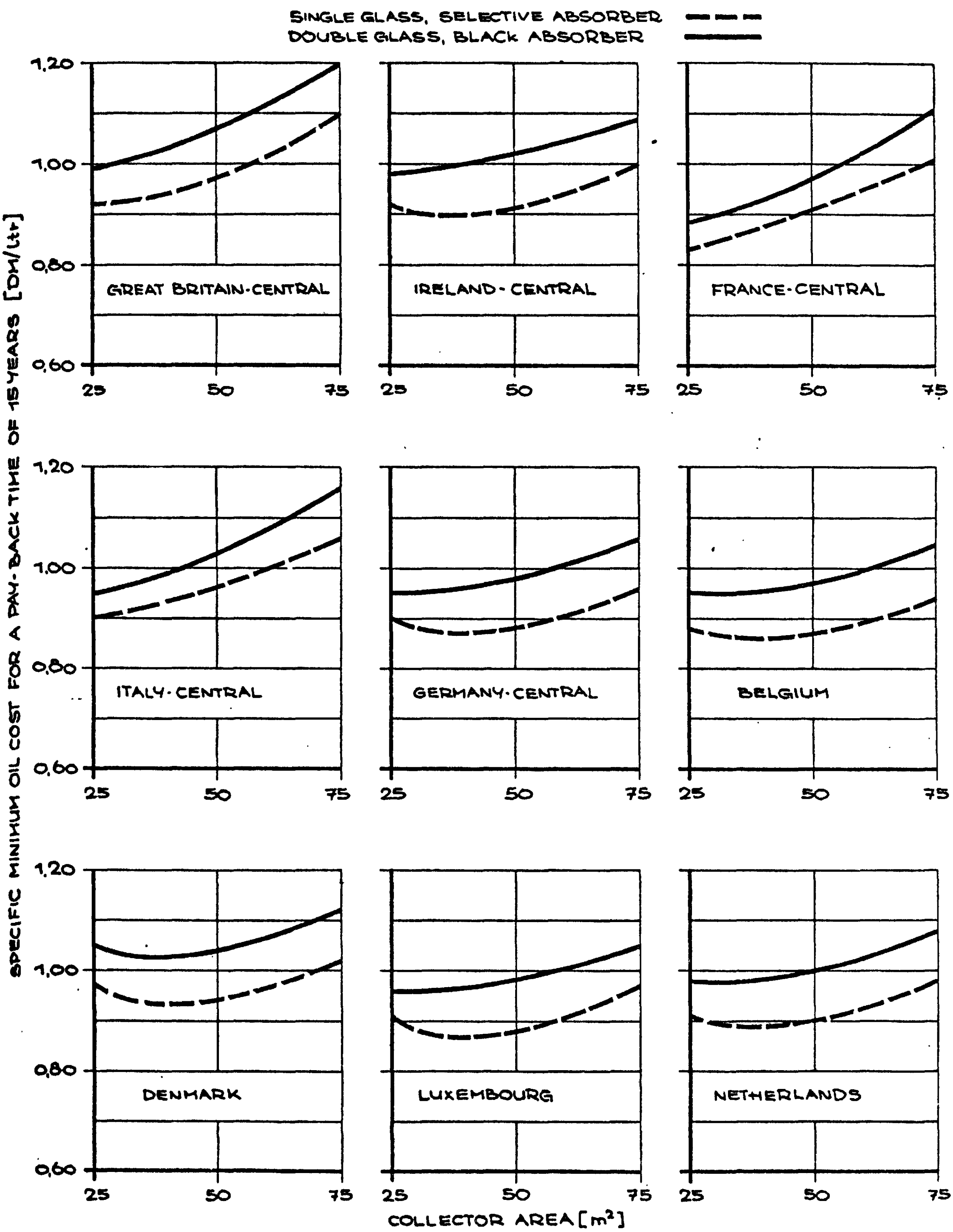


Fig. 28 MINIMUM OIL COST FOR 15 YEARS PAY-BACK TIME AS A FUNCTION OF COLLECTOR AREA FOR A STANDARD HOUSE WITH A SOLAR ENERGY SYSTEM FOR SPACE HEATING AND HOT WATER HEATING.



- under the assumption of equal retail costs for the two collectors it is clear that in the application of solar hot water preparation that the single glass selective absorber is superior, i.e. a smaller initial oil price is necessary for amortization.

- The graphical minima occur for smaller collector areas in the case of single glass selective absorber. The difference in the optimal collector areas is at most 1 m^2.

- In southern Italy the smallest initial oil price .42 DM/ltr. was necessary where as the largest value of the initial oil price .68 DM/ltr. occured in central Ireland.

- The necessary optimal collector area (selective absorber, single glass) varied from 4 m^2 (southern Italy) to 7 m^2 (in Ireland) for the preparation of hot water for a household with 4 people.

Fig.28 shows the specific minimum oil cost for a pay-back time of 15 years as a function of collector area for solar space heating and hot water preparation. The buffer storage tank size was assumed to be constant at 5 m^3. In these curves characteristic optimum values also appear, but the results sometimes deviate from those in Fig. 27. The following conclusions can be drawn:

- under the assumption of equal retail costs for the two collectors it is also clear that in the application of solar space heating and hot water preparation that the single glass selctive absorber is superior, i.e. a smaller initial oil price is necessary for amortization.

- The graphical minima in the case of the single glass selective absorber lies approximately at 10 m^2 higher than that of the double glass black absorber. The exceptions occur in central France and central Italy. This implies that in areas with more diffuse radiation due to cloudiness, that the single glass selective absorber over the entire year operates more effectively than the double glass black absorber. The optimum values for France and Italy lie by below 25 m^2.

- The necessary initial oilprice for a pay-back time of 15 years in the case of solar space heating and hot water preparation lie at about .87 DM/ltr. for nearly all E.C. countries except for France where this point is located at .80 DM/ltr. and for Great Britain and Ireland where this point is located at about .90 DM/ltr.

- The optimal collector area varies from about 20 m^2 (for France and Italy) up to 40 m^2 (for Belgium, the Netherlands, etc.)

If a shorter pay-back time X is desired one can use the following formula to calculate the initial oil cost g_x that is necessary

$$g_x = \frac{(Q_o/E_1)_{15\ \text{years}}}{(Q_o/E_1)_{x\ \text{years}}}\ g_{15\ \text{years}}$$

The value of $(Q_o/E_1)_{x\ \text{years}}$ can be obtained from the linear approximation given in sec. 4.12.

4.23 Economical Considerations as a Function of Solar System Component Effectiveness

The effect of different collector types on the economics of solar heating systems has been discussed above. One can now calculate how much more expensive the sinle glass selective collector can be over and above that of the double glass black collector and still be economically equivalent. The other two collectors discussed in chapter 3, i.e. double glass selective and single glass black collector were not further investigated since they are clearly economically inferior than the double glass black collector.

With respect to the curves shown in Fig.27 and 28 one can calculate the economically maximum price of the single glass selective collector as compared to that of the double glass black collector. This retail cost calculation was performed for West Germany. The results are shown in Table 10 . In the case of solar hot water preparation the single glass selective collector can be 100 DM/m^2 more expensive than the double glass black collector and still be as economically effective, where as in the case of solar space heating and hot water preparation the additional cost can be 60 DM/m^2. More specifically the manufacturing cost of the selective coating can be as much as 20 DM/m^2 more than the cost of simple black coating. Since this additional cost of 20 DM/m^2 and the long-term endurance of the selective coating is achievable in mass produced quantities within the next two years, one would strongly recommend the implementation for all solar system applications and specifically for solar cooling with LiBr/H_2O-absorption cooling machine (T-generator up to 110°C) the single glass selective collector!

Table 10 : Calculation of Competitive Collector Prices** using Single Glass, Selective Absorber and Double Glass, Black Abs.

Example	1	2
Country Application	Southern Germany Solar Hot Water Preparation	Central Germany Solar Space Heating and Hot Water Preparation
System Size	6 m^2 / 0.5 m^3	50 m^2 / 5 m^3
Considered Oil price increase (see Fig.xx)	0.62 DM/1 (27)	0.98 DM/1 (28)
Annual Oil Savings for		
- single glass, selective absorber	948 1	2 329 1*
- double glass, black absorber	865 1	2 099 1*
Total Investment Cost		
- double glass, black absorber	6970.-- DM	26470.-- DM
- Calculation for single glass, selective absorber	7580.-- DM	29440.-- DM
Difference in Investment Costs	610.-- DM	2980.-- DM
Increase in specific collector cost	100.-- DM/m^2	60.-- DM/m^2
Competitive Collector Retail Cost using		
- single glass, selective Absorber	400.-- DM/m^2	360.-- DM/m^2
- double glass, black Absorber	300.-- DM/m^2	300.-- DM/m^2

* 6% additional annual oil savings due to passive collector integration was assumed.

** The price calculation is based on mass production and was performed using the cost model given in section 4.21

4.3 Trends in the Economical Application of Solar Energy in the European Community

4.31 Marketing Trends

The most important marketing trends to be observed at the end of 1977 are summarized as follows:

- Simple solar energy systems in South European latitudes, especially for hot water heating (i. e. thermosiphon), application of single cover glass collectors with selective absorber.

- More sophisticated solar energy systems in Middle European latidudes for space heating and hot water heating with 1-glass cover and selective absorber, with more attention to precise controls and safety features. The use of double glass covers and selective absorber only in areas with either very high wind velocities or very high collector inlet temperatures (i. e. solar cooling).

- Cost reduction through Mass Production. Collector manufacturing using assembly lines and prefabricated system modules for easy installation.

- Small and medium solar energy system size (collector area) for economical application. Heat storage tank size not more than about 1/10 of collector area (i. e. 50 m^2 of collector area, 5 m^3 storage tank).

- Heat pump application for high energy demand and small roof area only, the most efficient primary energy use is the gaseous fuel driven heat pump.

- Solar cooling system applications especially for food conservation in South European latidudes and air conditioning of larger buildings such as hotels, hospitals, schools, etc. in Middle and South European Countries.

- Most suitable applications of solar energy systems in rural and in suburban areas. Due to excess energy distribution costs urban areas will be best supplied with nuclear power and conventional energy systems.

4.32 Need for Interdisciplinary Coordination among all Relevant Personell

Because in the implementation phase of solar energy systems into the market many craftsmen and specialists are necessary, solar energy techniques become an interdisciplinary problem. Development, mass production, application technique, and operation service are the most important disciplines which have to be coordinated. For this reason the following measures are recommended:

- Publication and advertising of pertinent materials for builders and house owners

- Consideration and coordination of architectural aspects, building physics aspects, and installation or system integration aspects

- Instructing of engaged craftsmen, marketing engineers and officials

- Feed-back of application experience to the solar energy system manufacturer

- Standardisation of integration regulations, safety instructions, power measurements and integration parameters

In general the state of the art is determined by the research and development engineers. However since the solar system implementation is highly dependent upon the physical installers of the system, such as: roofers, pipe fitters, heating system builders, electricians, and also upon designers and planners, such as architects, masons, etc., one must transfer as much information as is necessary from the engineers to the designers and installers.

4.33 Government Incentives for More Rapid Implementation of Solar Energy Applications

The government can play an exceedingly strong role for the rapid implementation of solar energy systems. Experience has shown that the bureaucratic hindrances from old existing building codes can be extremely detrimental to the implementation of new technology in existing building codes. The Government can improve these anitquated building codes by either new laws or the delegation of new building codes to already existing technically orientated institutions.

On the other hand the government can improve the present high investment cost of solar heating system by subsidies to the home owners. In certain countries in the E. C. certain energy saving measures have been prepared and adopted. This is one of the most efficient ways of saving energy for heating purposes, i. e. minimum insulation values for house building materials and thermostatic controls of the heating distribution network.

From the above discussion the following proposals would be desirable:

- Increase of passive energy saving measures via tax-write-offs for the purchase and installation of better insulation of the walls, windows, cellar and attic

- Increased implementation of active energy saving measures by tax-incentives for the purchase and integration of appropriate solar energy systems

- Generalized local and international building codes for the acceptance of roof integrated collector areas

- Solar Energy System Implementation Program containing several commercial pilot projects for controlled components long term life expectancy of solar energy system components

5. Conclusion

5.1 Summary of Results

As a result of this study one can conclude the following in reference to the application of solar energy in the E.C.

- There is theoretically enough solar energy available in every country in the E.C. to cover a significant portion of the energy need in that country.

- The single glass selective collector is at present the most efficient collector in all applications of solar energy provided that the additional cost for the selective coating is not more than 20 DM/m^2 (for all countries in the E.C.).

- The most appropriate heat storage in connection with solar energy utilisation is water.

- The implementation of working fluids other than water has to be made with caution. The circulating pumps that are in the collector loop must be stronger if synthetic or organic working fluids are used.

- A closed collector loop in connection with a heat exchanger should be used in the E.C. as opposed to an open collector loop.

- In the case of hot water preparation a buffer storage volume should be provided for between collector area and boiler for all countries in the E.C., except for southern Italy in which case a thermosiphon system can be implemented. For hot water preparation approximately 80% of the hot water heating load can be covered for a single family using a single glass selective collector, and a total collector area of approximately 6 m^2. (For all countries in the E.C.)

The correct ratio of storage tank volume to collector area in the case of space heating and hot water preparation are:

For the double glass black absorber:

a) 1 m^3 of storage tank volume to 10 m^2 of collector area.

For the single glass selective absorber:

b) 1 m^3 of storage tank volume to 8 m^2 of collector area.

- In the case of space heating and hot water preparation for a typical detatched single family house approximately 50% of the total heat demand can be met, using a single glass selective absorber with 50 m^2 of collector area and storage volume of 5 m^3. For all of the countries in the E.C. except for southern Italy where 95% of the total heat load can be met.

- For solar energy applications in space heating, floor heating is desirable as opposed to radiator heating.

- Outdoor swimming pools should be covered when not in use, to minimize heat loss. The heat load in small outdoor swimming pools is very sensitive with tespect to: desired water temperature, wind velocity, and whether or not the pool is covered.

- Solar cooling is reasonably applicable in France and Italy but not in the other countries in the E.C.

- The tilt angle of the collector and the deviation of the collector from due south do not have as large an effect on the amount of fuel saved in the case of space heating and hot water as is often claimed. (For countries in the E.C.)

- The difference in the oil demand between a well insulated house and a poorly insulated house can be a factor of two.

- No original investigation of heat pumps had to be performed. It was clear that electrically driven heat pumps were not ideal in connection with solar energy applications from other studies. Only for large heat loads and poor geometry for solar installation can one recommend the use of a heat pump. In this case the most suitable heat pump is the natural gas driven compression heat pump.

- If one is to perform an adequate economic analysis all costs of the solar energy system must be included for example: purchase cost, installation cost, operating cost, and service cost.

- The most appropriate economic criteria for energy systems is the cost effectiveness ratio.

- For all the countries in the E.C. there exists economically optimal collector areas for both hot water preparation and space heating. The tendency is to smaller systems.

- For hot water preparation for a 15 year pay back time the average cost of a liter of oil (in the E.C.) must increase to approximately 0.55 DM/ltr.

- For space heating and hot water preparation for a 15 year pay back time the cost of liter of oil (in the E.C.) must increase on the average to approximately 0.85 DM/ltr.

- Economic implementation of solar energy can be significantly enhanced through the following measures:

  - mass production of solar heating systems
  - an oil price increase
  - government subsidy to homeowners that install a solar system
  - more direct marketing of solar components (less middlemen)
  - Interdisciplinary coordination among all relevant personell
  - Reliable and safe solar heating systems.

5.2 Prediction of Solar Energy Coverage in the Energy Market

A prediction of solar energy coverage in the energy market of the E.C. countries is very difficult due to several assumptions which may vary in the future. For the calculation the following assumptions were made:

- basic value of the number of houses with solar installation up to 1985 in West Germany 0.7 million (see Ref. 8)
- Standard house type with 50 m^2 collector area and 5 m^3 heat storage
- ratio of populations between all E.C. countries constant
- heating oil density .86 kg/ltr.
- small solar energy system (i.e. hot water supply) will become less dominant in the future
- large public and industrial applications are not included in this analysis
- total annual oil equivalent demand of the E.C. countries from Table 1
- annual oil savings per house for each E.C. country from computer calculation.

The results of the calculation of the predicted annual oil savings from the application of solar energy to space heating and hot water preparation for the E.C. countries in 1985 is shown in Table 11.

The number of solar houses in 1985 were calculated for each E.C. country by scaling the predicted number of solar houses in West-Germany with the population of the individual countries.

Table 11: Calulation of Solar Energy Converage in the E,C. Energy Market in 1985

Country	Ratio of Population	Annual Oil Savings (ltr/year house)	Annual Oil Savings (10^9ltr/year)	Total Annual Oil Demand (10^9ltr/year)	Total Solar Energy Coverage (%)
Great Britain	0.905	1916	1.214	130.2	0.9
Ireland	0.0506	2021	0.072	11.5	0.6
France	0.856	2043	1.224	147.7	0.8
Italy	0.903	1955	1.236	156.9	0.8
Germany	1.0	2072	1.450	188.4	0.8
Belgium	0.158	2115	0.234	39.1	0.6
Denmark	0.0818	1906	0.109	15.8	0.7
Luxembourg	0.0058	2091	0.008	2.9	0.3
Netherlands	0.221	2032	0.314	73.3	0.4
E.C. Total			5.861	765.8	average 0.76

The calculated total solar energy coverage is not unexpectedly low considering the following reasons:

- solar system application are just recently being implemented
- as of 1985 solar systems will be economically competitive with fossil fuel heating (see necessary oil price increase in section 4.2)
- in the calculation no major solar heating applications for public and industrial use were included. These additional applications will have a large effect on the total solar energy coverage.

As time progresses and the world runs out of fossil fuel the total solar energy coverage will increase dramatically (there exist calculations which show that by the year 2000 that the total solar energy coverage for the European Community will be as high as 10%).

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7. APPENDIX A TO C

Appendix A

The input parameters and the detailed results of the computer simulation for space heating and hot water preparation in the case of the "standard house" are presented. The variables appearing in the results are described below:

Q-LOAD - The monthly heating requirement in KWh for both space heating and hot water preparation

ETAHZ - The monthly efficiency of the conventional heating system before the solar energy system is installed

TINLET - The monthly average collector inlet temperature

ETACOL - The monthly average collector efficiency

Q-SUN - The monthly solar energy entering the storage volume via the collectors

Q-EXTRA* - The excess energy available in the storage volume after the space heating and hot water demand have been satisfied

DTSP - The average monthly increase in the storage temperature over and above a calculated heating inlet temperature

QMVB - The monthly oil need before a solar energy system has been installed

QNEUMV - The monthly oil need after a solar energy system has been installed.

*In practice Q-EXTRA is available for other possible heat loads. If Q-EXTRA is not depleted there is an increase in both storage volume temperature and the collector inlet temperature.

```
NECESSARY INPUT PARAMETERS EG1
-------------------------------

TYPE OF COLLECTOR
SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10  = 1
DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10  = 2
SINGLE GLASS COVER.BLACK     ABSORBER ALPHA=.96 EPSILON=.86  = 3
DOUBLE GLASS COVER.BLACK     ABSORBER ALPHA=.96 EPSILON=.86  = 4
1

PRESENT FUEL
 OIL            = 1
 ELECTRICITY    = 2
 NATURAL GAS    = 3
 CITY GAS       = 4
1

MAXIMUM HEATING-INLET TEMPERATURE IN DEG-C
60

TYPE OF FURNACE
 BOILER IN FURNACE (UP TO 4 YEARS OLD)    = 1
 BOILER IN FURNACE (G.T. 4 YEARS OLD)     = 2
 BOILER IN FURNACE (AUT. B.F. VALVE )     = 3
 BOILER AND FURNACE SEPARATE              = 4
 ELECTRIC HOT WATER PREPARATION           = 5
1

APPLICATION
 HOT WATER PREPARATION                = 1
 HOT WATER AND SPACE HEATING          = 2
 INDOOR OR OUTDOOR SWIMMING POOL      = 3
 HOUSE WITH SWIMMING POOL             = 4
 HOT WATER,HEATING,AND AIR COND.      = 5
2

HOUSE GEOMETRY
 TILT ANGLE OF ROOF
 DEVIATION OF NORMAL TO ROOF FROM THE SOUTH
 LENGTH
 WIDTH
 HEIGHT
 WINDOW (SINGLE PANE=1 ,DOUBLE PANE=2
35,0,12,10, 6.5,2

WINDOW AREA(SQ.M) FIRST WINDOW ON WALL 2
2,2,2,5,0,0

TYPE OF HOUSE
 DETATCHED                   = 1
 END HOUSE                   = 2
 ROW HOUSE                   = 3
 DISPLACED END HOUSE         = 4
 DISPLACED ROW HOUSE         = 5
1
```

U-VALUES
.75,.75,.75,.75,.75,.75,.75

WINDOW U-VALUE
2.8
NUMBER OF OCCUPANTS
4
HOT WATER NEED IN LT/DAY PER PERSON
65
DESIRED ROOM TEMPERATURE
21
NUMBER OF COLLECTORS
LENGTH OF USABLE ROOF AREA (M)
WIDTH OF USABLE ROOF AREA (M)
STORAGE TANK VOLUME (CBM)
50,12,6.1,5

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4377.	0.670	68.6	0.393	622.	0.	3.6	640.	562.
FEB	3943.	0.660	70.6	0.413	1078.	0.	6.2	586.	450.
MAR	3152.	0.636	71.1	0.495	1749.	0.	10.1	486.	266.
APR	1889.	0.566	71.3	0.454	2554.	665.	14.8	327.	0.
MAY	939.	0.443	69.6	0.486	3107.	2168.	18.0	208.	0.
JUN	359.	0.260	73.6	0.491	3208.	2850.	18.6	135.	0.
JUL	359.	0.260	73.5	0.513	3200.	2842.	18.5	135.	0.
AUG	359.	0.260	71.7	0.545	2878.	2519.	16.7	135.	0.
SEP	922.	0.439	60.8	0.571	2598.	1676.	15.0	206.	0.
OCT	2230.	0.590	61.8	0.537	1677.	0.	9.7	370.	108.
NOV	3477.	0.647	63.6	0.493	889.	0.	5.2	527.	415.
DEC	4152.	0.665	65.7	0.421	555.	0.	3.2	612.	542.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	26158. KWH
YEARLY FUEL REQUIREMENTS	4368. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2024. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.463

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3362.	0.643	69.3	0.467	750.	0.	4.3	513.	418.
FEB	3069.	0.632	73.1	0.433	1207.	0.	7.0	476.	324.
MAR	2093.	0.581	73.3	0.450	1983.	0.	11.5	353.	21.
APR	951.	0.445	72.9	0.426	2743.	1792.	15.9	210.	0.
MAY	359.	0.260	73.2	0.421	3142.	2783.	18.2	135.	0.
JUN	359.	0.260	74.1	0.428	3305.	2946.	19.1	135.	0.
JUL	359.	0.260	74.3	0.469	3333.	2974.	19.3	135.	0.
AUG	359.	0.260	73.1	0.495	3126.	2767.	18.1	135.	0.
SEP	359.	0.260	70.0	0.520	2597.	2239.	15.0	135.	0.
OCT	1165.	0.483	60.3	0.569	1954.	789.	11.3	236.	0.
NOV	2458.	0.604	63.1	0.543	1049.	0.	6.1	399.	267.
DEC	3163.	0.636	66.0	0.503	675.	0.	3.9	488.	403.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	18055. KWH
YEARLY FUEL REQUIREMENTS	3349. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1916. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.572

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3948.	0.660	69.9	0.564	853.	0.	4.9	586.	479.
FEB	3584.	0.650	72.0	0.539	1286.	0.	7.4	540.	379.
MAR	2436.	0.603	71.2	0.522	2071.	0.	12.0	396.	71.
APR	1319.	0.506	70.5	0.515	2833.	1514.	16.4	256.	0.
MAY	359.	0.260	73.7	0.478	3223.	2864.	18.7	135.	0.
JUN	359.	0.260	74.8	0.480	3411.	3052.	19.8	135.	0.
JUL	359.	0.260	74.8	0.511	3427.	3069.	19.8	135.	0.
AUG	359.	0.260	73.7	0.520	3221.	2862.	18.7	135.	0.
SEP	359.	0.260	70.4	0.541	2666.	2308.	15.4	135.	0.
OCT	1645.	0.543	61.5	0.586	1961.	316.	11.4	297.	0.
NOV	3173.	0.636	65.5	0.589	1089.	0.	6.3	489.	352.
DEC	3892.	0.659	68.3	0.588	763.	0.	4.4	579.	483.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21790. KWH
YEARLY FUEL REQUIREMENTS	3819. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2054. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.538

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3663.	0.652	68.9	0.474	665.	0.	3.9	550.	467.
FEB	3280.	0.640	71.2	0.461	1121.	0.	6.5	502.	361.
MAR	2514.	0.607	73.1	0.465	1831.	0.	10.6	406.	134.
APR	1591.	0.538	74.5	0.427	2509.	919.	14.5	290.	0.
MAY	539.	0.335	72.6	0.439	3045.	2506.	17.6	158.	0.
JUN	359.	0.260	73.7	0.478	3230.	2871.	18.7	135.	0.
JUL	359.	0.260	73.5	0.546	3200.	2841.	18.5	135.	0.
AUG	359.	0.260	72.0	0.530	2944.	2585.	17.0	135.	0.
SEP	672.	0.378	68.8	0.541	2387.	1715.	13.8	174.	0.
OCT	1910.	0.567	62.3	0.585	1612.	0.	9.3	330.	58.
NOV	2999.	0.630	65.0	0.527	905.	0.	5.2	467.	353.
DEC	3557.	0.649	66.3	0.529	576.	0.	3.3	537.	465.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21801. KWH
YEARLY FUEL REQUIREMENTS	3820. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1982. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.519

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3809.	0.657	69.3	0.438	742.	0.	4.3	569.	476.
FEB	3316.	0.641	70.9	0.447	1227.	0.	7.1	507.	352.
MAR	2459.	0.604	70.7	0.515	1925.	0.	11.1	399.	105.
APR	1327.	0.507	70.8	0.488	2723.	1397.	15.8	257.	0.
MAY	412.	0.285	73.0	0.468	3107.	2695.	18.0	142.	0.
JUN	359.	0.260	74.0	0.512	3282.	2923.	19.0	135.	0.
JUL	359.	0.260	73.7	0.560	3234.	2875.	18.7	135.	0.
AUG	359.	0.260	72.2	0.558	2968.	2609.	17.2	135.	0.
SEP	718.	0.391	60.2	0.621	2573.	1855.	14.9	180.	0.
OCT	1887.	0.565	61.6	0.589	1713.	0.	9.9	327.	34.
NOV	3080.	0.633	64.8	0.528	984.	0.	5.7	477.	353.
DEC	3865.	0.658	67.9	0.495	627.	0.	3.6	576.	497.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21949. KWH
YEARLY FUEL REQUIREMENTS	3839. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2021. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.527

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3067.	0.632	70.0	0.488	864.	0.	5.0	476.	367.
FEB	2699.	0.616	73.1	0.457	1347.	0.	7.8	429.	260.
MAR	2038.	0.577	74.0	0.500	2001.	0.	11.6	346.	7.
APR	1167.	0.483	75.4	0.454	2674.	1507.	15.5	237.	0.
MAY	359.	0.260	73.4	0.457	3177.	2818.	18.4	135.	0.
JUN	359.	0.260	74.3	0.496	3336.	2978.	19.3	135.	0.
JUL	359.	0.260	74.1	0.532	3306.	2947.	19.1	135.	0.
AUG	359.	0.260	72.8	0.536	3074.	2715.	17.8	135.	0.
SEP	371.	0.266	69.5	0.567	2512.	2141.	14.5	137.	0.
OCT	1456.	0.523	63.4	0.590	1830.	374.	10.6	273.	0.
NOV	2571.	0.610	67.1	0.534	1093.	0.	6.3	413.	276.
DEC	3085.	0.633	68.2	0.538	748.	0.	4.3	478.	384.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	17890.	KWH
YEARLY FUEL REQUIREMENTS	3329.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2035.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.611	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3657.	0.652	71.0	0.432	1045.	0.	6.0	550.	418.
FEB	3200.	0.637	73.2	0.431	1533.	0.	8.9	492.	299.
MAR	1946.	0.570	72.6	0.432	2395.	449.	13.9	335.	0.
APR	905.	0.435	71.2	0.442	3045.	2140.	17.6	204.	0.
MAY	359.	0.260	73.9	0.418	3261.	2903.	18.9	135.	0.
JUN	359.	0.260	74.7	0.443	3403.	3044.	19.7	135.	0.
JUL	359.	0.260	75.0	0.458	3445.	3086.	20.0	135.	0.
AUG	359.	0.260	74.3	0.459	3324.	2965.	19.3	135.	0.
SEP	359.	0.260	72.0	0.481	2936.	2578.	17.0	135.	0.
OCT	1153.	0.481	61.8	0.550	2354.	1200.	13.6	235.	0.
NOV	2714.	0.617	65.5	0.510	1377.	0.	8.0	431.	258.
DEC	3602.	0.651	68.5	0.485	927.	0.	5.4	543.	426.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	18971.	KWH
YEARLY FUEL REQUIREMENTS	3465.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2062.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.595	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4137.	0.665	71.6	0.489	1132.	0.	6.6	610.	468.
FEB	3440.	0.646	72.2	0.472	1664.	0.	9.6	522.	313.
MAR	1810.	0.559	69.7	0.477	2632.	823.	15.2	317.	0.
APR	539.	0.335	73.1	0.443	3123.	2584.	18.1	158.	0.
MAY	359.	0.260	74.5	0.422	3369.	3010.	19.5	135.	0.
JUN	359.	0.260	75.4	0.446	3516.	3157.	20.4	135.	0.
JUL	359.	0.260	75.6	0.437	3557.	3199.	20.6	135.	0.
AUG	359.	0.260	75.1	0.461	3478.	3119.	20.1	135.	0.
SEP	359.	0.260	73.0	0.481	3115.	2756.	18.0	135.	0.
OCT	1095.	0.472	60.9	0.567	2550.	1455.	14.8	228.	0.
NOV	2936.	0.627	64.5	0.572	1453.	0.	8.4	459.	276.
DEC	4013.	0.662	69.0	0.539	1036.	0.	6.0	594.	464.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	19764.	KWH
YEARLY FUEL REQUIREMENTS	3564.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2043.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.573	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3548.	0.649	71.2	0.442	1065.	0.	6.2	536.	402.
FEB	2771.	0.620	72.2	0.427	1702.	0.	9.9	438.	210.
MAR	1291.	0.502	69.2	0.468	2654.	1363.	15.4	252.	0.
APR	388.	0.274	72.3	0.461	2996.	2608.	17.3	139.	0.
MAY	359.	0.260	73.9	0.441	3272.	2913.	18.9	135.	0.
JUN	359.	0.260	74.7	0.462	3398.	3039.	19.7	135.	0.
JUL	359.	0.260	75.1	0.450	3479.	3120.	20.1	135.	0.
AUG	359.	0.260	75.0	0.449	3456.	3097.	20.0	135.	0.
SEP	359.	0.260	73.1	0.475	3121.	2762.	18.1	135.	0.
OCT	506.	0.323	68.9	0.492	2399.	1893.	13.9	154.	0.
NOV	2344.	0.597	64.1	0.516	1490.	0.	8.6	385.	167.
DEC	3489.	0.647	68.5	0.489	941.	0.	5.4	529.	410.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	16132.	KWH
YEARLY FUEL REQUIREMENTS	3108.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1918.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.617	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4441.	0.672	71.3	0.360	1085.	0.	6.3	648.	512.
FEB	3424.	0.645	70.1	0.412	1698.	0.	9.8	520.	307.
MAR	1572.	0.536	65.9	0.481	2699.	1127.	15.6	288.	0.
APR	359.	0.260	72.3	0.474	2982.	2623.	17.3	135.	0.
MAY	359.	0.260	74.0	0.473	3289.	2931.	19.0	135.	0.
JUN	359.	0.260	75.2	0.478	3493.	3134.	20.2	135.	0.
JUL	359.	0.260	75.9	0.453	3611.	3253.	20.9	135.	0.
AUG	359.	0.260	75.1	0.482	3468.	3110.	20.1	135.	0.
SEP	359.	0.260	72.1	0.513	2944.	2586.	17.1	135.	0.
OCT	745.	0.398	56.7	0.581	2591.	1847.	15.0	184.	0.
NOV	2802.	0.621	61.5	0.515	1476.	0.	8.5	442.	257.
DEC	4015.	0.662	67.7	0.390	1098.	0.	6.4	595.	457.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	19152. KWH
YEARLY FUEL REQUIREMENTS	3487. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1955. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.561

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3866.	0.658	71.1	0.507	1055.	0.	6.1	576.	443.
FEB	3196.	0.637	71.9	0.478	1585.	0.	9.2	492.	292.
MAR	1676.	0.546	68.9	0.500	2511.	835.	14.5	301.	0.
APR	359.	0.260	72.8	0.467	3072.	2713.	17.8	135.	0.
MAY	359.	0.260	74.4	0.431	3358.	2999.	19.4	135.	0.
JUN	359.	0.260	75.3	0.426	3501.	3142.	20.3	135.	0.
JUL	359.	0.260	75.7	0.397	3578.	3219.	20.7	135.	0.
AUG	359.	0.260	75.9	0.426	3608.	3250.	20.9	135.	0.
SEP	359.	0.260	73.7	0.482	3237.	2878.	18.7	135.	0.
OCT	359.	0.260	69.3	0.512	2472.	2113.	14.3	135.	0.
NOV	2049.	0.578	59.7	0.593	1533.	0.	8.9	348.	101.
DEC	3463.	0.646	67.2	0.525	1037.	0.	6.0	525.	395.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	16760. KWH
YEARLY FUEL REQUIREMENTS	3187. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1955. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.613

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	1972.	0.572	74.3	0.434	1602.	0.	9.3	338.	72.
FEB	1484.	0.526	75.6	0.438	2108.	623.	12.2	277.	0.
MAR	695.	0.384	71.3	0.487	2816.	2121.	16.3	177.	0.
APR	359.	0.260	73.8	0.463	3250.	2891.	18.8	135.	0.
MAY	359.	0.260	75.1	0.417	3478.	3119.	20.1	135.	0.
JUN	359.	0.260	75.7	0.402	3569.	3210.	20.7	135.	0.
JUL	359.	0.260	76.2	0.386	3653.	3294.	21.2	135.	0.
AUG	359.	0.260	76.7	0.399	3750.	3391.	21.7	135.	0.
SEP	359.	0.260	76.0	0.449	3633.	3274.	21.0	135.	0.
OCT	359.	0.260	72.8	0.480	3070.	2712.	17.8	135.	0.
NOV	359.	0.260	68.2	0.501	2286.	1927.	13.2	135.	0.
DEC	1578.	0.537	68.7	0.481	1662.	84.	9.6	288.	0.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	8599. KWH
YEARLY FUEL REQUIREMENTS	2161. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2088. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.966

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5077.	0.683	69.1	0.482	704.	0.	4.1	729.	641.
FEB	4551.	0.673	69.9	0.505	1141.	0.	6.6	663.	519.
MAR	3215.	0.637	70.0	0.459	1972.	0.	11.4	495.	244.
APR	1707.	0.548	67.8	0.496	2811.	1103.	16.3	306.	0.
MAY	359.	0.259	73.4	0.455	3178.	2819.	18.4	136.	0.
JUN	359.	0.259	74.4	0.434	3342.	2984.	19.4	136.	0.
JUL	359.	0.259	74.5	0.476	3373.	3014.	19.5	136.	0.
AUG	359.	0.259	73.4	0.446	3179.	2821.	18.4	136.	0.
SEP	359.	0.259	69.9	0.509	2577.	2218.	14.9	136.	0.
OCT	2110.	0.581	59.8	0.555	1913.	0.	11.1	356.	38.
NOV	3822.	0.656	62.7	0.548	987.	0.	5.7	571.	447.
DEC	4678.	0.676	65.5	0.502	648.	0.	3.8	679.	597.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	26954.	KWH
YEARLY FUEL REQUIREMENTS	4479.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1992.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.445	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP .DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4826.	0.679	69.8	0.514	833.	0.	4.8	697.	592.
FEB	4220.	0.667	70.1	0.530	1285.	0.	7.4	620.	459.
MAR	2872.	0.624	69.5	0.500	2118.	0.	12.3	451.	148.
APR	1377.	0.513	67.1	0.526	2957.	1580.	17.1	263.	0.
MAY	359.	0.260	73.8	0.501	3251.	2892.	18.8	135.	0.
JUN	359.	0.260	74.9	0.482	3434.	3075.	19.9	135.	0.
JUL	359.	0.260	74.9	0.496	3439.	3080.	19.9	135.	0.
AUG	359.	0.260	73.8	0.476	3255.	2896.	18.8	135.	0.
SEP	359.	0.260	70.9	0.501	2739.	2380.	15.9	135.	0.
OCT	1907.	0.567	60.7	0.556	2079.	173.	12.0	330.	0.
NOV	3693.	0.653	63.9	0.571	1102.	0.	6.4	554.	416.
DEC	4598.	0.675	67.4	0.502	764.	0.	4.4	668.	572.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	25286.	KWH
YEARLY FUEL REQUIREMENTS	4258.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2072.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.487	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4925.	0.681	72.0	0.510	1200.	0.	7.0	709.	558.
FEB	4273.	0.668	72.1	0.555	1690.	0.	9.8	627.	415.
MAR	2687.	0.616	71.7	0.510	2691.	4.	15.6	428.	0.
APR	1227.	0.492	69.3	0.537	3491.	2264.	20.2	244.	0.
MAY	359.	0.260	76.4	0.510	3701.	3343.	21.4	135.	0.
JUN	359.	0.260	77.4	0.479	3868.	3509.	22.4	135.	0.
JUL	359.	0.260	77.6	0.468	3900.	3542.	22.6	135.	0.
AUG	359.	0.260	76.9	0.476	3776.	3417.	21.9	135.	0.
SEP	359.	0.260	74.8	0.474	3412.	3053.	19.8	135.	0.
OCT	1693.	0.548	63.9	0.553	2728.	1034.	15.8	303.	0.
NOV	3636.	0.652	66.3	0.552	1575.	0.	9.1	547.	349.
DEC	4620.	0.675	69.3	0.504	1152.	0.	6.7	671.	526.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	24856. KWH
YEARLY FUEL REQUIREMENTS	4204. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2356. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.560

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

BELGIUM

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4797.	0.679	70.0	0.465	869.	0.	5.0	693.	584.
FEB	4342.	0.670	71.9	0.453	1321.	0.	7.6	636.	470.
MAR	2942.	0.627	70.4	0.478	2144.	0.	12.4	460.	156.
APR	1490.	0.527	68.7	0.482	2962.	1472.	17.2	277.	0.
MAY	359.	0.260	73.6	0.454	3211.	2852.	18.6	135.	0.
JUN	359.	0.260	74.6	0.468	3381.	3022.	19.6	135.	0.
JUL	359.	0.260	74.6	0.500	3382.	3024.	19.6	135.	0.
AUG	359.	0.260	73.5	0.506	3190.	2831.	18.5	135.	0.
SEP	359.	0.260	70.9	0.499	2746.	2387.	15.9	135.	0.
OCT	1952.	0.571	61.1	0.554	2098.	146.	12.1	335.	0.
NOV	3582.	0.650	63.8	0.540	1177.	0.	6.8	540.	392.
DEC	4536.	0.674	66.9	0.515	796.	0.	4.6	660.	560.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	25436.	KWH
YEARLY FUEL REQUIREMENTS	4277.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2115.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.494	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

DENMARK

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5097.	0.683	68.7	0.396	638.	0.	3.7	732.	652.
FEB	4913.	0.680	71.5	0.446	1029.	0.	6.0	709.	579.
MAR	3757.	0.654	72.0	0.434	1772.	0.	10.3	563.	341.
APR	1900.	0.564	69.1	0.444	2707.	808.	15.7	330.	0.
MAY	359.	0.258	72.8	0.415	3075.	2716.	17.8	136.	0.
JUN	359.	0.258	74.0	0.430	3279.	2920.	19.0	136.	0.
JUL	359.	0.258	74.2	0.454	3316.	2957.	19.2	136.	0.
AUG	359.	0.258	72.9	0.484	3087.	2728.	17.9	136.	0.
SEP	359.	0.258	70.0	0.473	2587.	2228.	15.0	136.	0.
OCT	2230.	0.589	58.5	0.580	1745.	0.	10.1	371.	95.
NOV	3752.	0.654	60.8	0.581	902.	0.	5.2	563.	449.
DEC	4675.	0.675	64.1	0.563	576.	0.	3.3	679.	606.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	28117.	KWH
YEARLY FUEL REQUIREMENTS	4628.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1906.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.412	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

LUXEMBOURG

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4774.	0.678	70.1	0.514	884.	0.	5.1	690.	579.
FEB	4214.	0.667	71.3	0.492	1346.	0.	7.8	620.	451.
MAR	2713.	0.617	69.5	0.493	2212.	0.	12.8	431.	98.
APR	1083.	0.470	66.5	0.515	3099.	2016.	17.9	226.	0.
MAY	359.	0.260	74.0	0.470	3280.	2921.	19.0	135.	0.
JUN	359.	0.260	75.0	0.493	3455.	3097.	20.0	135.	0.
JUL	359.	0.260	75.1	0.502	3469.	3110.	20.1	135.	0.
AUG	359.	0.260	73.8	0.508	3254.	2895.	18.8	135.	0.
SEP	359.	0.260	71.1	0.512	2781.	2422.	16.1	135.	0.
OCT	1904.	0.567	60.0	0.592	2034.	130.	11.8	329.	0.
NOV	3464.	0.646	62.6	0.606	1158.	0.	6.7	525.	380.
DEC	4525.	0.673	67.0	0.594	806.	0.	4.7	659.	557.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24470.	KWH
YEARLY FUEL REQUIREMENTS	4156.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2091.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.503	

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

NETHERLANDS

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4608.	0.675	69.6	0.469	798.	0.	4.6	669.	569.
FEB	4191.	0.666	71.5	0.472	1239.	0.	7.2	617.	461.
MAR	2981.	0.629	70.3	0.507	2006.	0.	11.6	465.	191.
APR	1482.	0.526	68.4	0.505	2872.	1389.	16.6	276.	0.
MAY	359.	0.260	73.5	0.466	3196.	2838.	18.5	135.	0.
JUN	359.	0.260	74.5	0.472	3372.	3013.	19.5	135.	0.
JUL	359.	0.260	74.5	0.520	3368.	3009.	19.5	135.	0.
AUG	359.	0.260	73.2	0.522	3149.	2790.	18.2	135.	0.
SEP	359.	0.260	70.2	0.526	2630.	2271.	15.2	135.	0.
OCT	1854.	0.563	59.4	0.591	1935.	81.	11.2	323.	0.
NOV	3373.	0.643	62.6	0.561	1094.	0.	6.3	514.	377.
DEC	4361.	0.670	66.4	0.543	721.	0.	4.2	638.	548.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	24643. KWH
YEARLY FUEL REQUIREMENTS	4177. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2032. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.486

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4377.	0.670	68.6	0.395	625.	0.	3.6	640.	562.
FEB	3943.	0.660	70.6	0.410	1068.	0.	6.2	586.	451.
MAR	3152.	0.636	70.6	0.469	1658.	0.	9.6	486.	278.
APR	1889.	0.566	71.0	0.443	2493.	604.	14.4	327.	0.
MAY	939.	0.443	69.0	0.468	2995.	2056.	17.3	208.	0.
JUN	359.	0.260	72.8	0.470	3076.	2717.	17.8	135.	0.
JUL	359.	0.260	72.5	0.485	3029.	2671.	17.5	135.	0.
AUG	359.	0.260	70.5	0.507	2677.	2318.	15.5	135.	0.
SEP	922.	0.439	59.6	0.527	2403.	1480.	13.9	206.	0.
OCT	2230.	0.590	61.1	0.500	1562.	0.	9.0	370.	131.
NOV	3477.	0.647	63.3	0.467	842.	0.	4.9	527.	421.
DEC	4152.	0.665	65.6	0.415	546.	0.	3.2	612.	543.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	26158.	KWH
YEARLY FUEL REQUIREMENTS	4368.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1982.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.454	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3362.	0.643	69.2	0.446	717.	0.	4.2	513.	422.
FEB	3069.	0.632	72.9	0.422	1177.	0.	6.8	476.	328.
MAR	2093.	0.581	72.9	0.437	1925.	0.	11.2	353.	33.
APR	951.	0.445	72.8	0.423	2728.	1777.	15.8	210.	0.
MAY	359.	0.260	73.2	0.422	3150.	2791.	18.2	135.	0.
JUN	359.	0.260	74.1	0.428	3300.	2941.	19.1	135.	0.
JUL	359.	0.260	73.7	0.456	3237.	2878.	18.7	135.	0.
AUG	359.	0.260	72.3	0.473	2985.	2627.	17.3	135.	0.
SEP	359.	0.260	69.1	0.489	2441.	2082.	14.1	135.	0.
OCT	1165.	0.483	59.4	0.524	1798.	633.	10.4	236.	0.
NOV	2458.	0.604	62.6	0.501	969.	0.	5.6	399.	277.
DEC	3163.	0.636	65.7	0.472	633.	0.	3.7	488.	408.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	18055. KWH
YEARLY FUEL REQUIREMENTS	3349. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1881. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.562

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GREAT BRITAIN
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3948.	0.660	69.5	0.516	780.	0.	4.5	586.	488.
FEB	3584.	0.650	71.4	0.498	1189.	0.	6.9	540.	391.
MAR	2436.	0.603	70.4	0.489	1939.	0.	11.2	396.	97.
APR	1319.	0.506	69.6	0.487	2678.	1360.	15.5	256.	0.
MAY	359.	0.260	73.0	0.462	3113.	2754.	18.0	135.	0.
JUN	359.	0.260	74.1	0.463	3293.	2934.	19.1	135.	0.
JUL	359.	0.260	73.8	0.484	3251.	2892.	18.8	135.	0.
AUG	359.	0.260	72.6	0.490	3036.	2677.	17.6	135.	0.
SEP	359.	0.260	69.4	0.504	2481.	2122.	14.4	135.	0.
OCT	1645.	0.543	60.5	0.535	1791.	146.	10.4	297.	0.
NOV	3173.	0.636	64.9	0.534	987.	0.	5.7	489.	365.
DEC	3892.	0.659	67.8	0.532	690.	0.	4.0	579.	492.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21790. KWH
YEARLY FUEL REQUIREMENTS	3819. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1985. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.520

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3663.	0.652	68.7	0.451	633.	0.	3.7	550.	471.
FEB	3280.	0.640	71.0	0.443	1077.	0.	6.2	502.	367.
MAR	2514.	0.607	72.7	0.447	1760.	0.	10.2	406.	148.
APR	1591.	0.538	74.3	0.423	2483.	892.	14.4	290.	0.
MAY	539.	0.335	72.4	0.435	3012.	2474.	17.4	158.	0.
JUN	359.	0.260	73.1	0.462	3119.	2760.	18.1	135.	0.
JUL	359.	0.260	72.2	0.508	2979.	2620.	17.2	135.	0.
AUG	359.	0.260	71.0	0.497	2758.	2399.	16.0	135.	0.
SEP	672.	0.378	67.9	0.503	2219.	1547.	12.9	174.	0.
OCT	1910.	0.567	61.4	0.533	1469.	0.	8.5	330.	87.
NOV	2999.	0.630	64.6	0.490	841.	0.	4.9	467.	361.
DEC	3557.	0.649	66.1	0.491	534.	0.	3.1	537.	470.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21801. KWH
YEARLY FUEL REQUIREMENTS	3820. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1917. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.502

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3809.	0.657	69.2	0.426	722.	0.	4.2	569.	478.
FEB	3316.	0.641	70.7	0.433	1190.	0.	6.9	507.	357.
MAR	2459.	0.604	70.0	0.484	1807.	0.	10.5	399.	128.
APR	1327.	0.507	70.1	0.468	2609.	1282.	15.1	257.	0.
MAY	412.	0.285	72.5	0.455	3018.	2606.	17.5	142.	0.
JUN	359.	0.260	73.0	0.485	3110.	2751.	18.0	135.	0.
JUL	359.	0.260	72.3	0.518	2991.	2633.	17.3	135.	0.
AUG	359.	0.260	70.9	0.516	2744.	2385.	15.9	135.	0.
SEP	718.	0.391	58.7	0.562	2327.	1609.	13.5	180.	0.
OCT	1887.	0.565	60.7	0.536	1560.	0.	9.0	327.	64.
NOV	3080.	0.633	64.4	0.491	915.	0.	5.3	477.	362.
DEC	3865.	0.658	67.7	0.466	591.	0.	3.4	576.	502.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21949. KWH
YEARLY FUEL REQUIREMENTS	3839. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1948. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.507

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

IRELAND
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3067.	0.632	69.7	0.461	816.	0.	4.7	476.	373.
FEB	2699.	0.616	72.8	0.440	1295.	0.	7.5	429.	266.
MAR	2038.	0.577	73.4	0.472	1889.	0.	10.9	346.	29.
APR	1167.	0.483	74.9	0.442	2602.	1435.	15.1	237.	0.
MAY	359.	0.260	73.0	0.447	3108.	2750.	18.0	135.	0.
JUN	359.	0.260	73.5	0.474	3190.	2831.	18.5	135.	0.
JUL	359.	0.260	72.9	0.499	3099.	2740.	17.9	135.	0.
AUG	359.	0.260	71.6	0.501	2873.	2514.	16.6	135.	0.
SEP	371.	0.266	68.4	0.521	2309.	1938.	13.4	137.	0.
OCT	1456.	0.523	62.4	0.537	1665.	208.	9.6	273.	0.
NOV	2571.	0.610	66.6	0.494	1012.	0.	5.9	413.	286.
DEC	3085.	0.633	67.9	0.497	690.	0.	4.0	478.	391.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	17890.	KWH
YEARLY FUEL REQUIREMENTS	3329.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1983.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.596	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3657.	0.652	70.9	0.422	1021.	0.	5.9	550.	421.
FEB	3200.	0.637	73.0	0.422	1503.	0.	8.7	492.	303.
MAR	1946.	0.570	72.4	0.426	2364.	418.	13.7	335.	0.
APR	905.	0.435	71.0	0.437	3010.	2106.	17.4	204.	0.
MAY	359.	0.260	74.0	0.420	3281.	2922.	19.0	135.	0.
JUN	359.	0.260	74.5	0.438	3367.	3008.	19.5	135.	0.
JUL	359.	0.260	74.5	0.448	3373.	3014.	19.5	135.	0.
AUG	359.	0.260	73.8	0.449	3249.	2890.	18.8	135.	0.
SEP	359.	0.260	71.4	0.463	2824.	2465.	16.4	135.	0.
OCT	1153.	0.481	60.9	0.512	2190.	1037.	12.7	235.	0.
NOV	2714.	0.617	65.0	0.479	1294.	0.	7.5	431.	269.
DEC	3602.	0.651	68.2	0.460	879.	0.	5.1	543.	432.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	18971.	KWH
YEARLY FUEL REQUIREMENTS	3465.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2039.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.589	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4137.	0.665	71.2	0.464	1073.	0.	6.2	610.	475.
FEB	3440.	0.646	71.8	0.453	1595.	0.	9.2	522.	322.
MAR	1810.	0.559	69.2	0.460	2538.	729.	14.7	317.	0.
APR	539.	0.335	72.9	0.437	3084.	2545.	17.9	158.	0.
MAY	359.	0.260	74.6	0.423	3383.	3024.	19.6	135.	0.
JUN	359.	0.260	75.1	0.440	3473.	3114.	20.1	135.	0.
JUL	359.	0.260	75.5	0.435	3538.	3179.	20.5	135.	0.
AUG	359.	0.260	74.7	0.451	3399.	3040.	19.7	135.	0.
SEP	359.	0.260	72.4	0.463	2998.	2640.	17.4	135.	0.
OCT	1095.	0.472	59.8	0.525	2360.	1265.	13.7	228.	0.
NOV	2936.	0.627	63.7	0.524	1329.	0.	7.7	459.	292.
DEC	4013.	0.662	68.6	0.499	959.	0.	5.6	594.	474.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	19764. KWH
YEARLY FUEL REQUIREMENTS	3564. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2001. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.562

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
.SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3548.	0.649	71.0	0.429	1034.	0.	6.0	536.	406.
FEB	2771.	0.620	72.1	0.420	1674.	0.	9.7	438.	215.
MAR	1291.	0.502	68.7	0.454	2575.	1283.	14.9	252.	0.
APR	388.	0.274	71.9	0.450	2919.	2531.	16.9	139.	0.
MAY	359.	0.260	73.7	0.437	3236.	2877.	18.7	135.	0.
JUN	359.	0.260	74.2	0.451	3318.	2959.	19.2	135.	0.
JUL	359.	0.260	74.8	0.443	3427.	3068.	19.8	135.	0.
AUG	359.	0.260	74.7	0.443	3405.	3046.	19.7	135.	0.
SEP	359.	0.260	72.5	0.459	3015.	2657.	17.5	135.	0.
OCT	506.	0.323	68.2	0.469	2286.	1780.	13.2	154.	0.
NOV	2344.	0.597	63.6	0.484	1398.	0.	8.1	385.	186.
DEC	3489.	0.647	68.3	0.463	890.	0.	5.2	529.	417.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	16132.	KWH
YEARLY FUEL REQUIREMENTS	3108.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1884.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.606	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4441.	0.672	71.5	0.372	1121.	0.	6.5	648.	507.
FEB	3424.	0.645	70.0	0.411	1692.	0.	9.8	520.	308.
MAR	1572.	0.536	65.4	0.464	2608.	1036.	15.1	288.	0.
APR	359.	0.260	71.7	0.458	2882.	2524.	16.7	135.	0.
MAY	359.	0.260	73.5	0.458	3187.	2828.	18.5	135.	0.
JUN	359.	0.260	74.6	0.462	3378.	3020.	19.6	135.	0.
JUL	359.	0.260	75.6	0.446	3555.	3196.	20.6	135.	0.
AUG	359.	0.260	74.4	0.465	3345.	2987.	19.4	135.	0.
SEP	359.	0.260	71.1	0.485	2781.	2422.	16.1	135.	0.
OCT	745.	0.398	55.5	0.537	2393.	1648.	13.9	184.	0.
NOV	2802.	0.621	61.0	0.485	1389.	0.	8.0	442.	268.
DEC	4015.	0.662	67.8	0.394	1108.	0.	6.4	595.	455.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	19152.	KWH
YEARLY FUEL REQUIREMENTS	3487.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1949.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.559	

)OUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3866.	0.658	70.7	0.476	990.	0.	5.7	576.	451.
FEB	3196.	0.637	71.5	0.456	1513.	0.	8.8	492.	301.
MAR	1676.	0.546	68.2	0.475	2389.	713.	13.8	301.	0.
APR	359.	0.260	72.3	0.454	2983.	2624.	17.3	135.	0.
MAY	359.	0.260	74.4	0.429	3349.	2990.	19.4	135.	0.
JUN	359.	0.260	75.3	0.427	3509.	3150.	20.3	135.	0.
JUL	359.	0.260	76.3	0.408	3677.	3318.	21.3	135.	0.
AUG	359.	0.260	76.0	0.427	3623.	3265.	21.0	135.	0.
SEP	359.	0.260	73.1	0.464	3118.	2759.	18.1	135.	0.
OCT	359.	0.260	68.5	0.483	2331.	1972.	13.5	135.	0.
NOV	2049.	0.578	58.9	0.539	1393.	0.	8.1	348.	129.
DEC	3463.	0.646	66.8	0.489	966.	0.	5.6	525.	404.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	16760. KWH
YEARLY FUEL REQUIREMENTS	3187. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1901. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.597

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

ITALY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	1972.	0.572	74.0	0.423	1562.	0.	9.0	338.	80.
FEB	1484.	0.526	75.3	0.427	2058.	574.	11.9	277.	0.
MAR	695.	0.384	70.6	0.467	2699.	2004.	15.6	177.	0.
APR	359.	0.260	73.3	0.451	3168.	2809.	18.3	135.	0.
MAY	359.	0.260	75.3	0.421	3510.	3151.	20.3	135.	0.
JUN	359.	0.260	76.2	0.411	3654.	3295.	21.2	135.	0.
JUL	359.	0.260	77.0	0.401	3802.	3443.	22.0	135.	0.
AUG	359.	0.260	77.3	0.411	3858.	3499.	22.3	135.	0.
SEP	359.	0.260	75.8	0.443	3587.	3228.	20.8	135.	0.
OCT	359.	0.260	72.1	0.463	2956.	2597.	17.1	135.	0.
NOV	359.	0.260	67.5	0.475	2165.	1807.	12.5	135.	0.
DEC	1578.	0.537	68.2	0.458	1583.	5.	9.2	288.	0.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	8599. KWH
YEARLY FUEL REQUIREMENTS	2161. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2080. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.963

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5077.	0.683	68.9	0.459	670.	0.	3.9	729.	645.
FEB	4551.	0.673	69.6	0.476	1075.	0.	6.2	663.	528.
MAR	3215.	0.637	69.7	0.445	1912.	0.	11.1	495.	255.
APR	1707.	0.548	67.1	0.475	2691.	983.	15.6	306.	0.
MAY	359.	0.259	73.0	0.446	3113.	2754.	18.0	136.	0.
JUN	359.	0.259	74.3	0.432	3325.	2966.	19.3	136.	0.
JUL	359.	0.259	73.9	0.461	3263.	2904.	18.9	136.	0.
AUG	359.	0.259	73.1	0.439	3131.	2772.	18.1	136.	0.
SEP	359.	0.259	69.1	0.481	2437.	2078.	14.1	136.	0.
OCT	2110.	0.581	59.0	0.514	1774.	0.	10.3	356.	66.
NOV	3822.	0.656	62.2	0.506	911.	0.	5.3	571.	457.
DEC	4678.	0.676	65.3	0.473	611.	0.	3.5	679.	602.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	26954. KWH
YEARLY FUEL REQUIREMENTS	4479. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1927. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.430

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4826.	0.679	69.5	0.481	780.	0.	4.5	697.	599.
FEB	4220.	0.667	69.6	0.493	1196.	0.	6.9	620.	470.
MAR	2872.	0.624	68.9	0.475	2009.	0.	11.6	451.	169.
APR	1377.	0.513	66.1	0.496	2790.	1413.	16.2	263.	0.
MAY	359.	0.260	72.9	0.477	3099.	2740.	17.9	135.	0.
JUN	359.	0.260	74.2	0.465	3312.	2953.	19.2	135.	0.
JUL	359.	0.260	74.0	0.474	3289.	2930.	19.0	135.	0.
AUG	359.	0.260	73.2	0.460	3147.	2788.	18.2	135.	0.
SEP	359.	0.260	70.1	0.476	2603.	2244.	15.1	135.	0.
OCT	1907.	0.567	59.9	0.516	1927.	21.	11.2	330.	0.
NOV	3693.	0.653	63.3	0.523	1007.	0.	5.8	554.	428.
DEC	4598.	0.675	67.2	0.473	720.	0.	4.2	668.	577.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	25286.	KWH
YEARLY FUEL REQUIREMENTS	4258.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2016.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.473	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

GERMANY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4925.	0.681	71.5	0.479	1128.	0.	6.5	709.	567.
FEB	4273.	0.668	71.3	0.511	1558.	0.	9.0	627.	431.
MAR	2687.	0.616	70.9	0.483	2549.	0.	14.8	428.	27.
APR	1227.	0.492	68.1	0.505	3285.	2059.	19.0	244.	0.
MAY	359.	0.260	75.4	0.485	3519.	3160.	20.4	135.	0.
JUN	359.	0.260	76.7	0.464	3748.	3389.	21.7	135.	0.
JUL	359.	0.260	77.0	0.457	3806.	3447.	22.0	135.	0.
AUG	359.	0.260	76.2	0.462	3663.	3304.	21.2	135.	0.
SEP	359.	0.260	74.2	0.459	3307.	2949.	19.2	135.	0.
OCT	1693.	0.548	62.8	0.515	2540.	847.	14.7	303.	0.
NOV	3636.	0.652	65.6	0.510	1455.	0.	8.4	547.	364.
DEC	4620.	0.675	68.9	0.475	1087.	0.	6.3	671.	534.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	24856. KWH
YEARLY FUEL REQUIREMENTS	4204. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2280. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.542

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

BELGIUM

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4797.	0.679	69.8	0.447	835.	0.	4.8	693.	588.
FEB	4342.	0.670	71.7	0.439	1280.	0.	7.4	636.	475.
MAR	2942.	0.627	69.9	0.459	2059.	0.	11.9	460.	173.
APR	1490.	0.527	68.1	0.466	2860.	1370.	16.6	277.	0.
MAY	359.	0.260	73.2	0.445	3148.	2789.	18.2	135.	0.
JUN	359.	0.260	74.0	0.455	3288.	2929.	19.0	135.	0.
JUL	359.	0.260	73.7	0.477	3227.	2869.	18.7	135.	0.
AUG	359.	0.260	72.6	0.480	3030.	2672.	17.6	135.	0.
SEP	359.	0.260	70.1	0.475	2613.	2254.	15.1	135.	0.
OCT	1952.	0.571	60.2	0.514	1946.	0.	11.3	335.	1.
NOV	3582.	0.650	63.3	0.501	1091.	0.	6.3	540.	403.
DEC	4536.	0.674	66.6	0.482	745.	0.	4.3	660.	567.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	25436.	KWH
YEARLY FUEL REQUIREMENTS	4277.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2070.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.484	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

DENMARK

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5097.	0.683	68.7	0.398	641.	0.	3.7	732.	651.
FEB	4913.	0.680	71.3	0.434	1000.	0.	5.8	709.	583.
MAR	3757.	0.654	71.8	0.427	1742.	0.	10.1	563.	344.
APR	1900.	0.564	68.9	0.438	2670.	771.	15.5	330.	0.
MAY	359.	0.258	72.9	0.418	3096.	2737.	17.9	136.	0.
JUN	359.	0.258	73.9	0.429	3269.	2910.	18.9	136.	0.
JUL	359.	0.258	73.8	0.445	3252.	2893.	18.8	136.	0.
AUG	359.	0.258	72.2	0.465	2966.	2607.	17.2	136.	0.
SEP	359.	0.258	69.5	0.456	2496.	2137.	14.5	136.	0.
OCT	2230.	0.589	57.7	0.531	1599.	0.	9.3	371.	124.
NOV	3752.	0.654	60.4	0.529	822.	0.	4.8	563.	459.
DEC	4675.	0.675	63.8	0.516	527.	0.	3.1	679.	612.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	28117.	KWH
YEARLY FUEL REQUIREMENTS	4628.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1854.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.401	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

LUXEMBOURG

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4774.	0.678	69.8	0.482	828.	0.	4.8	690.	586.
FEB	4214.	0.667	70.8	0.467	1276.	0.	7.4	620.	459.
MAR	2713.	0.617	68.9	0.470	2108.	0.	12.2	431.	119.
APR	1083.	0.470	65.7	0.490	2946.	1864.	17.1	226.	0.
MAY	359.	0.260	73.4	0.456	3185.	2826.	18.4	135.	0.
JUN	359.	0.260	74.2	0.472	3311.	2952.	19.2	135.	0.
JUL	359.	0.260	74.2	0.478	3307.	2948.	19.2	135.	0.
AUG	359.	0.260	72.9	0.482	3088.	2729.	17.9	135.	0.
SEP	359.	0.260	70.2	0.484	2627.	2268.	15.2	135.	0.
OCT	1904.	0.567	59.0	0.540	1856.	0.	10.7	329.	9.
NOV	3464.	0.646	62.0	0.547	1045.	0.	6.1	525.	394.
DEC	4525.	0.673	66.5	0.537	729.	0.	4.2	659.	567.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24470.	KWH
YEARLY FUEL REQUIREMENTS	4156.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2021.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.486	

DOUBLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

NETHERLANDS

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4608.	0.675	69.4	0.450	764.	0.	4.4	669.	573.
FEB	4191.	0.666	71.2	0.452	1186.	0.	6.9	617.	468.
MAR	2981.	0.629	69.7	0.479	1893.	0.	11.0	465.	213.
APR	1482.	0.526	67.6	0.481	2735.	1252.	15.8	276.	0.
MAY	359.	0.260	73.0	0.454	3109.	2750.	18.0	135.	0.
JUN	359.	0.260	73.9	0.458	3272.	2913.	18.9	135.	0.
JUL	359.	0.260	73.4	0.491	3177.	2818.	18.4	135.	0.
AUG	359.	0.260	72.2	0.491	2964.	2606.	17.2	135.	0.
SEP	359.	0.260	69.3	0.493	2465.	2106.	14.3	135.	0.
OCT	1854.	0.563	58.4	0.539	1766.	0.	10.2	323.	17.
NOV	3373.	0.643	62.1	0.516	1004.	0.	5.8	514.	388.
DEC	4361.	0.670	66.1	0.502	666.	0.	3.9	638.	554.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24643.	KWH
YEARLY FUEL REQUIREMENTS	4177.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1964.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.470	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4377.	0.670	66.3	0.140	221.	0.	1.3	640.	612.
FEB	3943.	0.660	67.2	0.186	484.	0.	2.8	586.	525.
MAR	3152.	0.636	67.4	0.312	1101.	0.	6.4	486.	348.
APR	1889.	0.566	65.1	0.264	1483.	0.	8.6	327.	80.
MAY	939.	0.443	63.0	0.306	1956.	1017.	11.3	208.	0.
JUN	359.	0.260	66.7	0.310	2027.	1668.	11.7	135.	0.
JUL	359.	0.260	67.3	0.339	2116.	1757.	12.3	135.	0.
AUG	359.	0.260	66.8	0.385	2033.	1674.	11.8	135.	0.
SEP	922.	0.439	56.9	0.424	1930.	1007.	11.2	206.	0.
OCT	2230.	0.590	58.8	0.372	1163.	0.	6.7	370.	209.
NOV	3477.	0.647	61.5	0.297	535.	0.	3.1	527.	460.
DEC	4152.	0.665	63.8	0.179	235.	0.	1.4	612.	582.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	26158.	KWH
YEARLY FUEL REQUIREMENTS	4368.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1552.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.355	

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3362.	0.643	67.3	0.250	402.	0.	2.3	513.	462.
FEB	3069.	0.632	69.5	0.213	593.	0.	3.4	476.	401.
MAR	2093.	0.581	68.2	0.251	1107.	0.	6.4	353.	193.
APR	951.	0.445	65.5	0.227	1463.	512.	8.5	210.	0.
MAY	359.	0.260	64.5	0.219	1635.	1276.	9.5	135.	0.
JUN	359.	0.260	65.0	0.224	1729.	1371.	10.0	135.	0.
JUL	359.	0.260	66.4	0.277	1965.	1607.	11.4	135.	0.
AUG	359.	0.260	66.4	0.312	1971.	1612.	11.4	135.	0.
SEP	359.	0.260	65.1	0.348	1736.	1378.	10.1	135.	0.
OCT	1165.	0.483	57.3	0.420	1441.	276.	8.3	236.	0.
NOV	2458.	0.604	61.1	0.372	719.	0.	4.2	399.	309.
DEC	3163.	0.636	64.4	0.303	407.	0.	2.4	488.	436.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	18055.	KWH
YEARLY FUEL REQUIREMENTS	3349.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1548.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.462	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3948.	0.660	68.5	0.404	611.	0.	3.5	586.	509.
FEB	3584.	0.650	69.6	0.369	881.	0.	5.1	540.	430.
MAR	2436.	0.603	67.3	0.353	1398.	0.	8.1	396.	203.
APR	1319.	0.506	65.1	0.345	1900.	582.	11.0	256.	0.
MAY	359.	0.260	66.4	0.292	1972.	1613.	11.4	135.	0.
JUN	359.	0.260	67.0	0.292	2072.	1713.	12.0	135.	0.
JUL	359.	0.260	67.9	0.332	2229.	1870.	12.9	135.	0.
AUG	359.	0.260	67.4	0.345	2141.	1782.	12.4	135.	0.
SEP	359.	0.260	65.8	0.378	1863.	1505.	10.8	135.	0.
OCT	1645.	0.543	58.8	0.446	1492.	0.	8.6	297.	30.
NOV	3173.	0.636	64.0	0.445	823.	0.	4.8	489.	385.
DEC	3892.	0.659	67.2	0.441	572.	0.	3.3	579.	507.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	21790.	KWH
YEARLY FUEL REQUIREMENTS	3819.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1753.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.459	

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

IRELAND
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3663.	0.652	67.1	0.260	364.	0.	2.1	550.	505.
FEB	3280.	0.640	68.3	0.251	611.	0.	3.5	502.	425.
MAR	2514.	0.607	68.6	0.270	1062.	0.	6.2	406.	272.
APR	1591.	0.538	67.7	0.228	1341.	0.	7.8	290.	49.
MAY	539.	0.335	64.8	0.244	1691.	1152.	9.8	158.	0.
JUN	359.	0.260	66.4	0.293	1977.	1618.	11.4	135.	0.
JUL	359.	0.260	68.1	0.386	2264.	1905.	13.1	135.	0.
AUG	359.	0.260	66.7	0.364	2018.	1660.	11.7	135.	0.
SEP	672.	0.378	64.7	0.379	1671.	999.	9.7	174.	0.
OCT	1910.	0.567	60.0	0.442	1218.	0.	7.1	330.	136.
NOV	2999.	0.630	63.2	0.346	594.	0.	3.4	467.	392.
DEC	3557.	0.649	65.2	0.344	374.	0.	2.2	537.	490.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	21801.	KWH
YEARLY FUEL REQUIREMENTS	3820.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1551.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.406	

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

IRELAND
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3809.	0.657	67.0	0.208	352.	0.	2.0	569.	525.
FEB	3316.	0.641	67.5	0.234	643.	0.	3.7	507.	426.
MAR	2459.	0.604	66.9	0.341	1275.	0.	7.4	399.	232.
APR	1327.	0.507	65.0	0.309	1722.	395.	10.0	257.	0.
MAY	412.	0.285	65.8	0.280	1862.	1450.	10.8	142.	0.
JUN	359.	0.260	67.6	0.339	2170.	1811.	12.6	135.	0.
JUL	359.	0.260	68.6	0.405	2343.	1984.	13.6	135.	0.
AUG	359.	0.260	67.4	0.403	2141.	1783.	12.4	135.	0.
SEP	718.	0.391	57.2	0.499	2068.	1350.	12.0	180.	0.
OCT	1887.	0.565	59.2	0.449	1305.	0.	7.6	327.	114.
NOV	3080.	0.633	62.8	0.349	651.	0.	3.8	477.	395.
DEC	3865.	0.658	66.4	0.291	369.	0.	2.1	576.	529.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21949. KWH
YEARLY FUEL REQUIREMENTS	3839. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1617. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.421

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

IRELAND
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3067.	0.632	67.9	0.283	502.	0.	2.9	476.	412.
FEB	2699.	0.616	69.5	0.249	734.	0.	4.3	429.	337.
MAR	2038.	0.577	69.8	0.319	1276.	0.	7.4	346.	149.
APR	1167.	0.483	68.8	0.262	1542.	375.	8.9	237.	0.
MAY	359.	0.260	65.7	0.265	1844.	1485.	10.7	135.	0.
JUN	359.	0.260	67.3	0.316	2123.	1764.	12.3	135.	0.
JUL	359.	0.260	68.2	0.366	2271.	1912.	13.2	135.	0.
AUG	359.	0.260	67.3	0.371	2128.	1769.	12.3	135.	0.
SEP	371.	0.266	65.7	0.417	1844.	1473.	10.7	137.	0.
OCT	1456.	0.523	60.8	0.450	1397.	0.	8.1	273.	12.
NOV	2571.	0.610	65.0	0.358	733.	0.	4.2	413.	321.
DEC	3085.	0.633	66.8	0.360	500.	0.	2.9	478.	415.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	17890. KWH
YEARLY FUEL REQUIREMENTS	3329. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1682. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.505

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

FRANCE
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3657.	0.652	67.9	0.209	506.	0.	2.9	550.	486.
FEB	3200.	0.637	68.8	0.220	781.	0.	4.5	492.	394.
MAR	1946.	0.570	66.2	0.234	1298.	0.	7.5	335.	127.
APR	905.	0.435	63.5	0.249	1710.	805.	9.9	204.	0.
MAY	359.	0.260	64.7	0.214	1670.	1311.	9.7	135.	0.
JUN	359.	0.260	65.8	0.242	1862.	1504.	10.8	135.	0.
JUL	359.	0.260	66.3	0.260	1958.	1600.	11.3	135.	0.
AUG	359.	0.260	66.0	0.263	1901.	1543.	11.0	135.	0.
SEP	359.	0.260	65.4	0.295	1799.	1440.	10.4	135.	0.
OCT	1153.	0.481	57.9	0.394	1685.	532.	9.8	235.	0.
NOV	2714.	0.617	62.7	0.329	887.	0.	5.1	431.	320.
DEC	3602.	0.651	66.3	0.283	541.	0.	3.1	543.	475.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	18971. KWH
YEARLY FUEL REQUIREMENTS	3465. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1663. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.480

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

FRANCE
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4137.	0.665	68.9	0.295	682.	0.	3.9	610.	524.
FEB	3440.	0.646	68.3	0.279	983.	0.	5.7	522.	399.
MAR	1810.	0.559	63.9	0.295	1626.	0.	9.4	317.	36.
APR	539.	0.335	65.1	0.248	1747.	1208.	10.1	158.	0.
MAY	359.	0.260	65.0	0.216	1726.	1368.	10.0	135.	0.
JUN	359.	0.260	66.1	0.243	1915.	1556.	11.1	135.	0.
JUL	359.	0.260	65.8	0.228	1857.	1498.	10.8	135.	0.
AUG	359.	0.260	66.4	0.262	1975.	1616.	11.4	135.	0.
SEP	359.	0.260	66.0	0.293	1899.	1540.	11.0	135.	0.
OCT	1095.	0.472	57.0	0.419	1883.	789.	10.9	228.	0.
NOV	2936.	0.627	62.3	0.423	1074.	0.	6.2	459.	324.
DEC	4013.	0.662	67.1	0.368	708.	0.	4.1	594.	505.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	19764.	KWH
YEARLY FUEL REQUIREMENTS	3564.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1775.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.498	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

FRANCE
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3548.	0.649	68.1	0.223	538.	0.	3.1	536.	468.
FEB	2771.	0.620	67.4	0.219	871.	0.	5.0	438.	329.
MAR	1291.	0.502	63.1	0.281	1595.	304.	9.2	252.	0.
APR	388.	0.274	65.2	0.271	1761.	1373.	10.2	139.	0.
MAY	359.	0.260	65.4	0.241	1789.	1430.	10.4	135.	0.
JUN	359.	0.260	66.2	0.264	1940.	1581.	11.2	135.	0.
JUL	359.	0.260	65.9	0.244	1890.	1531.	10.9	135.	0.
AUG	359.	0.260	65.9	0.244	1875.	1516.	10.9	135.	0.
SEP	359.	0.260	65.8	0.283	1862.	1503.	10.8	135.	0.
OCT	506.	0.323	63.8	0.310	1513.	1007.	8.8	154.	0.
NOV	2344.	0.597	61.2	0.339	979.	0.	5.7	385.	261.
DEC	3489.	0.647	66.3	0.289	556.	0.	3.2	529.	459.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	16132. KWH
YEARLY FUEL REQUIREMENTS	3108. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1590. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.512

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

ITALY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4441.	0.672	67.0	0.117	353.	0.	2.0	648.	604.
FEB	3424.	0.645	65.0	0.202	832.	0.	4.8	520.	416.
MAR	1572.	0.536	60.0	0.300	1683.	111.	9.7	288.	0.
APR	359.	0.260	65.4	0.287	1804.	1446.	10.4	135.	0.
MAY	359.	0.260	66.3	0.281	1955.	1596.	11.3	135.	0.
JUN	359.	0.260	66.9	0.282	2059.	1700.	11.9	135.	0.
JUL	359.	0.260	66.2	0.243	1935.	1576.	11.2	135.	0.
AUG	359.	0.260	66.9	0.286	2059.	1700.	11.9	135.	0.
SEP	359.	0.260	66.1	0.336	1925.	1566.	11.1	135.	0.
OCT	745.	0.398	53.0	0.439	1955.	1210.	11.3	184.	0.
NOV	2802.	0.621	58.6	0.340	974.	0.	5.6	442.	320.
DEC	4015.	0.662	63.9	0.158	446.	0.	2.6	595.	539.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	19152. KWH
YEARLY FUEL REQUIREMENTS	3487. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1609. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.461

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

ITALY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3866.	0.658	68.8	0.318	663.	0.	3.8	576.	493.
FEB	3196.	0.637	68.2	0.285	944.	0.	5.5	492.	373.
MAR	1676.	0.546	63.8	0.324	1628.	0.	9.4	301.	9.
APR	359.	0.260	65.6	0.278	1829.	1470.	10.6	135.	0.
MAY	359.	0.260	65.2	0.225	1757.	1398.	10.2	135.	0.
JUN	359.	0.260	65.1	0.213	1747.	1388.	10.1	135.	0.
JUL	359.	0.260	63.8	0.168	1516.	1157.	8.8	135.	0.
AUG	359.	0.260	65.2	0.207	1758.	1399.	10.2	135.	0.
SEP	359.	0.260	66.3	0.290	1952.	1594.	11.3	135.	0.
OCT	359.	0.260	64.4	0.337	1625.	1266.	9.4	135.	0.
NOV	2049.	0.578	57.6	0.454	1174.	0.	6.8	348.	171.
DEC	3463.	0.646	65.1	0.345	683.	0.	4.0	525.	439.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	16760. KWH
YEARLY FUEL REQUIREMENTS	3187. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1701. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.534

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

ITALY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	1972.	0.572	69.8	0.223	821.	0.	4.8	338.	226.
FEB	1484.	0.526	69.9	0.235	1133.	0.	6.6	277.	69.
MAR	695.	0.384	65.2	0.305	1765.	1071.	10.2	177.	0.
APR	359.	0.260	66.0	0.270	1896.	1537.	11.0	135.	0.
MAY	359.	0.260	64.8	0.203	1697.	1338.	9.8	135.	0.
JUN	359.	0.260	64.0	0.174	1550.	1191.	9.0	135.	0.
JUL	359.	0.260	63.0	0.145	1375.	1016.	8.0	135.	0.
AUG	359.	0.260	63.9	0.164	1542.	1183.	8.9	135.	0.
SEP	359.	0.260	66.2	0.239	1932.	1573.	11.2	135.	0.
OCT	359.	0.260	65.7	0.290	1856.	1497.	10.7	135.	0.
NOV	359.	0.260	63.5	0.321	1465.	1106.	8.5	135.	0.
DEC	1578.	0.537	64.8	0.288	997.	0.	5.8	288.	114.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	8599. KWH
YEARLY FUEL REQUIREMENTS	2161. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1752. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.811

—SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

GERMANY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5077.	0.683	67.3	0.277	405.	0.	2.3	729.	678.
FEB	4551.	0.673	67.5	0.320	723.	0.	4.2	663.	572.
MAR	3215.	0.637	65.3	0.267	1148.	0.	6.6	495.	351.
APR	1707.	0.548	62.1	0.321	1820.	113.	10.5	306.	0.
MAY	359.	0.259	65.6	0.262	1828.	1469.	10.6	136.	0.
JUN	359.	0.259	65.3	0.231	1777.	1418.	10.3	136.	0.
JUL	359.	0.259	66.7	0.285	2020.	1661.	11.7	136.	0.
AUG	359.	0.259	65.2	0.247	1757.	1398.	10.2	136.	0.
SEP	359.	0.259	64.8	0.333	1688.	1330.	9.8	136.	0.
OCT	2110.	0.581	56.7	0.401	1382.	0.	8.0	356.	143.
NOV	3822.	0.656	60.9	0.383	689.	0.	4.0	571.	485.
DEC	4678.	0.676	64.0	0.306	395.	0.	2.3	679.	629.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	26954. KWH
YEARLY FUEL REQUIREMENTS	4479. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1621. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.362

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GERMANY
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4826.	0.679	68.1	0.328	531.	0.	3.1	697.	630.
FEB	4220.	0.667	67.7	0.358	869.	0.	5.0	620.	511.
MAR	2872.	0.624	65.2	0.324	1371.	0.	7.9	451.	279.
APR	1377.	0.513	61.7	0.362	2034.	657.	11.8	263.	0.
MAY	359.	0.260	67.1	0.322	2093.	1734.	12.1	135.	0.
JUN	359.	0.260	67.1	0.293	2090.	1732.	12.1	135.	0.
JUL	359.	0.260	67.5	0.311	2159.	1800.	12.5	135.	0.
AUG	359.	0.260	66.3	0.285	1949.	1591.	11.3	135.	0.
SEP	359.	0.260	65.2	0.322	1763.	1404.	10.2	135.	0.
OCT	1907.	0.567	57.4	0.404	1508.	0.	8.7	330.	78.
NOV	3693.	0.653	62.2	0.420	809.	0.	4.7	554.	452.
DEC	4598.	0.675	65.7	0.308	469.	0.	2.7	668.	609.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	25286. KWH
YEARLY FUEL REQUIREMENTS	4258. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1699. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.399

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GERMANY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4925.	0.681	69.5	0.328	772.	0.	4.5	709.	612.
FEB	4273.	0.668	69.3	0.400	1218.	0.	7.1	627.	474.
MAR	2687.	0.616	66.5	0.340	1796.	0.	10.4	428.	175.
APR	1227.	0.492	63.2	0.377	2450.	1223.	14.2	244.	0.
MAY	359.	0.260	69.1	0.334	2428.	2069.	14.1	135.	0.
JUN	359.	0.260	68.5	0.288	2324.	1965.	13.5	135.	0.
JUL	359.	0.260	68.1	0.270	2254.	1895.	13.1	135.	0.
AUG	359.	0.260	68.0	0.283	2245.	1887.	13.0	135.	0.
SEP	359.	0.260	66.9	0.285	2050.	1692.	11.9	135.	0.
OCT	1693.	0.548	59.6	0.400	1975.	281.	11.4	303.	0.
NOV	3636.	0.652	63.7	0.395	1127.	0.	6.5	547.	405.
DEC	4620.	0.675	66.9	0.318	728.	0.	4.2	671.	579.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24856.	KWH
YEARLY FUEL REQUIREMENTS	4204.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1959.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.466	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

:ELGIUM

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4797.	0.679	67.8	0.254	475.	0.	2.8	693.	633.
FEB	4342.	0.670	68.5	0.247	721.	0.	4.2	636.	545.
MAR	2942.	0.627	65.6	0.293	1316.	0.	7.6	460.	294.
APR	1490.	0.527	62.3	0.302	1856.	366.	10.8	277.	0.
MAY	359.	0.260	65.7	0.262	1849.	1490.	10.7	135.	0.
JUN	359.	0.260	66.6	0.277	2000.	1641.	11.6	135.	0.
JUL	359.	0.260	67.5	0.319	2156.	1798.	12.5	135.	0.
AUG	359.	0.260	67.0	0.327	2064.	1706.	12.0	135.	0.
SEP	359.	0.260	65.2	0.320	1761.	1402.	10.2	135.	0.
OCT	1952.	0.571	57.7	0.401	1516.	0.	8.8	335.	85.
NOV	3582.	0.650	61.7	0.373	813.	0.	4.7	540.	438.
DEC	4536.	0.674	65.3	0.330	509.	0.	3.0	660.	596.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	25436. KWH
YEARLY FUEL REQUIREMENTS	4277. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1685. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.394

SINGLE GLASS COVER.BLACK   ABSORBER ALPHA=.96 EPSILON=.86

DENMARK

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5097.	0.683	66.4	0.147	237.	0.	1.4	732.	702.
FEB	4913.	0.680	68.6	0.231	533.	0.	3.1	709.	642.
MAR	3757.	0.654	67.2	0.231	944.	0.	5.5	563.	445.
APR	1900.	0.564	62.3	0.252	1541.	0.	8.9	330.	70.
MAY	359.	0.258	64.1	0.212	1574.	1215.	9.1	136.	0.
JUN	359.	0.258	65.0	0.227	1731.	1372.	10.0	136.	0.
JUL	359.	0.258	65.8	0.256	1869.	1511.	10.8	136.	0.
AUG	359.	0.258	66.0	0.298	1899.	1540.	11.0	136.	0.
SEP	359.	0.258	64.0	0.285	1558.	1200.	9.0	136.	0.
OCT	2230.	0.589	56.1	0.437	1314.	0.	7.6	371.	180.
NOV	3752.	0.654	59.5	0.433	672.	0.	3.9	563.	478.
DEC	4675.	0.675	63.1	0.402	411.	0.	2.4	679.	627.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	28117.	KWH
YEARLY FUEL REQUIREMENTS	4628.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1484.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.321	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

LUXEMBOURG

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4774.	0.678	68.3	0.329	566.	0.	3.3	690.	619.
FEB	4214.	0.667	68.3	0.304	830.	0.	4.8	620.	515.
MAR	2713.	0.617	64.9	0.315	1412.	0.	8.2	431.	253.
APR	1083.	0.470	60.6	0.346	2082.	999.	12.1	226.	0.
MAY	359.	0.260	66.3	0.280	1957.	1598.	11.3	135.	0.
JUN	359.	0.260	67.5	0.309	2163.	1804.	12.5	135.	0.
JUL	359.	0.260	67.8	0.319	2206.	1847.	12.8	135.	0.
AUG	359.	0.260	67.2	0.329	2108.	1749.	12.2	135.	0.
SEP	359.	0.260	65.6	0.337	1832.	1473.	10.6	135.	0.
OCT	1904.	0.567	57.3	0.456	1567.	0.	9.1	329.	66.
NOV	3464.	0.646	61.2	0.474	906.	0.	5.2	525.	412.
DEC	4525.	0.673	65.9	0.453	615.	0.	3.6	659.	581.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24470.	KWH
YEARLY FUEL REQUIREMENTS	4156.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1709.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.411	

SINGLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

_ETHERLANDS

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4608.	0.675	67.6	0.259	440.	0.	2.6	669.	614.
FEB	4191.	0.666	68.4	0.273	715.	0.	4.1	617.	527.
MAR	2981.	0.629	66.3	0.333	1314.	0.	7.6	465.	299.
APR	1482.	0.526	62.8	0.333	1893.	411.	11.0	276.	0.
MAY	359.	0.260	66.0	0.277	1900.	1541.	11.0	135.	0.
JUN	359.	0.260	66.6	0.281	2009.	1651.	11.6	135.	0.
JUL	359.	0.260	68.0	0.347	2245.	1886.	13.0	135.	0.
AUG	359.	0.260	67.2	0.350	2109.	1750.	12.2	135.	0.
SEP	359.	0.260	65.3	0.357	1786.	1427.	10.3	135.	0.
OCT	1854.	0.563	56.8	0.454	1485.	0.	8.6	323.	72.
NOV	3373.	0.643	60.9	0.404	786.	0.	4.6	514.	415.
DEC	4361.	0.670	65.1	0.371	493.	0.	2.9	638.	576.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24643.	KWH
YEARLY FUEL REQUIREMENTS	4177.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1674.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.401	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4377.	0.670	67.6	0.282	446.	0.	2.6	640.	584.
FEB	3943.	0.660	69.0	0.306	799.	0.	4.6	586.	485.
MAR	3152.	0.636	69.0	0.390	1378.	0.	8.0	486.	313.
APR	1889.	0.566	68.1	0.356	2004.	115.	11.6	327.	0.
MAY	939.	0.443	66.1	0.389	2490.	1551.	14.4	208.	0.
JUN	359.	0.260	69.8	0.391	2555.	2197.	14.8	135.	0.
JUL	359.	0.260	69.8	0.411	2562.	2203.	14.8	135.	0.
AUG	359.	0.260	68.5	0.440	2325.	1966.	13.5	135.	0.
SEP	922.	0.439	58.1	0.469	2137.	1214.	12.4	206.	0.
OCT	2230.	0.590	59.9	0.432	1348.	0.	7.8	370.	173.
NOV	3477.	0.647	62.4	0.383	691.	0.	4.0	527.	440.
DEC	4152.	0.665	64.8	0.309	407.	0.	2.4	612.	561.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	26158.	KWH
YEARLY FUEL REQUIREMENTS	4368.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1812.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.415	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3362.	0.643	68.3	0.352	566.	0.	3.3	513.	441.
FEB	3069.	0.632	71.3	0.323	900.	0.	5.2	476.	363.
MAR	2093.	0.581	70.6	0.346	1524.	0.	8.8	353.	112.
APR	951.	0.445	69.3	0.329	2122.	1171.	12.3	210.	0.
MAY	359.	0.260	69.1	0.327	2437.	2078.	14.1	135.	0.
JUN	359.	0.260	69.8	0.332	2563.	2205.	14.8	135.	0.
JUL	359.	0.260	70.2	0.369	2622.	2263.	15.2	135.	0.
AUG	359.	0.260	69.3	0.392	2477.	2118.	14.3	135.	0.
SEP	359.	0.260	67.0	0.414	2070.	1711.	12.0	135.	0.
OCT	1165.	0.483	58.2	0.464	1591.	426.	9.2	236.	0.
NOV	2458.	0.604	61.8	0.431	833.	0.	4.8	399.	294.
DEC	3163.	0.636	65.1	0.388	521.	0.	3.0	488.	422.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	18055. KWH
YEARLY FUEL REQUIREMENTS	3349. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1717. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.513

_OUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GREAT BRITAIN
OUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3948.	0.660	69.0	0.452	684.	0.	4.0	586.	500.
FEB	3584.	0.650	70.5	0.429	1023.	0.	5.9	540.	412.
MAR	2436.	0.603	68.8	0.417	1654.	0.	9.6	396.	153.
APR	1319.	0.506	67.3	0.414	2279.	961.	13.2	256.	0.
MAY	359.	0.260	69.8	0.379	2555.	2196.	14.8	135.	0.
JUN	359.	0.260	70.6	0.380	2698.	2339.	15.6	135.	0.
JUL	359.	0.260	70.8	0.407	2734.	2375.	15.8	135.	0.
AUG	359.	0.260	69.9	0.415	2573.	2214.	14.9	135.	0.
SEP	359.	0.260	67.4	0.435	2144.	1785.	12.4	135.	0.
OCT	1645.	0.543	59.4	0.480	1607.	0.	9.3	297.	8.
NOV	3173.	0.636	64.3	0.478	884.	0.	5.1	489.	378.
DEC	3892.	0.659	67.4	0.475	617.	0.	3.6	579.	502.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21790. KWH
YEARLY FUEL REQUIREMENTS	3819. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1867. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.489

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

RELAND
ORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3663.	0.652	67.9	0.360	505.	0.	2.9	550.	487.
FEB	3280.	0.640	69.7	0.350	852.	0.	4.9	502.	395.
MAR	2514.	0.607	70.7	0.360	1415.	0.	8.2	406.	215.
APR	1591.	0.538	71.2	0.329	1931.	340.	11.2	290.	0.
MAY	539.	0.335	68.8	0.344	2383.	1845.	13.8	158.	0.
JUN	359.	0.260	69.8	0.379	2560.	2202.	14.8	135.	0.
JUL	359.	0.260	70.0	0.442	2590.	2231.	15.0	135.	0.
AUG	359.	0.260	68.7	0.426	2366.	2007.	13.7	135.	0.
SEP	672.	0.378	66.1	0.435	1919.	1247.	11.1	174.	0.
OCT	1910.	0.567	60.5	0.477	1314.	0.	7.6	330.	117.
NOV	2999.	0.630	63.8	0.415	712.	0.	4.1	467.	378.
DEC	3557.	0.649	65.6	0.415	451.	0.	2.6	537.	480.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21801. KWH
YEARLY FUEL REQUIREMENTS	3820. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1748. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.458

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

IRELAND
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3809.	0.657	68.2	0.325	551.	0.	3.2	569.	500.
FEB	3316.	0.641	69.2	0.338	929.	0.	5.4	507.	390.
MAR	2459.	0.604	68.4	0.409	1530.	0.	8.9	399.	182.
APR	1327.	0.507	67.6	0.389	2167.	840.	12.5	257.	0.
MAY	412.	0.285	69.2	0.370	2456.	2045.	14.2	142.	0.
JUN	359.	0.260	70.2	0.411	2631.	2272.	15.2	135.	0.
JUL	359.	0.260	70.2	0.455	2627.	2269.	15.2	135.	0.
AUG	359.	0.260	68.9	0.452	2405.	2046.	13.9	135.	0.
SEP	718.	0.391	57.7	0.517	2142.	1424.	12.4	180.	0.
OCT	1887.	0.565	59.8	0.481	1400.	0.	8.1	327.	95.
NOV	3080.	0.633	63.6	0.416	777.	0.	4.5	477.	379.
DEC	3865.	0.658	67.1	0.381	482.	0.	2.8	576.	515.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	21949. KWH
YEARLY FUEL REQUIREMENTS	3839. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1777. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.463

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

:RELAND
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3067.	0.632	68.8	0.373	661.	0.	3.8	476.	392.
FEB	2699.	0.616	71.2	0.347	1021.	0.	5.9	429.	301.
MAR	2038.	0.577	71.5	0.393	1572.	0.	9.1	346.	91.
APR	1167.	0.483	71.9	0.353	2081.	914.	12.1	237.	0.
MAY	359.	0.260	69.5	0.360	2501.	2142.	14.5	135.	0.
JUN	359.	0.260	70.4	0.395	2659.	2300.	15.4	135.	0.
JUL	359.	0.260	70.4	0.429	2663.	2304.	15.4	135.	0.
AUG	359.	0.260	69.3	0.432	2475.	2116.	14.3	135.	0.
SEP	371.	0.266	66.8	0.460	2037.	1666.	11.8	137.	0.
OCT	1456.	0.523	61.4	0.482	1495.	39.	8.7	273.	0.
NOV	2571.	0.610	65.7	0.421	863.	0.	5.0	413.	305.
DEC	3085.	0.633	67.3	0.424	588.	0.	3.4	478.	404.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	17890.	KWH
YEARLY FUEL REQUIREMENTS	3329.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1835.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.551	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

FRANCE
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3657.	0.652	69.5	0.323	780.	0.	4.5	550.	452.
FEB	3200.	0.637	71.0	0.326	1158.	0.	6.7	492.	347.
MAR	1946.	0.570	69.4	0.333	1849.	0.	10.7	335.	19.
APR	905.	0.435	67.4	0.348	2395.	1490.	13.9	204.	0.
MAY	359.	0.260	69.6	0.324	2528.	2169.	14.6	135.	0.
JUN	359.	0.260	70.4	0.346	2657.	2298.	15.4	135.	0.
JUL	359.	0.260	70.6	0.359	2699.	2340.	15.6	135.	0.
AUG	359.	0.260	70.1	0.360	2603.	2244.	15.1	135.	0.
SEP	359.	0.260	68.4	0.380	2315.	1957.	13.4	135.	0.
OCT	1153.	0.481	59.3	0.448	1916.	763.	11.1	235.	0.
NOV	2714.	0.617	63.8	0.402	1085.	0.	6.3	431.	295.
DEC	3602.	0.651	67.3	0.374	714.	0.	4.1	543.	453.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	18971. KWH
YEARLY FUEL REQUIREMENTS	3465. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1900. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.548

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

FRANCE
CENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4137.	0.665	70.1	0.381	881.	0.	5.1	610.	499.
FEB	3440.	0.646	70.1	0.368	1294.	0.	7.5	522.	360.
MAR	1810.	0.559	66.6	0.379	2090.	280.	12.1	317.	0.
APR	539.	0.335	69.2	0.347	2448.	1908.	14.2	158.	0.
MAY	359.	0.260	70.1	0.327	2611.	2252.	15.1	135.	0.
JUN	359.	0.260	70.9	0.347	2741.	2382.	15.9	135.	0.
JUL	359.	0.260	71.0	0.339	2757.	2398.	16.0	135.	0.
AUG	359.	0.260	70.8	0.361	2721.	2362.	15.8	135.	0.
SEP	359.	0.260	69.2	0.380	2456.	2097.	14.2	135.	0.
OCT	1095.	0.472	58.3	0.466	2094.	999.	12.1	228.	0.
NOV	2936.	0.627	62.9	0.464	1179.	0.	6.8	459.	311.
DEC	4013.	0.662	67.8	0.429	825.	0.	4.8	594.	491.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	19764.	KWH
YEARLY FUEL REQUIREMENTS	3564.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1904.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.534	

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FRANCE
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MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3548.	0.649	69.6	0.332	800.	0.	4.6	536.	435.
FEB	2771.	0.620	69.8	0.324	1289.	0.	7.5	438.	276.
MAR	1291.	0.502	66.0	0.369	2097.	806.	12.1	252.	0.
APR	388.	0.274	68.7	0.363	2358.	1970.	13.7	139.	0.
MAY	359.	0.260	69.8	0.344	2550.	2191.	14.8	135.	0.
JUN	359.	0.260	70.4	0.361	2659.	2300.	15.4	135.	0.
JUL	359.	0.260	70.7	0.350	2704.	2345.	15.7	135.	0.
AUG	359.	0.260	70.5	0.349	2685.	2326.	15.5	135.	0.
SEP	359.	0.260	69.2	0.373	2450.	2091.	14.2	135.	0.
OCT	506.	0.323	66.0	0.389	1893.	1387.	11.0	154.	0.
NOV	2344.	0.597	62.3	0.409	1181.	0.	6.8	385.	228.
DEC	3489.	0.647	67.3	0.377	726.	0.	4.2	529.	437.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	16132.	KWH
YEARLY FUEL REQUIREMENTS	3108.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1731.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.557	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

TALY
_ORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4441.	0.672	69.5	0.257	776.	0.	4.5	648.	551.
FEB	3424.	0.645	67.7	0.312	1287.	0.	7.5	520.	359.
MAR	1572.	0.536	62.8	0.384	2159.	587.	12.5	288.	0.
APR	359.	0.260	68.6	0.374	2353.	1994.	13.6	135.	0.
MAY	359.	0.260	70.0	0.372	2588.	2229.	15.0	135.	0.
JUN	359.	0.260	70.9	0.375	2742.	2383.	15.9	135.	0.
JUL	359.	0.260	71.2	0.351	2800.	2442.	16.2	135.	0.
AUG	359.	0.260	70.8	0.378	2722.	2363.	15.8	135.	0.
SEP	359.	0.260	68.5	0.408	2338.	1980.	13.5	135.	0.
OCT	745.	0.398	54.1	0.481	2145.	1400.	12.4	184.	0.
NOV	2802.	0.621	59.8	0.410	1176.	0.	6.8	442.	294.
DEC	4015.	0.662	66.0	0.287	807.	0.	4.7	595.	493.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	19152. KWH
YEARLY FUEL REQUIREMENTS	3487. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1790. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.513

_OUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

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_ENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3866.	0.658	69.8	0.396	825.	0.	4.8	576.	472.
FEB	3196.	0.637	69.9	0.371	1232.	0.	7.1	492.	337.
MAR	1676.	0.546	66.0	0.399	2004.	329.	11.6	301.	0.
APR	359.	0.260	69.0	0.368	2422.	2063.	14.0	135.	0.
MAY	359.	0.260	70.1	0.334	2603.	2244.	15.1	135.	0.
JUN	359.	0.260	70.6	0.328	2696.	2337.	15.6	135.	0.
JUL	359.	0.260	70.7	0.301	2710.	2351.	15.7	135.	0.
AUG	359.	0.260	71.1	0.327	2772.	2413.	16.1	135.	0.
SEP	359.	0.260	69.7	0.379	2546.	2187.	14.7	135.	0.
OCT	359.	0.260	66.4	0.407	1963.	1604.	11.4	135.	0.
NOV	2049.	0.578	58.1	0.485	1254.	0.	7.3	348.	156.
DEC	3463.	0.646	65.9	0.414	819.	0.	4.7	525.	422.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	16760.	KWH
YEARLY FUEL REQUIREMENTS	3187.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1799.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.565	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

TALY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	1972.	0.572	72.0	0.325	1201.	0.	7.0	338.	151.
FEB	1484.	0.526	72.6	0.333	1602.	118.	9.3	277.	0.
MAR	695.	0.384	67.9	0.386	2233.	1539.	12.9	177.	0.
APR	359.	0.260	69.8	0.364	2554.	2196.	14.8	135.	0.
MAY	359.	0.260	70.5	0.321	2675.	2316.	15.5	135.	0.
JUN	359.	0.260	70.7	0.305	2709.	2350.	15.7	135.	0.
JUL	359.	0.260	70.9	0.289	2740.	2381.	15.9	135.	0.
AUG	359.	0.260	71.4	0.302	2837.	2478.	16.4	135.	0.
SEP	359.	0.260	71.3	0.348	2818.	2459.	16.3	135.	0.
OCT	359.	0.260	69.0	0.378	2413.	2054.	14.0	135.	0.
NOV	359.	0.260	65.4	0.396	1804.	1445.	10.4	135.	0.
DEC	1578.	0.537	66.5	0.372	1287.	0.	7.5	288.	57.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	8599. KWH
YEARLY FUEL REQUIREMENTS	2161. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1953. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.904

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

GERMANY
NORTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5077.	0.683	68.2	0.373	545.	0.	3.2	729.	661.
FEB	4551.	0.673	68.5	0.398	900.	0.	5.2	663.	550.
MAR	3215.	0.637	67.6	0.359	1542.	0.	8.9	495.	301.
APR	1707.	0.548	64.6	0.399	2260.	553.	13.1	306.	0.
MAY	359.	0.259	69.5	0.357	2496.	2137.	14.5	136.	0.
JUN	359.	0.259	70.0	0.337	2597.	2238.	15.0	136.	0.
JUL	359.	0.259	70.4	0.375	2658.	2300.	15.4	136.	0.
AUG	359.	0.259	69.3	0.347	2476.	2117.	14.3	136.	0.
SEP	359.	0.259	66.9	0.405	2050.	1691.	11.9	136.	0.
OCT	2110.	0.581	57.7	0.452	1557.	0.	9.0	356.	108.
NOV	3822.	0.656	61.5	0.440	791.	0.	4.6	571.	472.
DEC	4678.	0.676	64.7	0.392	506.	0.	2.9	679.	615.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	26954. KWH
YEARLY FUEL REQUIREMENTS	4479. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1772. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.396

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

ERMANY
ENTRAL

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4826.	0.679	68.8	0.404	655.	0.	3.8	697.	614.
FEB	4220.	0.667	68.6	0.422	1025.	0.	5.9	620.	492.
MAR	2872.	0.624	67.0	0.398	1686.	0.	9.8	451.	232.
APR	1377.	0.513	63.9	0.428	2403.	1026.	13.9	263.	0.
MAY	359.	0.260	70.0	0.400	2594.	2235.	15.0	135.	0.
JUN	359.	0.260	70.7	0.381	2716.	2357.	15.7	135.	0.
JUL	359.	0.260	70.8	0.393	2729.	2370.	15.8	135.	0.
AUG	359.	0.260	69.8	0.374	2563.	2204.	14.8	135.	0.
SEP	359.	0.260	67.6	0.398	2175.	1816.	12.6	135.	0.
OCT	1907.	0.567	58.5	0.454	1695.	0.	9.8	330.	41.
NOV	3693.	0.653	62.7	0.463	892.	0.	5.2	554.	442.
DEC	4598.	0.675	66.5	0.392	597.	0.	3.5	668.	593.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	25286. KWH
YEARLY FUEL REQUIREMENTS	4258. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1844. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.433

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

ERMANY
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4925.	0.681	70.5	0.403	949.	0.	5.5	709.	590.
FEB	4273.	0.668	70.2	0.449	1368.	0.	7.9	627.	455.
MAR	2687.	0.616	68.7	0.410	2166.	0.	12.5	428.	102.
APR	1227.	0.492	65.6	0.439	2858.	1631.	16.5	244.	0.
MAY	359.	0.260	72.2	0.409	2972.	2613.	17.2	135.	0.
JUN	359.	0.260	72.8	0.380	3066.	2707.	17.8	135.	0.
JUL	359.	0.260	72.8	0.369	3073.	2714.	17.8	135.	0.
AUG	359.	0.260	72.3	0.376	2984.	2625.	17.3	135.	0.
SEP	359.	0.260	70.6	0.375	2699.	2340.	15.6	135.	0.
OCT	1693.	0.548	61.1	0.453	2235.	541.	12.9	303.	0.
NOV	3636.	0.652	64.6	0.446	1274.	0.	7.4	547.	387.
DEC	4620.	0.675	67.9	0.397	909.	0.	5.3	671.	556.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	24856. KWH
YEARLY FUEL REQUIREMENTS	4204. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2114. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.503

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

BELGIUM

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4797.	0.679	68.9	0.356	666.	0.	3.9	693.	609.
FEB	4342.	0.670	70.2	0.348	1015.	0.	5.9	636.	508.
MAR	2942.	0.627	67.8	0.377	1692.	0.	9.8	460.	245.
APR	1490.	0.527	65.3	0.386	2373.	883.	13.7	277.	0.
MAY	359.	0.260	69.6	0.357	2526.	2167.	14.6	135.	0.
JUN	359.	0.260	70.4	0.369	2666.	2308.	15.4	135.	0.
JUL	359.	0.260	70.6	0.398	2693.	2334.	15.6	135.	0.
AUG	359.	0.260	69.7	0.403	2541.	2182.	14.7	135.	0.
SEP	359.	0.260	67.6	0.396	2180.	1822.	12.6	135.	0.
OCT	1952.	0.571	58.9	0.452	1709.	0.	9.9	335.	48.
NOV	3582.	0.650	62.4	0.433	943.	0.	5.5	540.	422.
DEC	4536.	0.674	66.0	0.406	627.	0.	3.6	660.	581.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	25436.	KWH
YEARLY FUEL REQUIREMENTS	4277.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1864.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.436	

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

NMARK

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	5097.	0.683	67.7	0.288	463.	0.	2.7	732.	674.
FEB	4913.	0.680	70.1	0.340	784.	0.	4.5	709.	610.
MAR	3757.	0.654	69.6	0.334	1363.	0.	7.9	563.	392.
APR	1900.	0.564	65.8	0.350	2133.	234.	12.4	330.	0.
MAY	359.	0.258	68.8	0.321	2381.	2022.	13.8	136.	0.
JUN	359.	0.258	69.7	0.334	2546.	2187.	14.7	136.	0.
JUL	359.	0.258	70.0	0.355	2592.	2233.	15.0	136.	0.
AUG	359.	0.258	69.1	0.383	2438.	2079.	14.1	136.	0.
SEP	359.	0.258	66.8	0.371	2031.	1672.	11.8	136.	0.
OCT	2230.	0.589	56.7	0.475	1430.	0.	8.3	371.	157.
NOV	3752.	0.654	59.9	0.472	733.	0.	4.2	563.	471.
DEC	4675.	0.675	63.4	0.453	463.	0.	2.7	679.	621.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	28117. KWH
YEARLY FUEL REQUIREMENTS	4628. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1704. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.368

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

UXEMBOURG

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4774.	0.678	69.0	0.405	697.	0.	4.0	690.	602.
FEB	4214.	0.667	69.6	0.386	1056.	0.	6.1	620.	487.
MAR	2713.	0.617	66.9	0.392	1759.	0.	10.2	431.	187.
APR	1083.	0.470	63.2	0.418	2516.	1433.	14.6	226.	0.
MAY	359.	0.260	70.0	0.371	2590.	2231.	15.0	135.	0.
JUN	359.	0.260	70.9	0.392	2744.	2385.	15.9	135.	0.
JUL	359.	0.260	71.0	0.399	2757.	2399.	16.0	135.	0.
AUG	359.	0.260	70.0	0.404	2591.	2232.	15.0	135.	0.
SEP	359.	0.260	67.8	0.408	2216.	1857.	12.8	135.	0.
OCT	1904.	0.567	57.9	0.488	1675.	0.	9.7	329.	45.
NOV	3464.	0.646	61.4	0.497	950.	0.	5.5	525.	406.
DEC	4525.	0.673	66.1	0.484	657.	0.	3.8	659.	576.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50
STORAGE TANK VOLUME	5.0 CBM
YEARLY ENERGY REQUIREMENTS	24470. KWH
YEARLY FUEL REQUIREMENTS	4156. LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1852. LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.446

DOUBLE GLASS COVER.BLACK ABSORBER ALPHA=.96 EPSILON=.86

NETHERLANDS

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	4608.	0.675	68.5	0.360	611.	0.	3.5	669.	592.
FEB	4191.	0.666	69.9	0.366	959.	0.	5.6	617.	496.
MAR	2981.	0.629	67.9	0.404	1597.	0.	9.2	465.	264.
APR	1482.	0.526	65.2	0.407	2313.	831.	13.4	276.	0.
MAY	359.	0.260	69.6	0.368	2524.	2165.	14.6	135.	0.
JUN	359.	0.260	70.4	0.372	2661.	2302.	15.4	135.	0.
JUL	359.	0.260	70.6	0.417	2697.	2339.	15.6	135.	0.
AUG	359.	0.260	69.6	0.418	2520.	2161.	14.6	135.	0.
SEP	359.	0.260	67.2	0.421	2105.	1746.	12.2	135.	0.
OCT	1854.	0.563	57.4	0.486	1591.	0.	9.2	323.	51.
NOV	3373.	0.643	61.4	0.453	881.	0.	5.1	514.	403.
DEC	4361.	0.670	65.5	0.433	574.	0.	3.3	638.	566.

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	24643.	KWH
YEARLY FUEL REQUIREMENTS	4177.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1804.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.432	

Appendix B

The input parameters and the deailed results of the computer simulation for the "Standard outdoor swimming pool" are presented. The variables appearing in the results are described below:

Q-LOAD - The monthly heating requirement in KWh for both space heating and hot water preparation

ETAHZ - The monthly efficiency of the conventional heating system before the solar energy system is installed

TINLET - The monthly average collector inlet temperature

ETACOL* - The monthly average collector efficiency

Q-SUN - The monthly solar energy intering the storage volume via the collectors

Q-EXTRA** The excess energy available in the storage volume after the space heating and hot water demand have been satisfied

DTSP - The average monthly increase in the storage temperature over and above a calculated heating inlet temperature

QMVB - The monthly oil need before a solar energy system has been installed

QNEUMV - The monthly oil need after a solar energy system has been installed

*The extremely high collector efficiencies are due to the very low collector inlet temperatures which can be achieved when the swimming pool itself is used as the storage volume (see Fig.).

**In practice Q-EXTRA is available for other possible heat loads If Q-EXTRA is not depleted there is an increase in both storage volume temperature and the collector inlet temperature.

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

BELGIUM "Standard outdoor swimming pool"

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
APR	3680.	0.653	30.1	0.758	1859.	0.	1.1	553.	319.
MAY	2410.	0.601	30.3	0.774	2164.	0.	1.3	393.	48.
JUN	1486.	0.526	30.3	0.790	2249.	763.	1.3	277.	0.
JUL	1235.	0.494	30.2	0.800	2138.	903.	1.2	245.	0.
AUG	1492.	0.527	30.2	0.799	2004.	512.	1.2	278.	0.
SEP	2567.	0.610	30.0	0.786	1740.	0.	1.0	413.	162.

RESULTS

COLLECTOR AREA IN SQUARE METERS	20	
STORAGE TANK VOLUME	50.0	CBM
YEARLY ENERGY REQUIREMENTS	12870.	KWH
YEARLY FUEL REQUIREMENTS	2158.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	1628.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.755	

Appendix C

The input parameters and the detailed results of the computer simulation for space heating, hot-water preparation, and air-conditioning in the case of the "Standard house" are presented. The variables appearing in the results are described below:

Q-LOAD	-	The monthly heating and cooling load for space heating, hot water preparation, and air-conditioning
ETAHZ	-	The monthly efficiency of the conventional heating system before the solar energy system is installed
TINLET	-	The monthly average collector inlet temperature
ETACOL	-	The monthly average collector efficiency
Q-SUN	-	The monthly solar energy entering the storage volume via the collectors
Q-EXTRA*	-	The excess enrgy available in the storage volume after the space heating and hot water demand have been satisfied
DTSP	-	The average monthly increase in the storage temperature over and above a calculated heating inlet temperature
QMVB	-	The monthly oil need before a solar energy system has been installed
QNEUMV	-	The monthly oil need after a solar energy system has been installed
QPLUS	-	The excess energy that has to be extracted from the house such that the house will remain in thermal equilibrium at 21°C

*In practice Q-EXTRA is available for other possible heat loads. If Q-EXTRA is not depleted there is an increase in both storage volume temperature and the collector inlet temperature.

THAUS - The average monthly house temperature that would set in if one were to not air-condition the house

SPT - See TINLET

TKON - The average monthly condenser temperature

DT - The average number of hours per day which the absorptive cooling machine must operate so that the house remains in thermal equilibrium at the desired house temperature.

SINGLE GLASS COVER.SELECTIVE ABSORBER ALPHA=.92 EPSILON=.10

FRANCE
SOUTH

MONTHLY RESULTS

MONTH	Q-LOAD KWH	ETAHZ	TINLET	ETACOL	Q-SUN KWH	Q-EXTRA KWH	DTSP DEG-C	QMVB LT/MON	QNEUMV LT/MON
JAN	3548.	0.649	71.2	0.442	1065.	0.	6.2	536.	402.
FEB	2771.	0.620	72.2	0.427	1702.	0.	9.9	438.	210.
MAR	1291.	0.502	69.2	0.468	2654.	1363.	15.4	252.	0.
APR	388.	0.274	72.3	0.461	2996.	2608.	17.3	139.	0.
MAY	359.	0.260	73.9	0.441	3272.	2913.	18.9	135.	0.
JUN	1080.	0.469	91.8	0.374	2753.	1673.	15.9	226.	0.
JUL	2192.	0.588	87.9	0.413	3198.	1006.	18.5	366.	0.
AUG	1370.	0.512	90.9	0.376	2897.	1527.	16.8	262.	0.
SEP	885.	0.431	91.1	0.372	2445.	1560.	14.2	201.	0.
OCT	506.	0.323	68.9	0.492	2399.	1893.	13.9	154.	0.
NOV	2344.	0.597	64.1	0.516	1490.	0.	8.6	385.	167.
DEC	3489.	0.647	68.5	0.489	941.	0.	5.4	529.	410.

MONTHLY RESULTS FOR COOLING

MONTH	QPLUS KWH/MON	THAUS (GRD)	SPT (GRD)	TKON (GRD)	DT H
JAN	0.	21.0	71.2	9.6	0.0
FEB	0.	21.0	72.2	10.7	0.0
MAR	0.	21.0	69.2	14.3	0.0
APR	0.	21.0	72.3	16.5	0.0
MAY	0.	21.0	73.9	19.9	0.0
JUN	591.	21.9	91.8	23.7	2.0
JUL	1503.	23.2	87.9	25.8	5.7
AUG	829.	22.2	90.9	25.8	2.9
SEP	431.	21.6	91.1	23.3	1.4
OCT	0.	21.0	68.9	18.3	0.0
NOV	0.	21.0	64.1	13.6	0.0
DEC	0.	21.0	68.5	10.4	0.0

RESULTS

COLLECTOR AREA IN SQUARE METERS	50	
STORAGE TANK VOLUME	5.0	CBM
YEARLY ENERGY REQUIREMENTS	20223.	KWH
YEARLY FUEL REQUIREMENTS	3622.	LT OIL
YEARLY SAVINGS WITH SOLAR ENERGY	2432.	LT OIL
FRACTION COVERED BY SOLAR ENERGY	0.672	