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23 July 1987
English

ENERGY CONSERVATION IN THE OPERATION OF BUILDINGS

DP/HUN/80/001

HUNGARY

Terminal report *

Prepared for the Government of Hungary
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of The Hungarian Institute
for Building Science, Budapest

Backstopping officer: B. Der Petrossian, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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1./ DEVELOPMENT PROBLEM AND IMMEDIATE PROBLEMS ATTACKED

1.1./Development problem

Hungary s energy demand is only partly supplied by its own resources. Substantial quantities of crude oil, other fuels and electric energy have to be imported. Therefore it is of primary importance for the government to keep the growth rate of energy consumption under control.

The operation of buildings including heating, hot water supply, ventilation, air-conditioning, cooking, washing, lighting etc. consumes approximately 40% of the national total energy. Most of this consumption is afforded to heating and hot water supply.

The target set by the government has been to achieve a decrease in the specific energy consumption by 20% in housing, in case of buildings erected after 1980. This UNDP project was intended to contribute to the realization of this goal. The development problem was to promote energy conservation in the operation of buildings.

1.2./Immediate problem

The immediate objective of the project was to accelerate the transfer of research and development results to the practice by developing the laboratory and on-site experimental facilities of the Hungarian Institute for Building Science /HIBS/ in the fields of:

- promoting utilization of solar energy in Hungary;
- energy conservation due to installation and operation of up-to-date heating, ventilating and air-conditioning /HVAC/ systems.

1.3./The logic of approach

Since the HIBS acts as a basic R and D institute of the building industry and the Ministry of Building and Urban Development, it plays an important role in the preparation of governmental decisions concerning energy management in buildings. Therefore in solving the development problem the logic of approach was as follows:

i./ Contacting and keeping in touch with leading research and development institutions of developed countries to study and review relevant experiences and achievements.

ii./ To compile computer controlled data acquisition systems including the necessary software for monitoring purpose, the compatibility of which enables research cooperation and information exchange with these institutions.

iv./ To improve our own research and development activities in the field.

v./ Based on the study results and enhanced experimental facilities: to improve and refine governmental actions and design practice.

vi./ To develop and adopt components and systems and to establish pilot projects for observation and reference.

vii./To publish findings and plant research and development results as applicable in the industry.

1.4./Matters relevant to the design of the project

It can be stated that the targets outlined in the preparation of the project proved to be correct and mostly achievable. In spite of the recent radical drop of the oil prices research and development efforts for the reduction of the energy consumption of buildings still are in the foreground. This especially applies for Hungary where the price of the imported oil is controlled by certain bilateral agreements (the Bucharest treaty) and follows the world price trend with a 5 year delay.

The drop of the oil prices first of all queries the cost-effectivness and feasibility of some developments, equipments and systems and do not effect the general long term requirement of reducing energy consumption.

In spite of the fact that, rightly due to informations and partial results of the project itself and the above changes in the oil market conditions, some details came to different light and were duely modified on the course of the project, it can be said that the main goals are accomplished.

2. OUTPUTS PRODUCED AND PROBLEMS ENCOUNTERED

2.1./Outputs which should have been produced

According to the Project Document the outputs to be produced were the following:

2.1.1./ Increased capacity of the laboratories of the HIBS, enabling to conduct efficient research in the field of the two immediate objectives of the project outlined in 1.2.

2.1.2./ Pilot installation of various types of solar systems and components (collectors, daily and seasonal storage tanks, automation, etc.) for auxiliary hot water supply and heating, selected and adapted for climatic and economic conditions in Hungary.

2.1.3./ Final report and recommendations to the government for future development based on the project findings.

2.2./Outputs actually produced

Since the planned and realized activities well fitted in the project this largely contributed to the succesful achievement of the outlined targets of the project. Generally two significant factors promoted the succesful execution of the project:

- the efficient, professional and accurate cooperation with UNIDO as acting agency of the project,
- the Hungarian Ministry of Building and Urban Development (ÉVM) as the governmental authority in charge for energy conservation in construction and operation of buildings, realizing the importance of the project, promoted the accomplishment of the project with a number of research programs and contributed to the expenses far beyond the amount of Governmental Budget outlined in the Project Document.

ad.2.1.1./ The HIBS improved its laboratory and in-situ measuring instrumentation. This was possible only by the financial support to the project. The acquired equipments are listed in App.4. With these equipments computer controlled data acquisition systems are set up for monitoring purpose, and long-term automatic observation, measurement and analysis of energy flows in buildings have become available. Due to this development the HIBS has become the best instrumented scientific institute in Hungary in this field.

Due to the fellowships and study tours provided by the project (i.e.: University of Birmingham,UK, Chalmers Univ., Sweden) a number of software were adapted and developed, compatible to international standards even in documentation requirements.

These hardware and software components together enables the HIBS to take part in direct scientific cooperation with well advanced and experienced institutions as an equal partner. One such cooperation with a Swedish counterpart is working (KALOCSA SOLAR PROJECT) and this is one significant output of the project. Besides, the monitoring systems can also be used for other research works as well, though their capacity is engaged for evaluation of building energy problems.

In realizing the first output it was an impeding factor that some of the equipments purchased were subject to export licence. This caused some delay in their delivery, as an effect of which some measurements had to be postponded by one year, and this lead to our request for extending the project.

The utilization of solar energy has been developed in Hungary , and the project has contributed to this. The ÉVM regards the solar energy use as an important part of the State Priority Program of Energy Conservation. In this program the HIBS played an important role, due to the project outputs, in the design of the Solar Projects and later in their monitoring and evaluation. The industrial background has also been developed and now some solar components are commercialised. The collectors and other equipments got out of the laboratories to the construction sites. Though many technical development problems of these components have been succesfully solved by the project however the real wide spread utilization of the solar technique is still impeded by market and some financial factors. Energy prices are governmentally subsidized in Hungary, while the taxatation on equipments increases their prices and very long amortization periods can be encountered in this regard.

It can be generally said that, similarly to the experiences of more developed countries, solar systems can be primarily used for Domestic Hot Water (DHW) production. Due to some increase of the state subsidy on experimental solar systems a range of such applications have been installed from the one and half storey row-house (KALOCSA SOLAR PROJECT) to the solar DHW system for 10-storey block house (DEBRECEN SOLAR PROJECT). The HIBS, cooperating with the manufacturers of the components to these systems, performed engineering, design, monitoring and evaluation tasks in these Pilot Projects. The final achievement of this output overgrew the originally planned level in the project (see ad.2.1.2.) in working out the fundamentals for passive use of solar energy in Hungarian climatic conditions. Besides this output well served the solution of the immediate objective, but it has a lesser benefit in the solution of the development problem because of the low number of solar systems in use.

In reducing the operational energy consumption of buildings we concentrated our efforts on developing the controll systems of HVAC systems. Laboratory tests were carried out on thermal characteristics of heating system components. Studies were made on the control dynamics properties of systems. Energy saving heating systems were worked out for single family houses, and there are results in the development of central heating systems for multistorey buildings.

Computer simulation algorythms and programs were elaborated and experimentally verified on dynamic energetic behaviour of buildings.

These programs have been in use for improving the quality and accuracy of the design of building energy systems, especially solar ones.

Following the new code of practice concerning the improved thermal insulation of buildings measures were taken to improve the insulation and air-tightness of windows. While the excess air-infiltration is radically decreased by the use of the new windows and doors unwanted side effects occur in a growing number showing the symptomes of insufficient ventilation: poor indoor air quality, condensation, mould. These all show that the importance of the ventilation is increasing both from energy and comfort aspects.

One of the most important output of the project and the project-initiated development is the GYŐR VENTILATION PROJECT. Here one block of flats in an 11-storey building had been equipped with a balanced mechanical ventilation system. The system consists of a rooftop central unit, a supply and an exhaust ductwork. The fresh, heated air is supplied to the 2 or 3 rooms of the flats. The air is exhausted from the bathrooms, kitchens and lavatories. In the central unit an air-to-air recuperative aluminium plate heat exchanger utilizes part of the heat of the exhaust air. Comperative measurements were performed on this block of flats and on another one equipped with the usual mechanical exhaust ventilation, including the outdoor and indoor climate and the energy consumption.

Beside the main targets some relevant minor problems were also involved. One is the development of knowledge and investigation technique of perimetric conditions to the operation of buildings, solar systems, energy conserving HVAC installations and measures. Another secondary output of the project is a great amount of information, personal and official contact with foreign institutions engaged in the research in this field. Here publications, demonstration of experimental and measurement technique of natural ventilation of buildings, wind effects should be mentioned.

The output is difficult to be quantified since in the meanwhile, partly on the HIBS s initiation, several governmental decisions, both technical and market influencing, were made for the promotion of energy saving in housing. Nevertheless it is a fact that the specific energy consumption in the operation of the buildings, both new and old, decreased by 8-10%.

ad.2.1.2./ in the course of the project implementation the following Pilot Projects were established and executed:

Debrecen Solar Project
Balaton Nord Solar Project
Gyor Ventilation Project
Kalocsa Solar Project
Ördögszikla Solar Project

Since long term observation is targeted, monitoring 2 of these 5 Pilot Project is still going on,

ad.2.1.3./ The Hungarian Ministry of Building and Urban Development has been being continuously informed of the state and results of the research and development works of the project in form of research reports and recommendations.

3. OBJECTIVES ACHIEVED OR LIKELY TO BE ACHIEVED IN THE NEAR FUTURE

According to the Project Document the immediate objective of the project was to transfer research and development results to the pracical application by enhancing the capacities of the laboratories of the HIBS to enable to deal with:

i./ Utilization of solar energy for auxiliary DHW supply and supplementary heating of single family houses and small public buildings.

ii./ Energy conservation by the installation and operation of automatically controlled HVAC sytems.

The project reached its planned goal. There is a significant development in Hungary both in the active and passive use of solar energy and the specific energy consumption of residential buildings decreased by 10%. The HIBS established a succesful cooperation with institutions working in the field. Both the knowledge of the researchers and the experimental hardware and software are improved and became compatible.

The quality of the research and development work is improved and this contributed to the better preparation of corresponding governmental decisions and measures and to the development of the design practice.

These significant results are, of course, due not only to the present UNDP project. Several decisions taken by our authorities as well as certain market effects also contributed. The UNDP project stimulated and largely promoted the research activities and development in reducing energy consumption in the operation of buildings. Its special benefit, far beyond the financial support, is the provided possibility for obtaining most recent knowledge and experiences that would not have been obtained otherwise at all but with years of delay from the professional literature. Without the technical and financial support the project provided for that purpose there would not have been chance to improve the monitoring instrumentation to the present world standard level.

4. FINDINGS AND LESSONS LEARNED

In the following the Pilot Projects (monitoring of the Pilot Systems) and the results are briefly presented.

Debrecen Solar Project

The main purpose of this Pilot Project and Research program was to determine the possibilities and conditions of joint operation of a district heating and a local solar system and the thermal performance and characteristics of the solar system itself. The Pilot system is installed in Debrecen, one big country town in the Eastern part of Hungary.

The solar system

This solar system is an application of solar technology under conditions that may be regarded as internationally new. The system was installed in 1983/84. Monitoring measurements and analysis of the system were carried out from 15 May to 27 September in 1985 practically covering the whole summer season. Set on the flat roof of one 4-storey block of the housing development the system takes part in the DHW supply of 1582 dwellings. The collectors make use of the whole available roof area. The heating center is attached to the Northern facade of the building onto which the collectors are mounted. Though this building is surrounded by 10-storey blocks the shading effect of these is negligible. The rooftop solar system consists of three arrays of collectors, each of different Hungarian makes and were filled with fresh water quality heat transporter media. Pumps make the water circulate in each of the 3 separate collector arrays and these are connected to the fresh water supply network through a heat exchanger. A set of valves makes possible the paralell or serial switching of the collector circuits. The supplied fresh water may be passed by the heat exchangers if required. (See Fig.1.,2.)

It was found that in lack of automatic control system and because of the difficult accessibilty of the manual control valves the personel can t but use the parallel connection. The three systems are manually started on a given value of the outdoor temperature.

Measurements

One of the computer controlled data acquisition systems supplied by the project was used for the measurements. Scanning all measuring points every minute the computer evaluated and stored the data in a compressed form of hourly means. A number of sensors and transducers bought by the project was also used, f.i.: Kipp and Zonen CM-10 solar radiation sensors, Schintzel pipe flow transducers, R.M.Young Gill propeller anemometers. Status signals of different switch and valve settings were also monitored. Auxiliary data such as readings from analogue meters of the consumption of electric energy and DHW were noted by the local staff every day. All measured data were stored on tape cartridges for further analysis.

Data processing

In the first step data gathered on the cartridges were simply evaluated, checked and printed out. The final evaluation took place after completing the measurements in an analysis of the thermal performance and energy flows on daily, monthly and whole period basis.

Results and conclusions

During the observation period the mean values of the most characteristic factors of the ambiance were: outdoor air temperature 19.6 oC, wind speed 0.9 m/s, cold water temperature 18.8 oC. The insolation on horizontal surface was 2128 GJ/m2. The relatively high temperature of the water supply mains is explained by the that the wells are situated in an area where hot springs are frequent. The total consumption of DHW during the observation period was 35731 m3 at an average temperature level of 48 oC. The share of the solar system in the total supplied heat during the observation period is 7.1% amounting 316720 MJ. Regarding the numer of the supplied dwellings and the total 354.6 m2 collector area this contribution is significant. (See Fig. 3.)

Of the three collector arrays the one made of VEIKI SKV 2010 collectors had the highest specific output (963 MJ/m2) but the two other types were not much worse. The thermal performance of the uncovered BME-HRI collectors also laid close to that of the other two though this collector is quite different from the others. This was explained by the increased flow rate in the circuit that resulted in a relatively low temperature level.(See Fig.4.)

Since the solar system had no storage tank it was exposed to the momentary changes in the consumption of DHW. It was concluded that a storage tank would have been necessary.

In spite of the original idea for enabling the solar system to operate serial mode with the district heating system the actual implementation did not make this possible and only a paralell operation could be maintained. This is regarded as a shortcoming and the versatility and economy of similar future systems should be designed and installed in an integrated system concept.

It was also concluded that more effort should have been put into the installation of an automatic control system (ACS) and a less complex solar circuitry. An ACS would have enabled radiation dependent switching on and off and an automatic paralell-serial switching. The lack of an ACS prevents the optimal use of the system, which becomes dependent on human interventions, and eventually impedes the obtaining generalised experiences necessary for the fututr applications, design and use.

We recommended to the users that a supplementary installation of an ACS be taken into account. This would make possible to utilize not only solar energy but gains from the ambient air and rain. A microprocessor controlled programmable ACS would cover the needs and is available on the world market at a realistic price.

This Pilot System being experimental no usual economy analysis could be carried out, since several supplementary system components were installed for the sake of the experiment at extra costs. Actually the system was much more complex than a normal solar application necessary for the given application. Neither of the three types of collectors were manufactured in economic series, and this increased their price. The cost of the supporting structure of the VEIKI and ESZKV collectors is high while for the BME-HRI ones it was negligible. Because of the weight of the collectors and the supporting rigs the roof slabs of the building had to be reinforced also at extra costs.

Usually the thermal performance of the solar systems and components may not be separately evaluated from cost efficiency factors. From this point the BME-HRI collectors were the best their thermal performance being not much worse than that of the other two types and their cost was much less. It should be noted that the low utilization temperature level of these uncovered collectors necessitate the careful analysis of operation before application.

Summary

This Pilot Project concluded in the following requirements which are preconditions to the economic application of similar solar systems:

- preliminary computer analysis of the expectable operation and economy is necessary,
- the solar system must be integrated with the DHW part of the district heating system,
- the system circuit must be simple,
- inexpensive components should be used,
- collectors could be taylored to the necessary size at the site,
- quick and easy installation,
- integrated with the building
- optimal operation.

The Pilot System of the Debrecen Solar Project limitedly meets these requirements, but highlighted the shortcomings and now the techniques and equipments for improvement are available. and the further research and development of integrated solar and district heating systems are justified.

The Debrecen Solar Project led to many useful experiences. The measurements quantified the thermal performance of the system revealed poor and verified good ideas, and made easier the future application of similar systems.

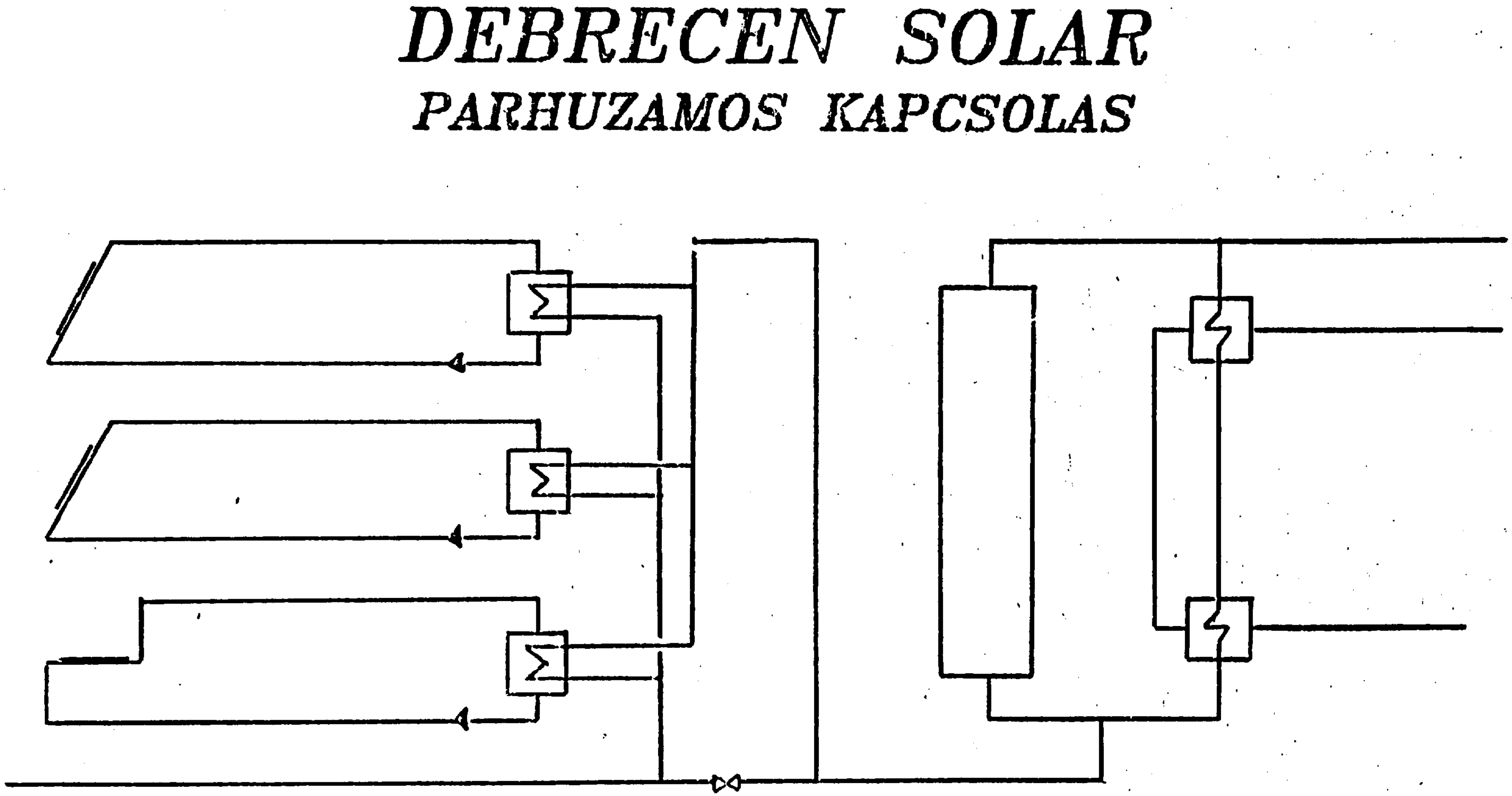


Fig. 1. Serial mode.

DEBRECEN SOLAR
SOROS KAPCSOLAS

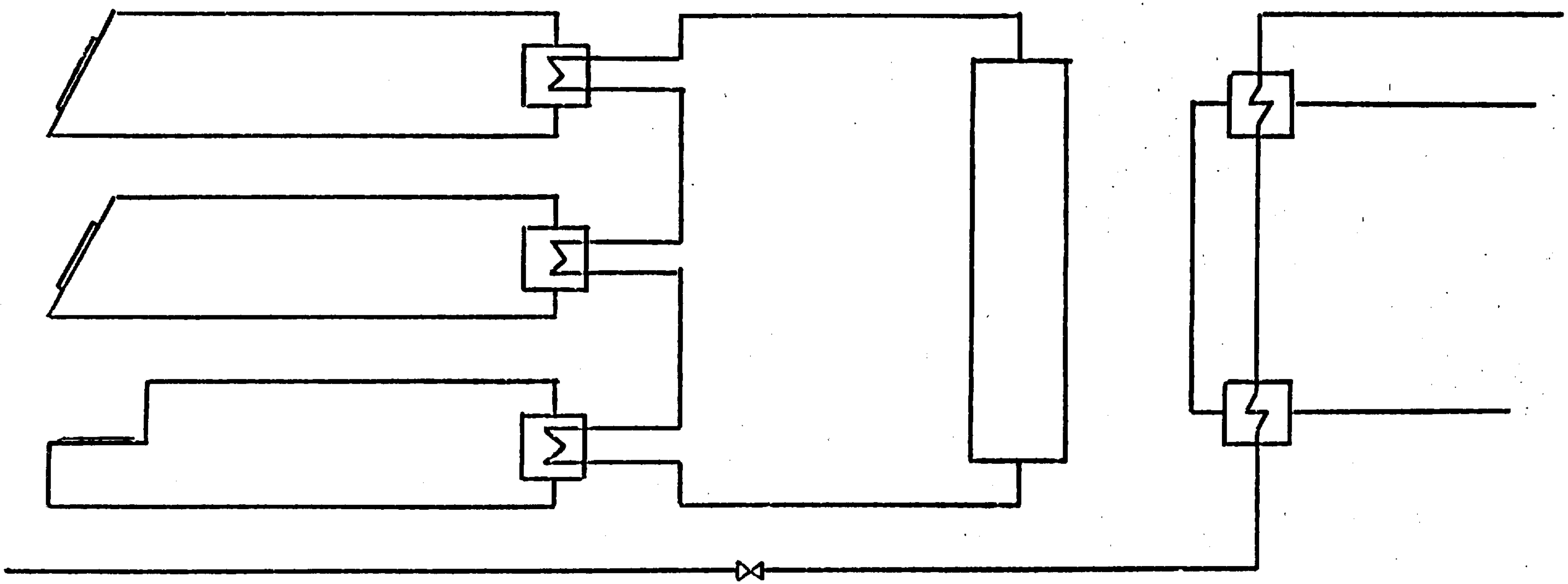
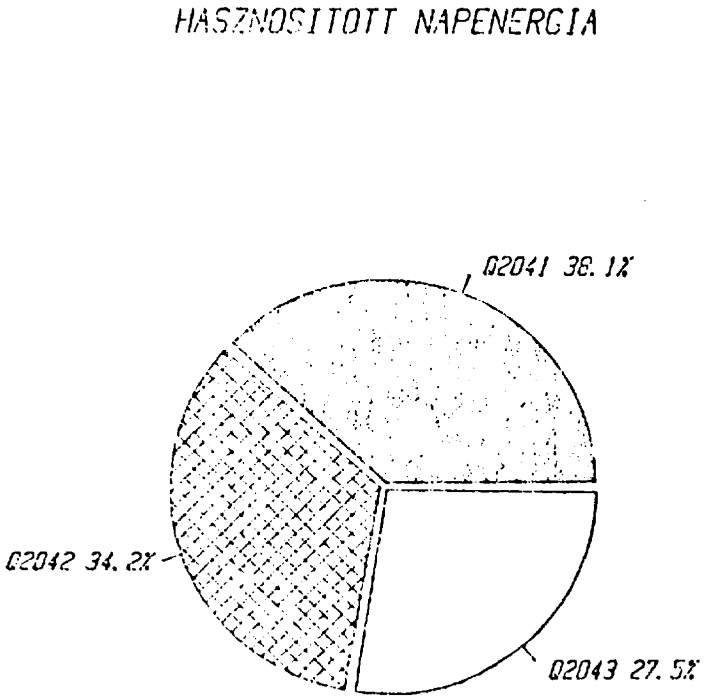


Fig. 2. Paralell mode

DEBRECEN SOLAR



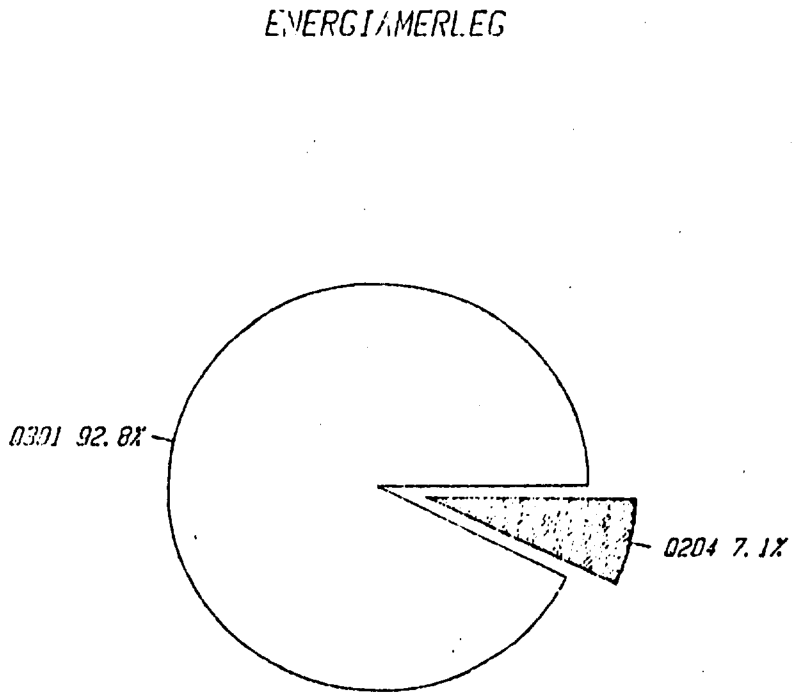


Fig. 3. Utilized solar energy

Fig. 4. Energy balance

BALATON SOLAR PROJECT

The aim of this Pilot Project was the evaluation of two solar systems at the northern lakeside of the Balaton. Both systems were designed and installed by Austrian companies in two hotels, the "Annabella" at Balatonfüred and the "Helikon" at Keszthely. Both systems serve the supplementary heat supply to the swimming pools and auxiliary premises of the hotels. The traditional heating center is serial to the solar system. Hydraulic circuits of the two systems are shown on Fig. 5.,6.

Both hotels are situated close to the lakeside in a pleasant park area.(See Fig.7.,8.). Except the main blocks of the hotels themselves there are no shading buildings in the neighbourhood. The Austrian made "UNIVERSA" collectors are mounted on the flat roof of the swimming pool buildings:

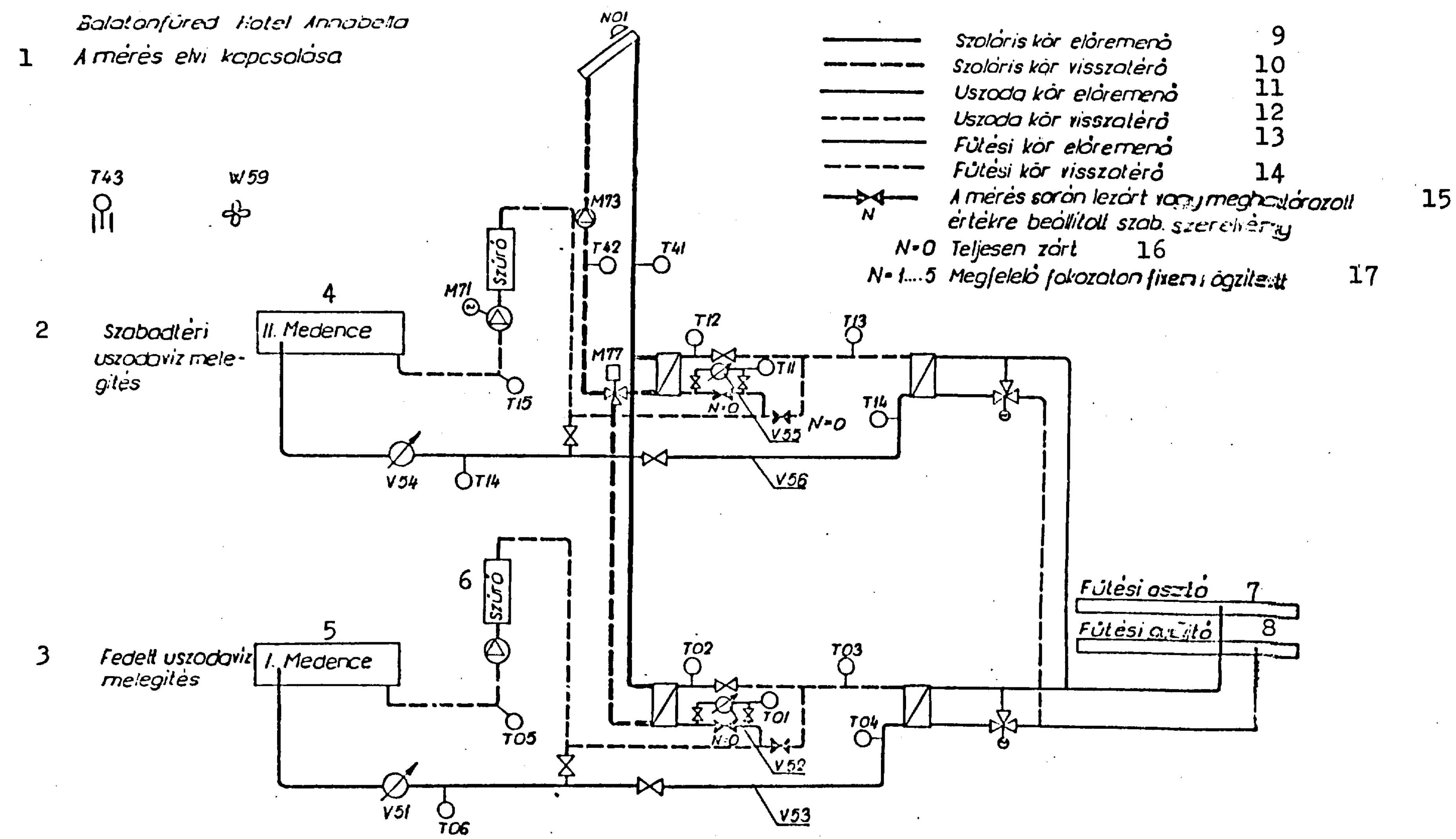
- at the "Annabella" hotel 24 collectors give a total area of 46.08 m2, oriented to SW, inclination angle to the horizontal is 40 degrees,
- at the "Helikon" hotel 42 collectors (80.6 m2 total area) are oriented to SW with an inclination of 50 degrees as shown on Fig.9.-11.

The "UNIVERSA" collector has a single glazing cover, copper absorber coil with aluminium ribs, and this design facilitates a radiation-trap operation.

In the solar circuit of both systems 50% ethylene-glycol - water solution is circulated, and transfers the solar heat to the secondary circuits that are the following:

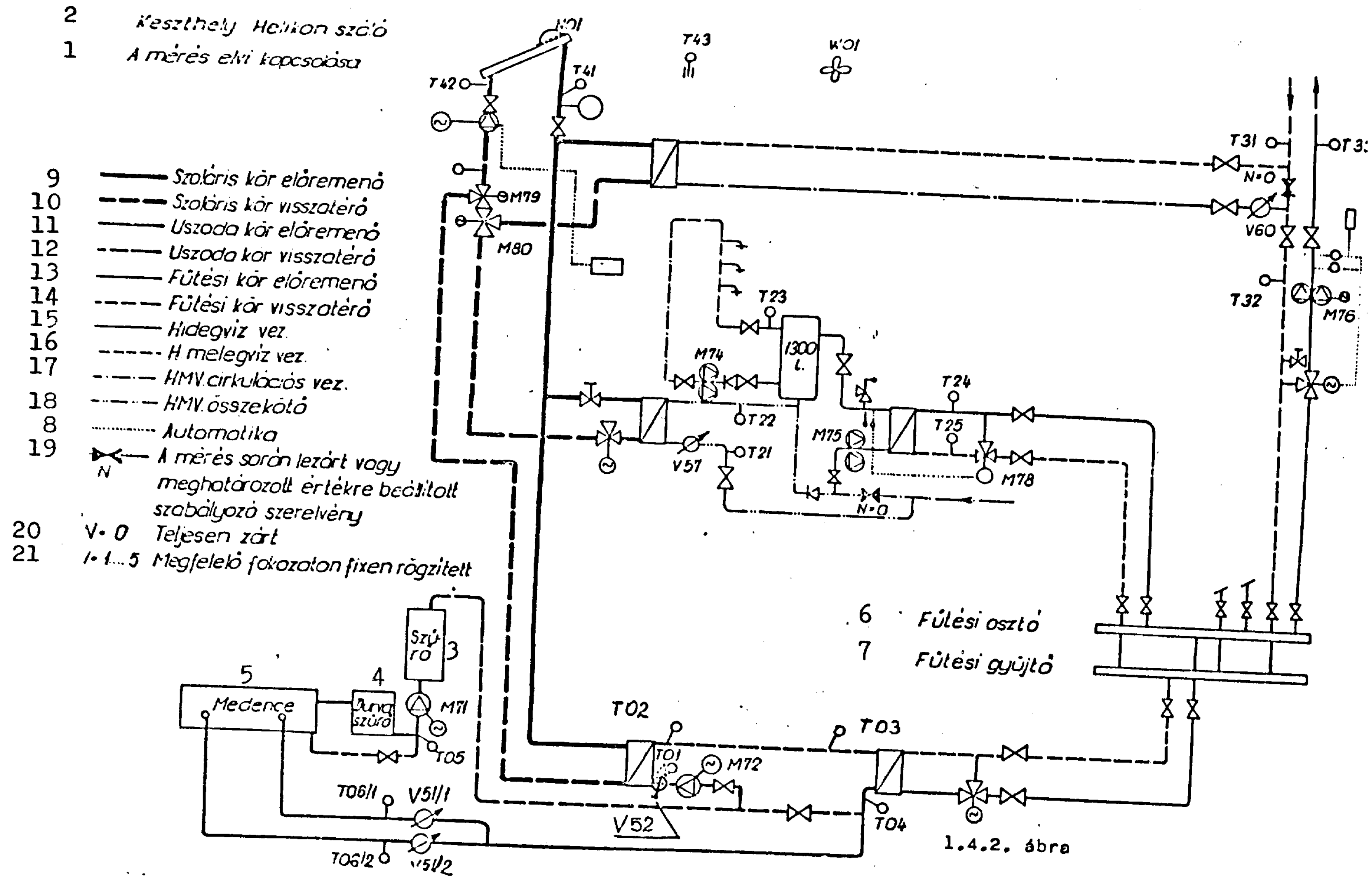
- at the "Annabella": indoor (I) and outdoor (II) swimming pools,
- at the "Helikon": indoor swimming pool, DHW for swimming pool showers, floor heating in the swimming pool.

The solar circuit is thermally coupled to the secondary circuits by high performance heat exchangers. Components of the secondary circuits such as the pools (200-300 m3), the DHW boilers and, in case of floor heating, the floor mass itself serve as heat storage capacities of the systems.



1.4.1. ábra

Fig. 5.


2 Keszthely Helikon szálló
1 A mérés elvi kapcsolása
9 Szoláris kör előremenő
10 Szoláris kör visszatérő
11 Uszoda kör előremenő
12 Uszoda kör visszatérő
13 Fűtési kör előremenő
14 Fűtési kör visszatérő
15 Hidegvíz vez.
16 H melegvíz vez.
17 HMV cirkulációs vez.
18 HMV összekötő
8 Automatika
19 N A mérés során lezárt vagy meghatározott értékre beállított szabályozó szerelvény
20 V• 0 Teljesen zárt
21 /• 1...5 Megfelelő fokozaton fixen rögzített
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7 Fűtési gyűjtő
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1.4.2. ábra

Fig. 6.

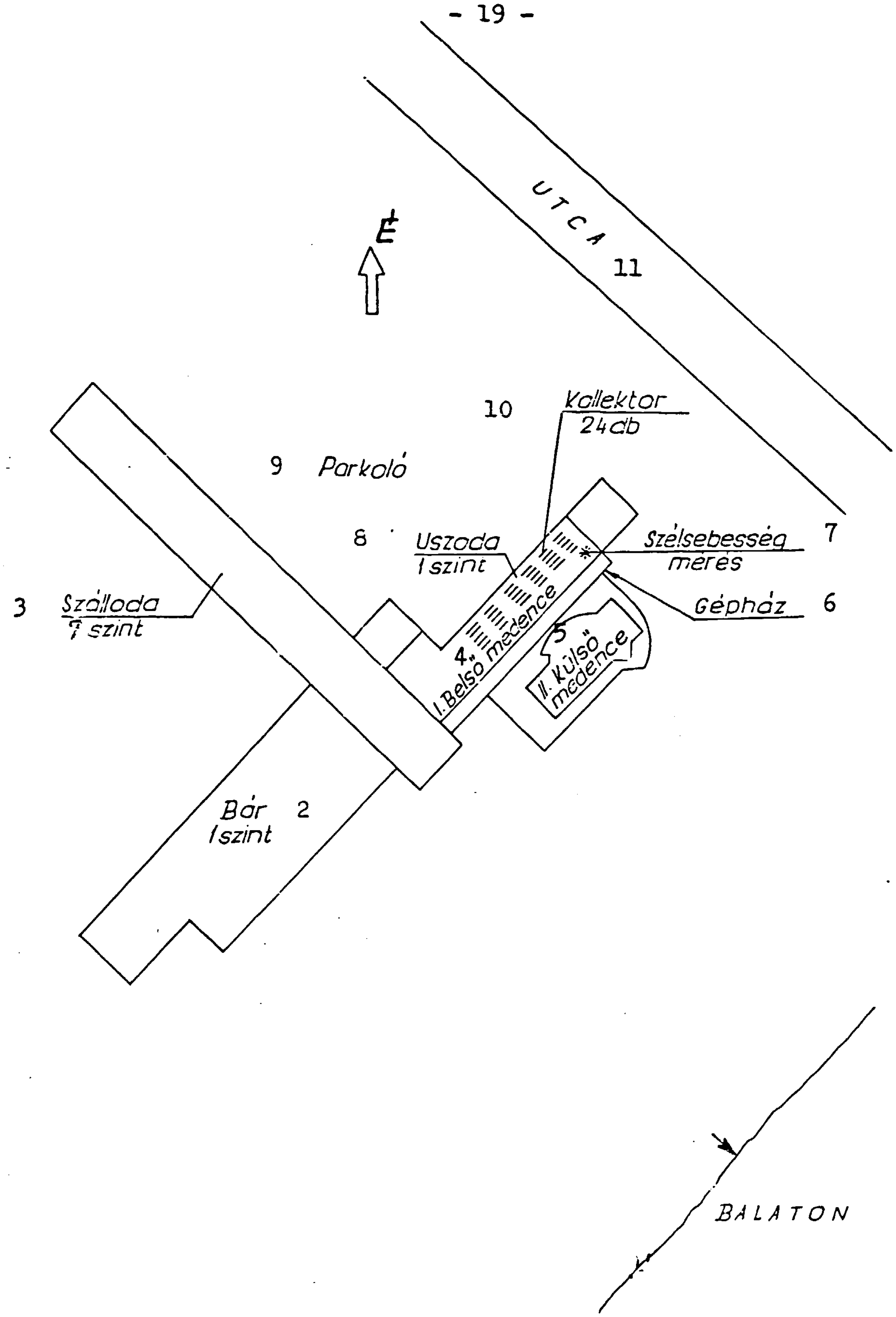


Fig. 7.
Layout of the Annabella hotel and the solar system

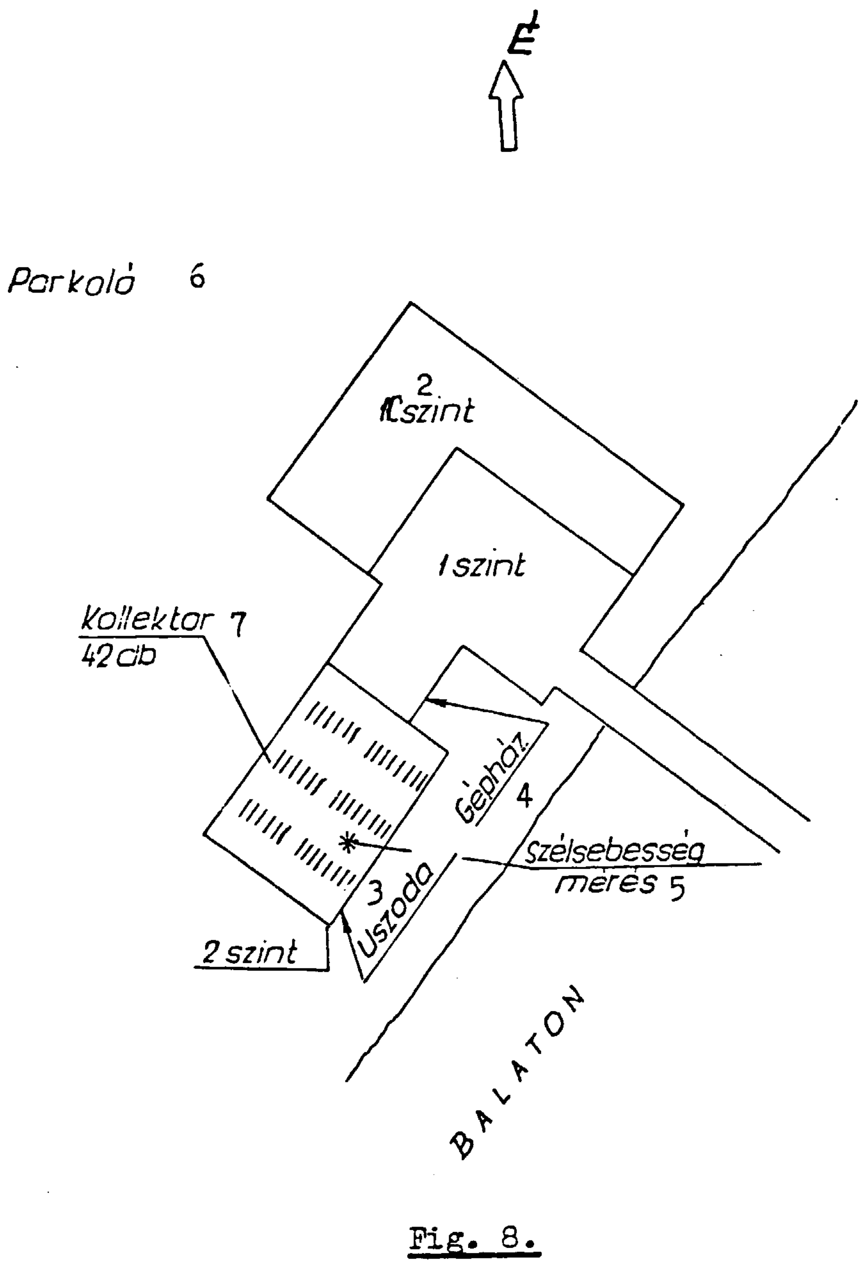


Fig. 8.

Layout of the Helikon hotel and the solar system

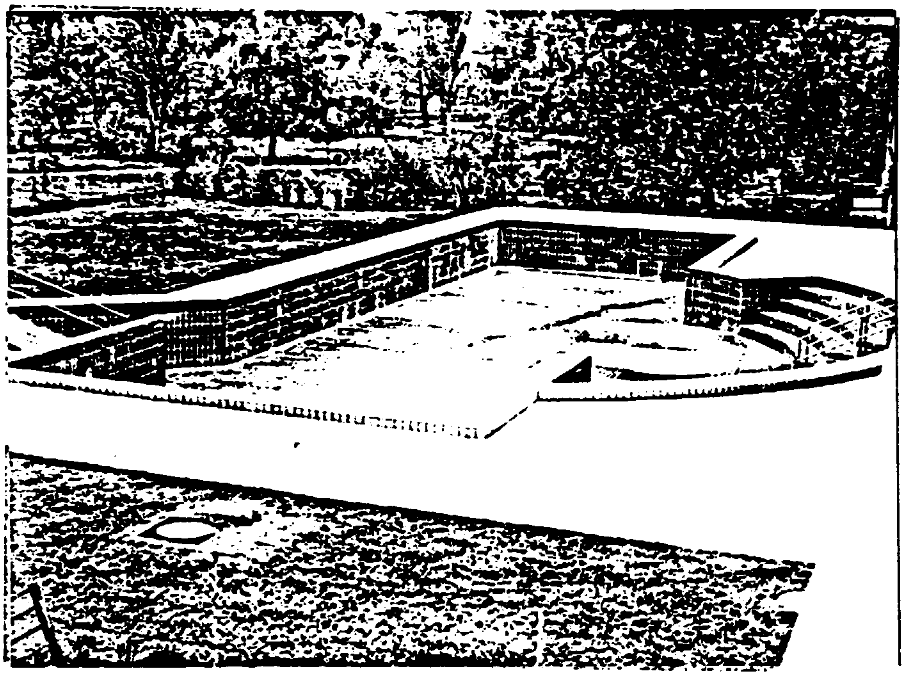


Fig. 9.

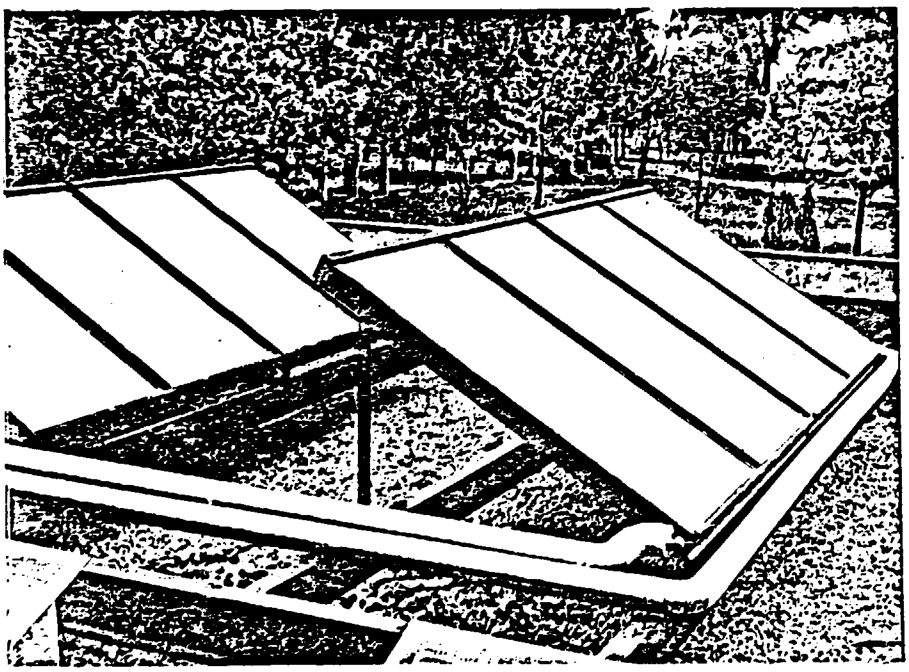


Fig. 10.

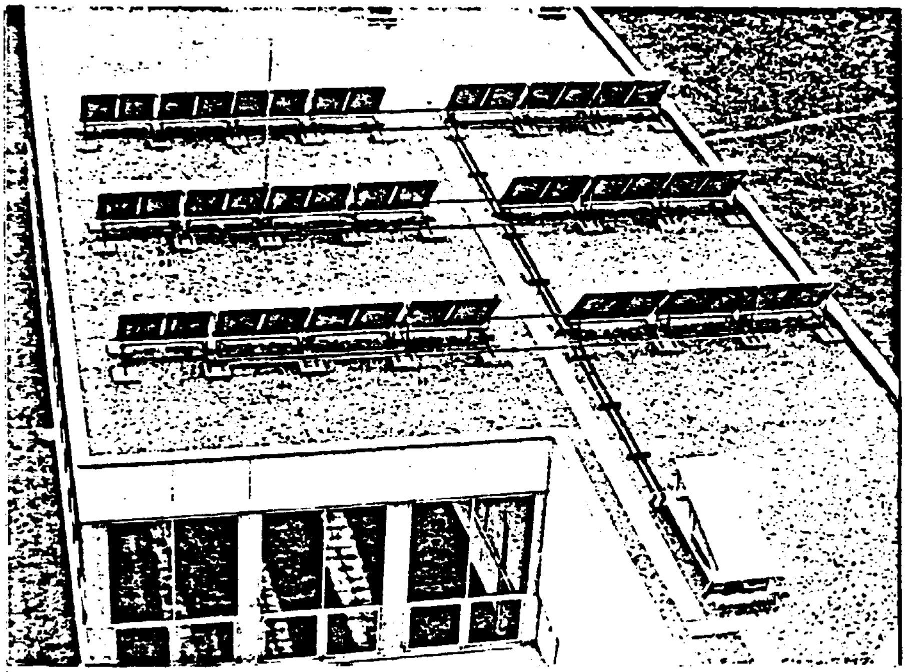


Fig. 11.

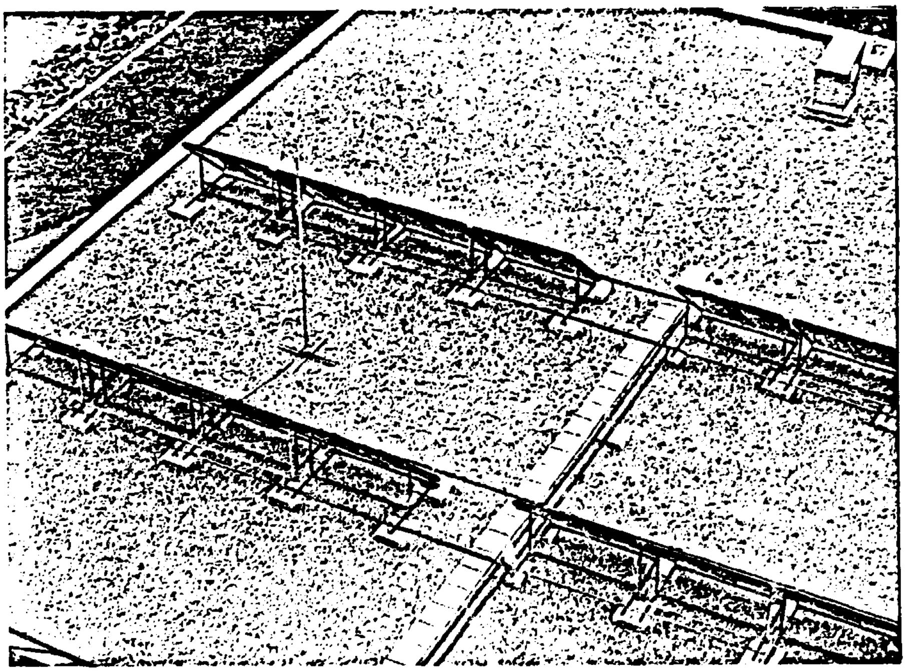


Fig. 12.

The "Annabella" hotel is open from 15 April to 15 October. The equipments of the swimming pool (filters, pumps, heating, etc) are continuously operating during 18 hours of the day, but the solar system is manually started because of some failure in the principle of the control system. The supplementary heating is also manually started.

The "Helikon" hotel is open all the year round. The swimming pool equipments , the auxiliary heating and the solar system automatically controlled and continuously operates.

The monitoring of the two Pilot Projects targeted the thermal performance and operation analysis of the systems for a longer period, in accordance and cooperation with the local technical staff.

All data relevant to the thermal peformance of the systems were measured on the secondary circuit of the systems. Two HP-85 computer based data acquisition systems (acquired from the UNDP project) were simulteneously used at the two sites together with a number of different sensors and transducers, part of which again had been purchased from the project funds. The measuring technique, procedure and data storage was the same as described in the presentation of the DEBRECEN SOLAR PROJECT. Auxiliary data regarding readings from analogue meters were also noted and filed to measured data.

Observation periods:
- at the "Annabella" hotel: 02.08.1985.-14.10.1985.
- at the "Helikon" hotel: 27.08.1985.-20.11.1985.

From the evaluation of the measured data the following shortcomings came to light:
- delay of the ACS in switching on the solar system; this was due to the positioning of some temperature sensors, the thermal inertia of the system and the orientation of the collectors,
- gravity forces caused circulation in the solar loops when the pumps stopped and this lead to heat losses,
- "thermosyphoning" effect often caused a complete fall out of the solar heat exchanger,

- minor discrepancies of safety valve caused a big heat loss due to permanent leaking of DHW

It can mostly be explained by these faults that the utilization efficiency of the systems as related to the total incident solar radiation showed 26% for the Annabella hotel, and 20% for the Helikon hotel. As a consequence of the low efficiencies and the other shortcomings 12.2 GJ utilized solar energy were measured at the Annabella hotel, while the same errors and the existence of the solar system caused a net 4 GJ heat loss in the Helikon hotel. If one wants to extrapolate these data for the whole year, the given values should be multiplied by 3-4.

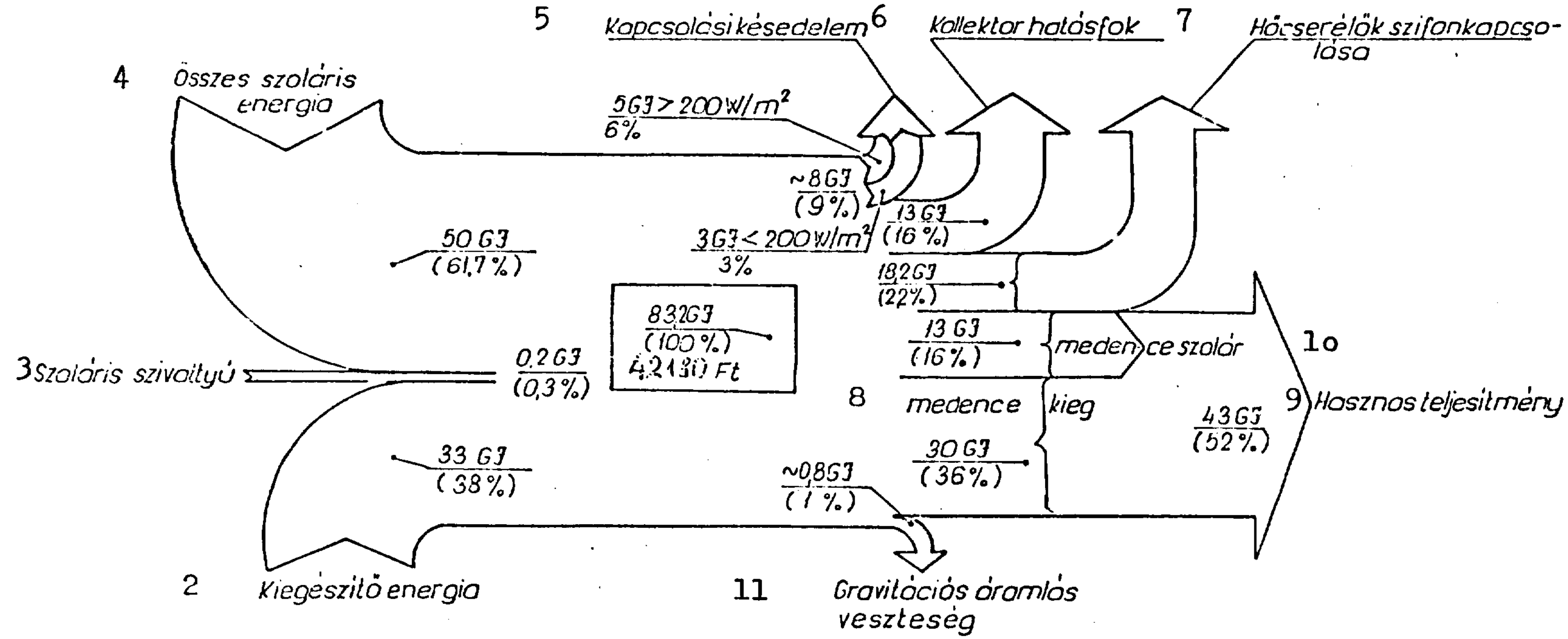
For the observation period energy flows of the solar and auxiliary heating systems are presented on Fig.25.,26. As it can be seen, because of the different losses, the total useful heat is only about half of the total input, that could have been avoided by a more careful design and installation. Amendments are possible , however, and rather inexpensive. In the conclusions of the projects recommendations were made as regards the necessary repairs and modifications.

Conclusions

It was found that solar systems built of advanced, high quality components can also be sensitive to minor shortcomings in design and installation. The less information is available for the user on the actual operating conditions of his system the more likely that these error would remain unnoticed and the energy bill would be higher than expected. Complex systems therefore must have intelligent ACS.

Thanks to the monitoring sufficient information was obtained as to the necessary improvements.

It was also found that the pools themselves also act as solar collectors utilizing part of the solar gain through the large glazed side walls. The observation periods were too short to make amendments and check their effects.



1.4.3. ábra ANNABELLA szálloda Energiafelhasználás SHANKEY diagramja

1985. 08. 02. — 10.14

<u>**Fig. 12.**</u>

Energy balance of the swimming pools in the Annabella hotel

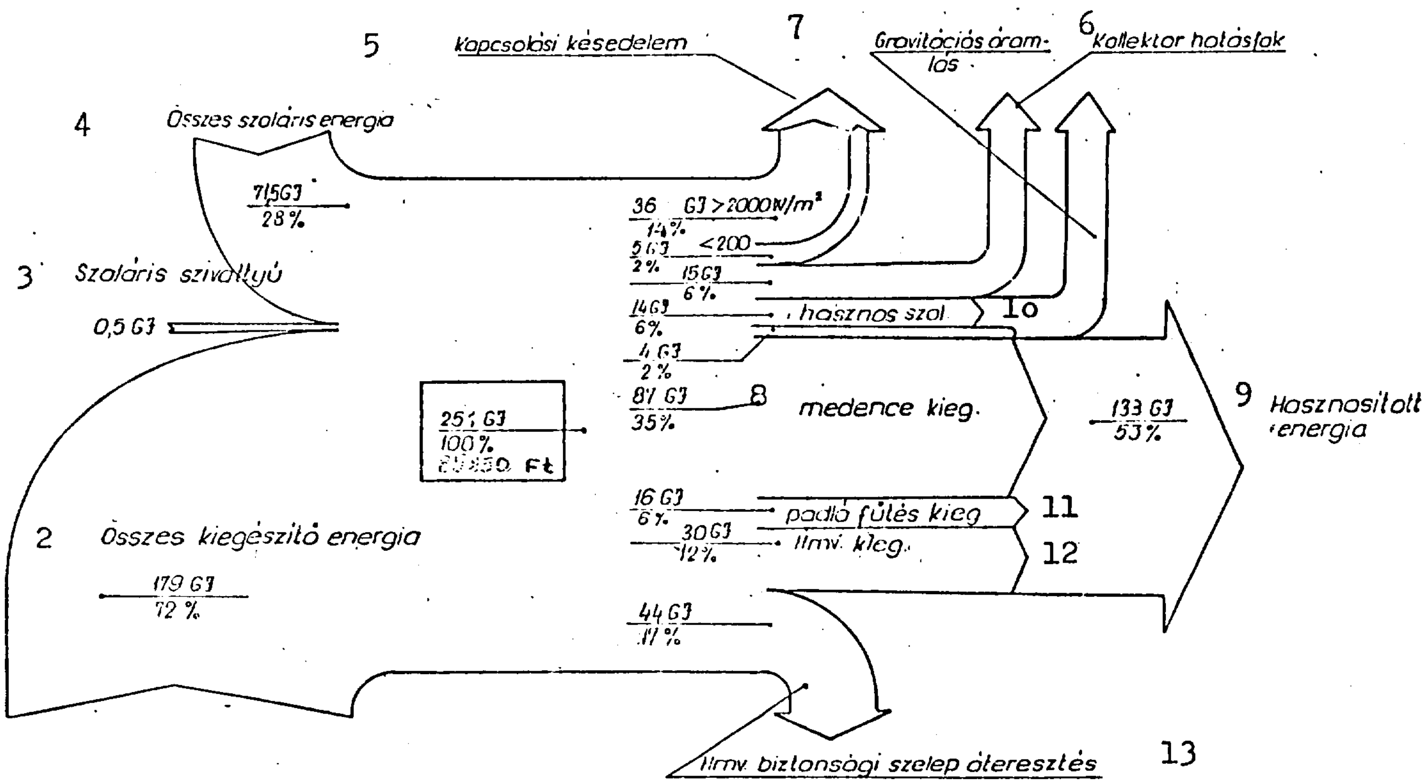


Fig. 13.

Energy balance of the swimming pools and building in the Helikon hotel

GYŐR VENTILATION PROJECT

This Pilot System and the corresponding project aimed at the development, design, installation and monitoring of a nearly balanced ventilation sytem with an air-to-air heat recovery unit in one section of a multistorey residential building in Győr, one medium country town in the Western part of Hungary.

The experimental ventilation system served one section, but the adjacent, separate section (with its own staircase) was also instrumented for the monitoring measurements as reference. Both sections contained 33 dwellings, 3 on each floor. The reference section had a mechanical exhaust ventilation typical in recently built 11-storey blocks of flats.

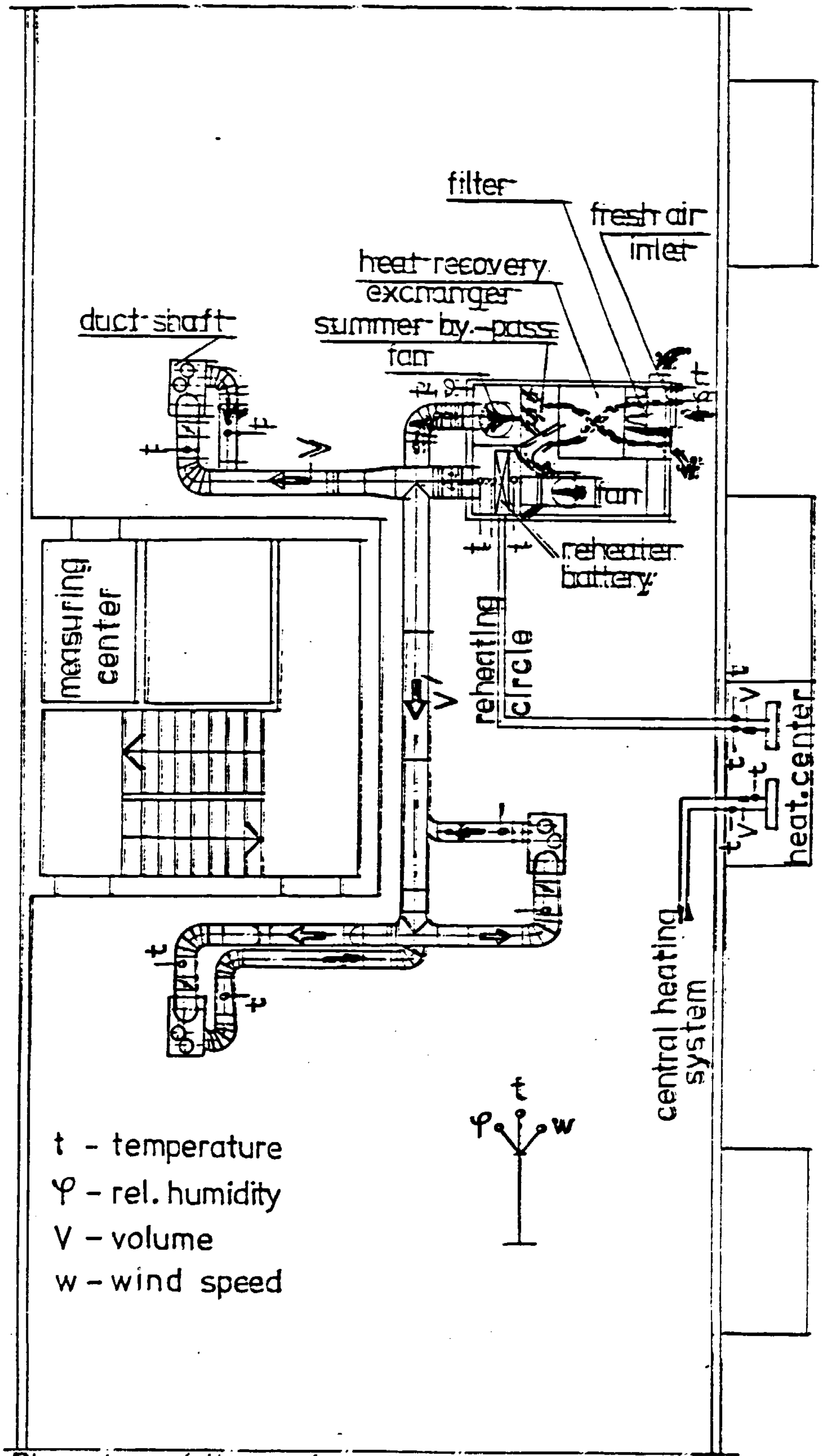
The same measuring instrumentation and data acquisition system was used as in case of the previous Pilot Projects. The measurements involved the whole heating season and a couple of 2-week periods after, until the end of summer.

The rooftop central air handling unit is shown on Fig.14.

The same data acquisition and processing principles were used as in the other projects. The final evaluation of the gathered data targeted the energy balance of the ventilation comparing the experimental section to the reference one. This is presented on Fig.15.

To generalize the measured values meteorological statistics were used, and values for a full heating period were calculated. Seasonal total of the recovered heating energy was also calculated on this basis. This is shown on Fig.16.

It should be added to the rather favourable results shown on the figures that the experimental system had another benefit providing a permanent, stable ventilation to the dwellings. As a result there are no complaints for the indoor air quality, condensation and no mould occured, while in some of the flats of the reference sections these typical symptomes of insufficient ventilation occured.



Plan view of the roof, roof-top ventilation unit and duct network

Fig. Fig. 14.

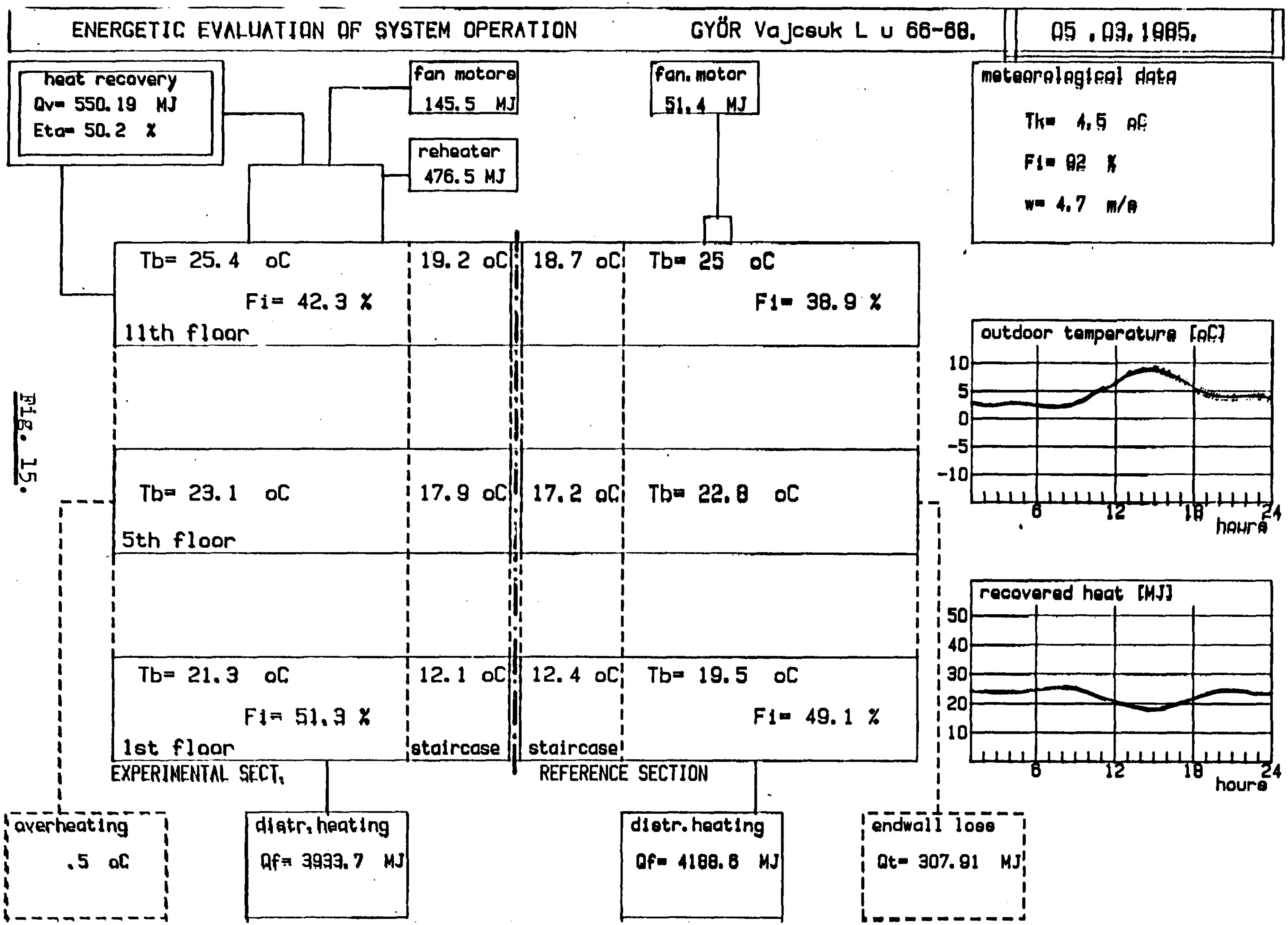
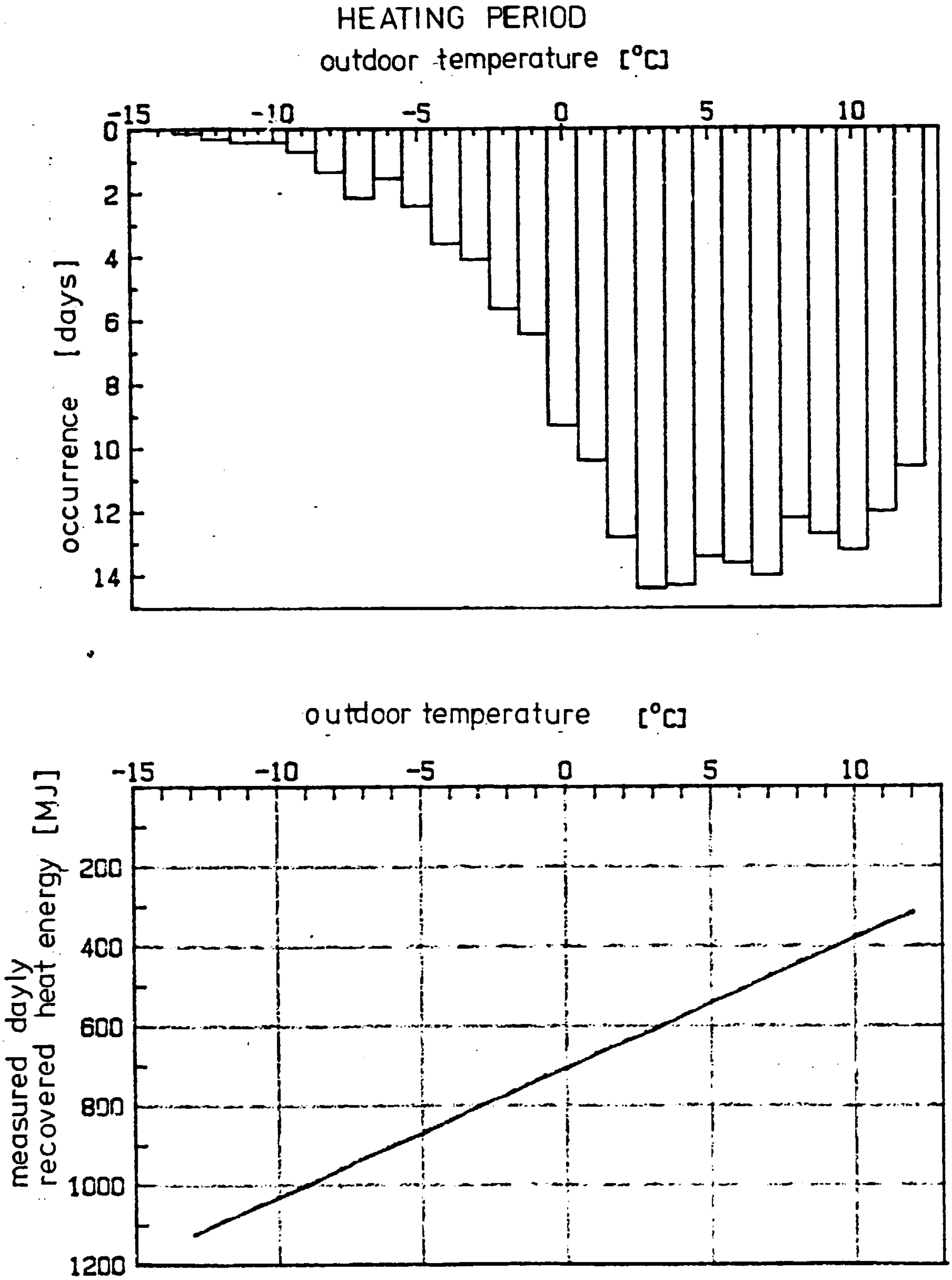

ENERGETIC EVALUATION OF SYSTEM OPERATION
GYŐR Vajcsuk L u 66-68.
05 .03.1985.
heat recovery
Qv= 550.19 MJ
Eta= 50.2 %
fan motors
145.5 MJ
reheater
476.5 MJ
fan. motor
51.4 MJ
meteorological data
Tk= 4.5 oC
Fi= 82 %
w= 4.7 m/s
Tb= 25.4 oC
Fi= 42.3 %
11th floor
19.2 oC
18.7 oC
Tb= 25 oC
Fi= 38.9 %
Tb= 23.1 oC
5th floor
17.9 oC
17.2 oC
Tb= 22.8 oC
Tb= 21.3 oC
Fi= 51.3 %
1st floor
12.1 oC
staircase
12.4 oC
staircase
Tb= 19.5 oC
Fi= 49.1 %
EXPERIMENTAL SECT.
REFERENCE SECTION
outdoor temperature [oC]
10
5
0
-5
-10
6
12
18
24
hours
recovered heat [MJ]
50
40
30
20
10
6
12
18
24
hours
overheating
.5 oC
distr. heating
Qf= 3933.7 MJ
distr. heating
Qf= 4188.8 MJ
endwall loss
Qt= 307.91 MJ

Fig. 15.



Summarized recovered heat energy weighted with the relative occurrence	:	106.8	[GJ]
Summarized surplus energy consumption	:	17.8	[GJ]
Regainable energy during a heating period	:	89.0	[GJ]

Fig. 16.

KALOCSA SOLAR PROJECT

The purpose of this Pilot Project is the experimental research, use and durability test of a Swedish (Hultmark Co) roof integrated solar system in Hungary. The project includes the experimental installation, operation and monitoring of a solar DHW system in Kalocsa (a medium country town in the Southern part of Hungary) in a 18-flat rowhouse. The monitoring itself is carried cut from 1985 to 1990.

The system is expected to provide more than 50% of the DHW heat demand (about 60 MWh/year). The total collector area is about 150 m2, the storage tank volume is 8 m3. The tank has an electric auxiliary heating of 15 kW that is used if the solar gain is insufficient. The system has two loops, one is the solar circuit from the collector to the heat exchanger, this loop is filled with 50% polipropilene-glycol - water solution, the other is a water circuit from the heat exchanger to the tank. The habitants get the DHW directly from the tank, mixed with cold water to the necessary temperature.(See Fig.17.)

When this report is written the system has been installed and a one year observation is over. The monitoring system used for the measurements and data acquisition is the same in type as those purchased in the UNDP project, but it is Swedish property. Here the compatibility of the project provided instrumentation is very useful. The first experiences of this Pilot System are very favourable, and the cost efficiency appers to be excellent.

ÖRDÖGSZIKLA SOLAR HOUSE PROJECT

This Pilot Project includes a single family house with active and passive solar energy utilization components providing energy to space heating and DHW production. The project targets low energy consumption and mediterrain-like condition inside the building.

The house is situated in Budapest. The position of the site is latitude 47.5 oN and longitude of 19 oE. The altitude of

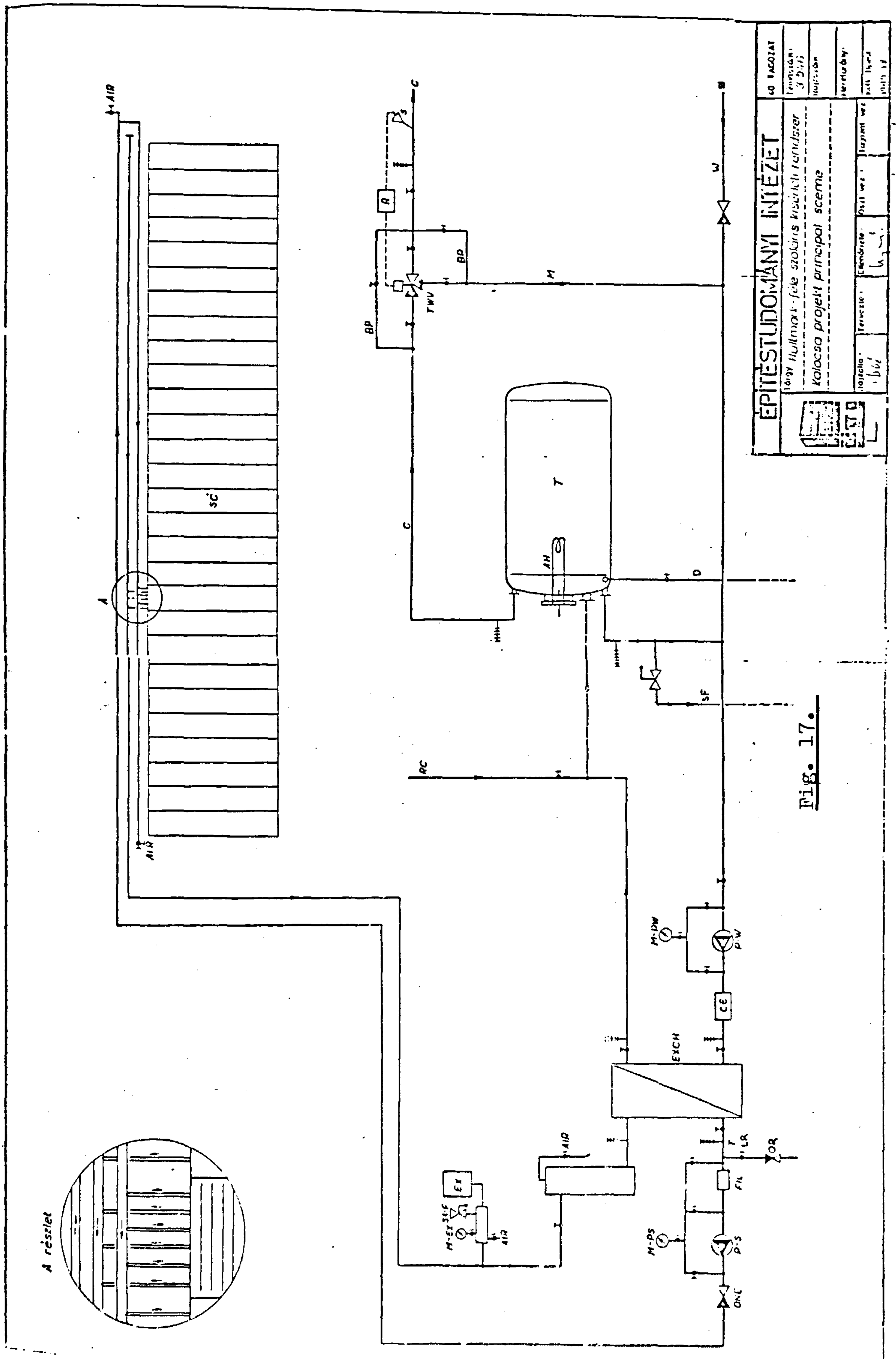

ÉPITÉSTUDOMÁNYI INTÉZET
Kalocsa projekt principal scema
AIR
SC
A
T
AH
C
G
R
TWV
BP
M
W
D
SF
RC
M-DW
P-W
CE
EXCH
FIL
M-PS
P-S
ONC
OR
EX
A részlet

Fig. 17.

the site is 300 m approximately. The climate in Budapest is continental, moderate. The annual average outside temperature is 10-11^{o}C and the annual horizontal insolation is 4.6 GJ/m2.

System components

The main features of the building are the following:
- solar collector arrays with water-glycol medium,
- 4 heat storage tanks with water medium,
- floor and wall heating with water and air medium,
- protective zones and removable additive glazing on the North facade,
- fireplace with water-medium heat exchanger,
- coal/gas burning auxiliary heat supply.

The mass of the building was fitted to the South-East slope of the site. Since the main direction of the wind is northernly, the area or the exposed North facade was minimized. The shape of the building is quasi hemi-spherical in order to reduce the outside surface. The outside walls were built of multilayer structure with an U value of 0.42 W/m2,K. The maximal total heat loss of the building is about 10 kW. There are functional connection between the building and the vegetation.

The greenhouse faces the South and contains a pool heat storage tank of 24 m3, opened during summer and closed in winter. The collector arrays are integrated into the structure of the greenhouse. The air warmed up in the greenhouse flows through the ducting in the intermediate floor slab and the inside main wall. The flow departs from the top of the greenhouse space and blowed back into it just above the floor.

The closed circuit of the 24 m2 collector arrays is connected to the base circuit through a heat exchanger. The base circuit includes the following components:
- solar heat exchanger,
- DHW heat exchanger,
- swimming pool heat exchanger,
- base storage tank of 6 m3,

- two Floor heat storage tanks 2 m3 each.

In the solar circuit the medium is propilene-glycol and water mixture. The collector arrays are divided into two parts so that paralell and serial connections can be realised. In this way the optimal energy and temperature conditions can be utilized. The Base and Pool tanks are in the floor of the greenhouse and parallel connected with each other to the base circuit seasonally. The Floor tanks are in concrete bed in order to increase their active mass.

The living areas were placed around the warm centre of the building that consists of the fireplace, chimneys, air-ducts and the Central heat storage water tank of 2 m3.

The main heating system is floor heating because it can use the low temperature energy stored in the tanks. At the dimensioning of the heating sytem the heat losses of the Central heat storage tank were considered.

There is a secondary greenhouse in the Nord-West side of the building. Its main task is to protect the house against the more disadvantageous weather conditions and in wintertime a protective glazing is installed over the windows here. Another function of this greenhouse is protection of vegetable plants.

Operation

During the summer period the solar energy from the collectors is stored in the Base or Floor heat storage tanks under the floor of the greenhouse. The energy coming from the solar circuit or from the Base or Floor heat storage tanks preheats the supply water for the electric boiler and for the Pool storage tank through heat exchangers. The Pool tank can also be used for swimming.

In winter the Central heat storage tank in the warm centre of the building is heated up from the Base heat storage tank through a heat exchanger. The warm air from the greenhouse heats the floors and the walls. The Pool tank provides the heat balance of the greenhouse.

The direct energy source of the space heating is the Central tank since the boiler and the fireplace work for this tank only. The Central tank can be heated by solar energy through the Base tank at the price of some loss in temperature level.

This Pilot Project has just started and the actual monitoring using the same data acquisition as in case of the other projects will begin this year. Figures 18.-22. present the main features of this solar house.

4.1.Byproducts of the Project Activities

Development of a solar water heating system with rubber collectors

On the request of a manufacturer a minor project was devoted to the development of rubber collector and water heating systems made of them. Three types were developed, one for single family houses, a bigger one for public buildings (nurseries, schools, leisure center buildings, camping sites etc.) and a third one for swimming pools.

In the first stage a computer simulation program was produced for a preliminary study of the energy behaviour of the solar systems. The simulation results helped design decisions and thus accelerated the design process. Meanwhile a prototype of the rubber collector was tested in the laboratory of the HIBS and actual thermal performance data were obtained.

Thermal comfort studies relevant to energy conservation

Dimensioning and designing the thermal comfort of enclosures has become a task of finding the optimal compromise between human comfort requirements and energy conservation intentions and measures. This two group of requirement are obviously counteracting. The HIBS Microclimate Laboratory has worked out a method of finding the optimum between the conflicting requirements and published a Handbook of "Designing the indoor thermal comfort in residential and communal buildings". This volume utilizes some experiences of the Pilot Projects and

ÖRDÖGSZIKLA SOLAR HOUSE PROJECT

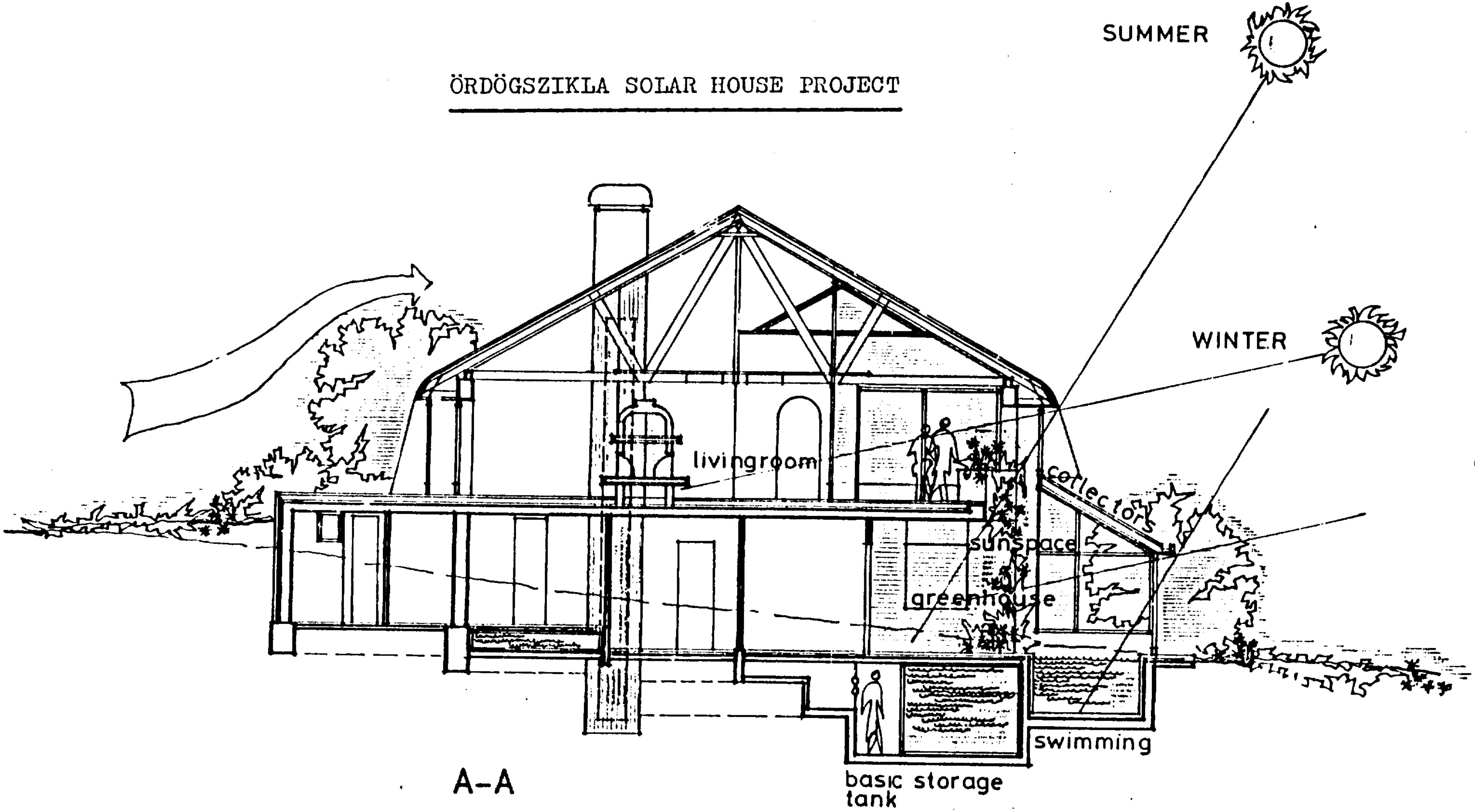


Fig. 18.

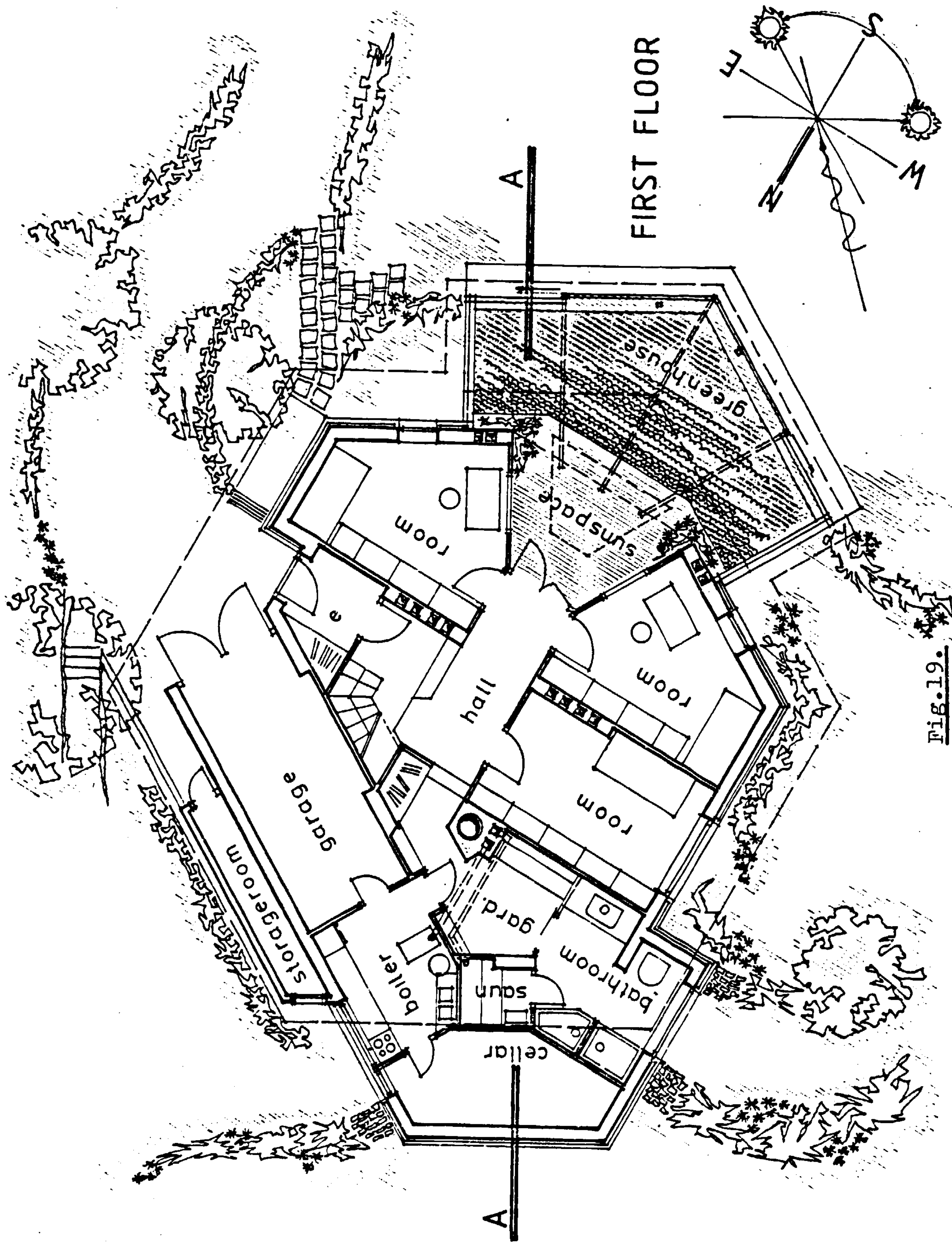

FIRST FLOOR
A
A
E
S
W
N
greenhouse
sunspace
room
room
hall
room
garage
storageroom
boiler
saun
gard.
bathroom
cellar

Fig.19.

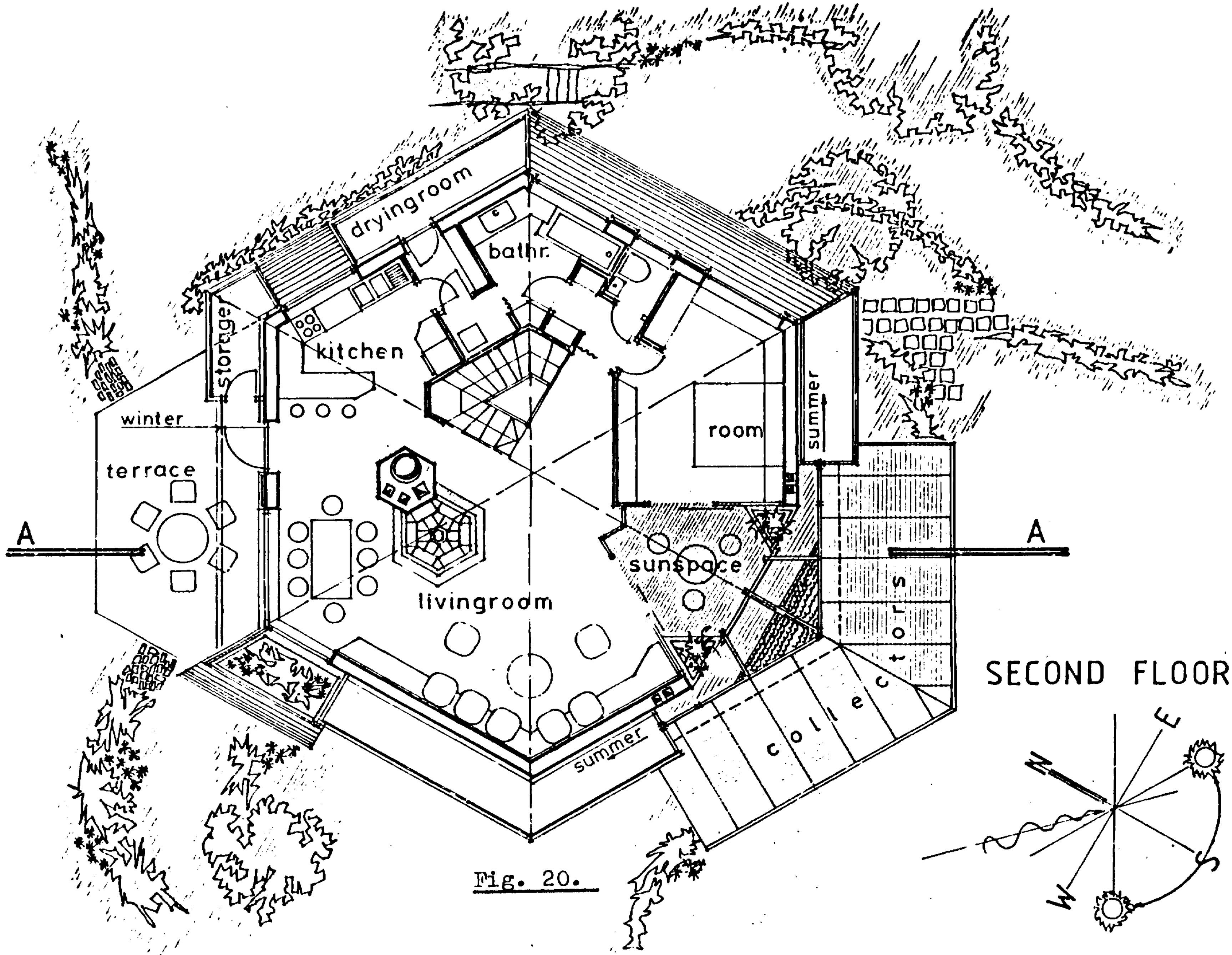

SECOND FLOOR
drying room
bathr.
kitchen
storage
winter
terrace
livingroom
room
summer
sunspace
summer
collectors
A
A
N
E
S
W

Fig. 20.

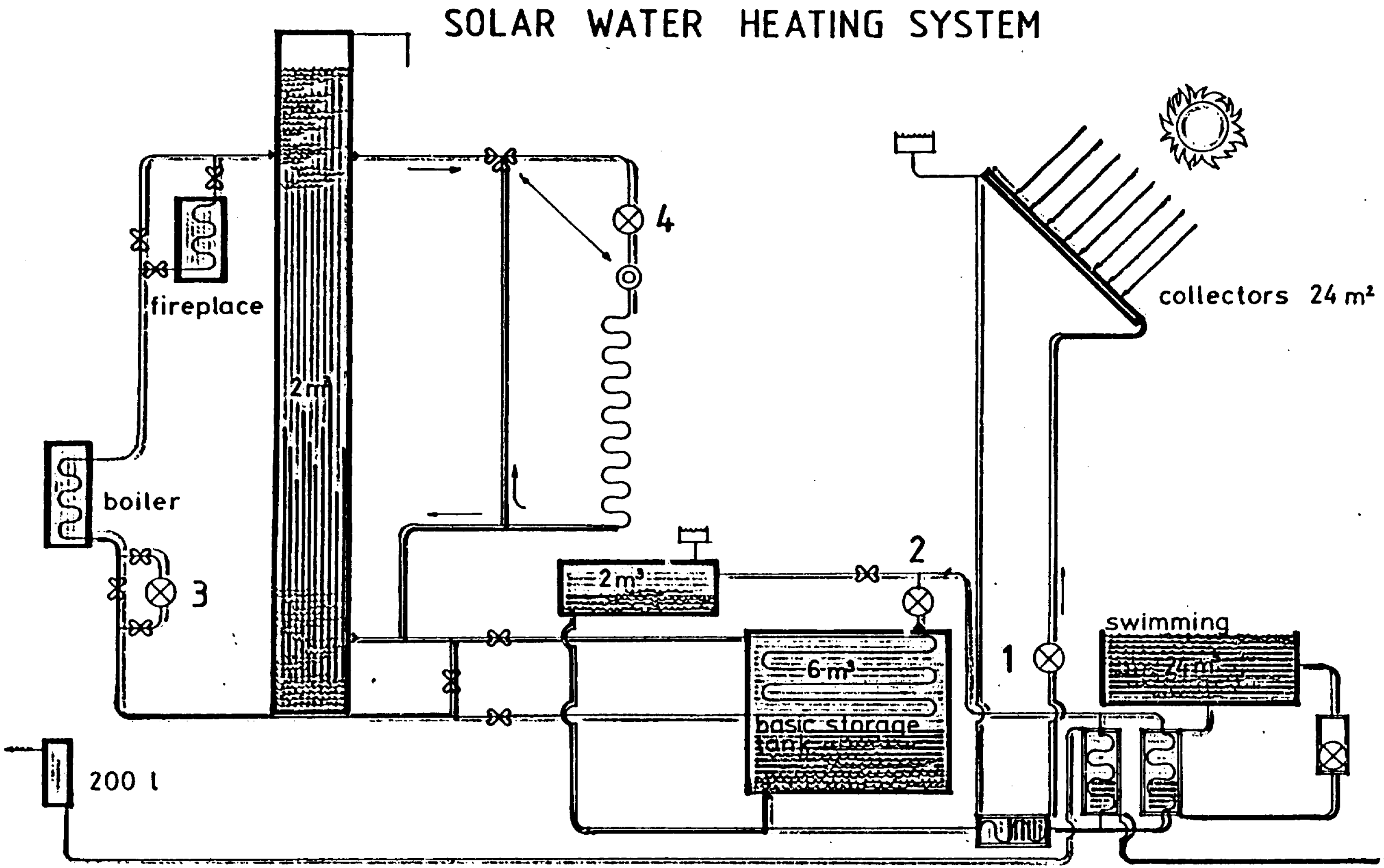
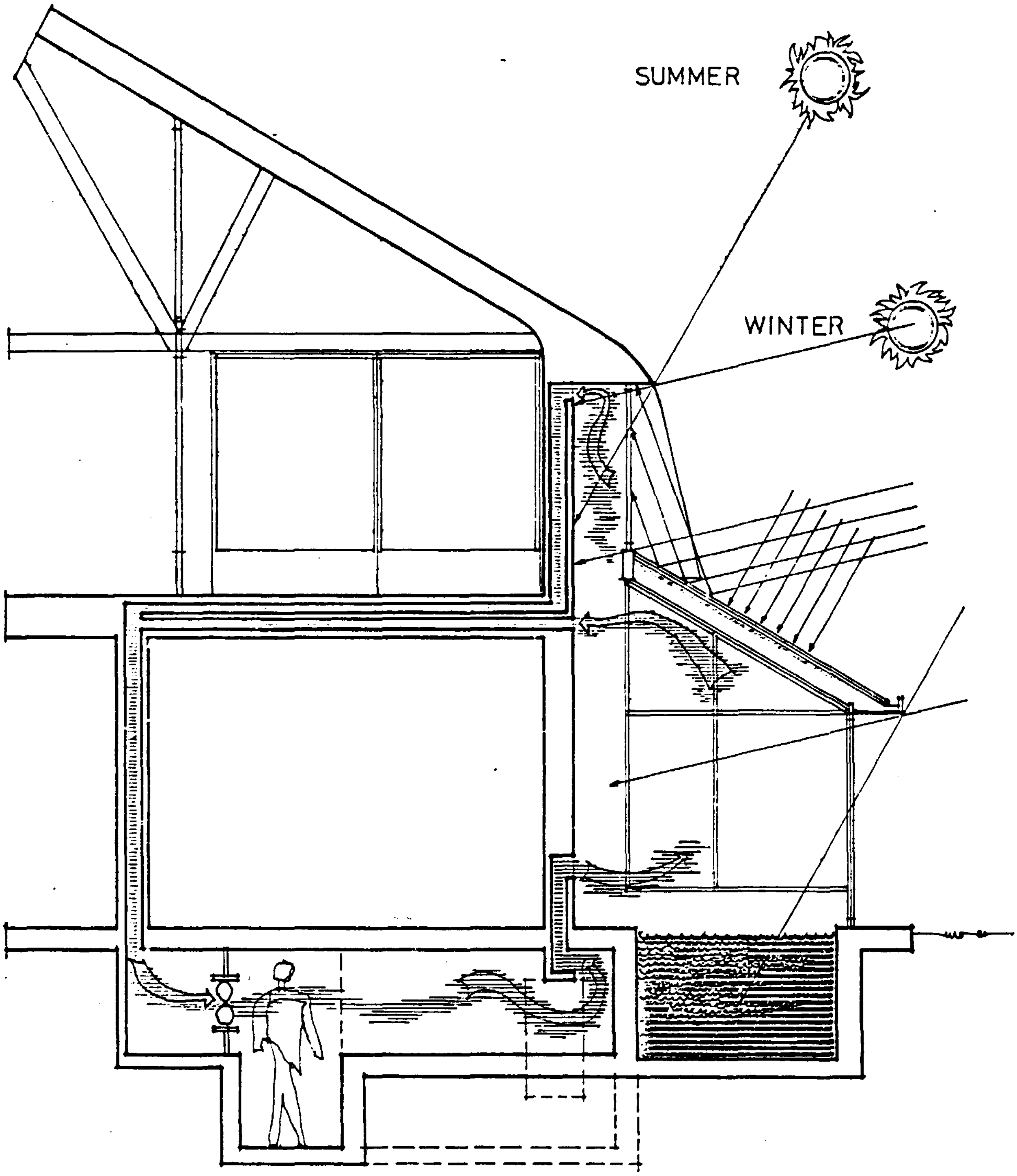

SOLAR WATER HEATING SYSTEM
fireplace
2 m³
4
collectors 24 m²
boiler
3
2 m³
2
6 m³
basic storage tank
1
swimming
24 m²
200 l

Fig. 21.



SOLAR SPACE AIRHEATING SYSTEM

Fig. 22.

supplies calculation algorythms and several data for the design practice. The dimensioning of the thermal comfort on indoor spaces is based on the results of a comprehensive investigation on the effect of thermal environment and ergonomy factors on the human labour /mentnal and physical/ performance. Another UNIDO Project also linked to the present one. A thermal manikin developed in that project was used in this one for the determination of subjective comfort and the composition of energy gains and losses of the human body in enclosures where the effect of different energy saving measures were simulated.

5. CONCLUSIONS

Forcing energy saving in the operation of buildings "at any price" leads to problems and in many cases damages of the building. A Hungarian example is the occurence of mould and condensation due to radical decrease of the indoor temperature and ventilation air change rate. Provision of the proper indoor air quality is an inevitable necessity even if this decreases the energy savings achieved. This requires the further development of heating and ventilation of buildings.

On the course of implementing the project special tasks, and involved Pilot Projects, it became obvious that the efficiency of one particular measure for energy saving is largely influenced by the state and quality of other building components that are not directly targeted by the given measure. Another conclusion in this respect is, that the application of energy saving methods may have adverse effect on "other-than energy" qualities of the building. One example: application of solar systems generally did not give the expected high savings in energy consumption, because the heat losses of the hot water supply system were much higher than expected due to some minor, almost unnoticeable shortcomings. Another example: improvement of the airtightness of buildings resulted in insufficient natural ventilation rates and poor indoor air quality.

This calls attention to the complex problem of "sick" buildings. This problem is now one of the main targets of the building research worldwide . The problem complex includes the thermal insulation discrepancies, cold-bridges, local inhomogenities in the thermal insulations, air-leakage of the building and components, insufficient ventilation and its harmful effect on the inhabitants and the structural components, failures and shortcomings in the operation of heating and ventilation systems, etc.

It was concluded that it is necessary to elaborate a method and a mobile facility for the diagnosis of environmental, energetical, thermal and other "building diseases". This should involve capacities for quick recommendations for improvement measures and drawing general conclusions for new buildings and rehabilitations.

Therefore it was concluded, that a new project is suggested on "Sick building diagnostics". This new project could be a follow-up of the present one. Its main objective would be the elaboration, organization and pilot applications of a mobile "Sick Building Diagnosis Laboratory. The instrumentation might be partly based on the measuring technique acquired in the present project. The purpose of this mobile diagnosis laboratory is the quick investigation and quantification of building-diseases at the site with short term observations, giving the diagnosis and advise on the curing measures.

Under the present conditions of Hungarian price system solar systems must be simple and consist of inexpensive components otherwise there is no hope for an acceptable repayment period of the investment.

The level of insolation in Hungary gives realistic conditions for the active utilization of solar energy.
In case of solar space heating passive or hybrid methods have

to be prefered.

In case of solar systems of low thermal performance (f.i. DHW production for single family houses) or individual laregge solar systems preliminary computer simulation should be used to analyse annual or seasonal operation of the systen, to design thermal coupling and to estimate the expectable economy.

Application of intelligent monitoring systems to the observation and measurement of building energy systems greatly improves the reliability and accuracy of the measurements and thus those of the conclusions drawn from them.

In the application of solar collectors those should be preferred that can be taylored at the construction site and are easy to mount and to be integrated into the building structure.

The heat losses due to air changes gain a growing importance due to their increasing share in the total heat loss of a building. This trend comes from the improved thermal insulation. Natural ventilation and air infiltration, however, are very difficult to predict and control. Though most of the buildings are naturally ventilated, this is very approximately calculated and predicted in the present Hungarian design practice. Knowledge of many widely varying factors such as wind pressures, leakage characteristics and human behaviour is inevitable, and internationally accepted and verified methods are necessary.

6. RECOMMENDATIONS

Based on the Project activities and achievements, for further development in the field of energy conservation in the operation or buildings, the following recommendations are made.

It is recommended to the Hungarian government to consider a change process in the present price system by relocating the governmental subsidies now given to the fuels and energy carriers to industrial products (systems, equipments, materials) that are proved to promote energy conservation. This measure would promote the wide proliferation of real energy economizing technologies, which now is blockaged by too long amortization periods due to the pressed energy prices.

Taking into account the Hungarian economic conditions it is recommended that the centralised research and development funds should be allocated in a way that provides the optimal ratio between basic research and applied research and development. Results from basic research in this field are directly used in building design and education and enables to integrate the most recent foreign achievements. It is also necessary to finance the applied research and development centrally since the corresponding funds and staff of the companies are usually rather poor.

Transfer of experience and building energy technology to the developing countries is a declared aim of the UNDP, but it is clear that it serves the development, economical and cooperational interests of both the source and developing countries as well. Therefore it is recommended to both the UNDP and the Hungarian Governmental Executing Agency that the project results, reports and Pilot Systems be available for experts from developing countries.

It is suggested to the Hungarian Government that a financial preference system be worked out for accelerating the proliferation of solar systems in Hungary.

6.1. Recommendations for main areas of future research

Further research is necessary in the field of ventilation of dwellings with special emphasis on determining and ensuring the minimal necessary air change during the heating season. Development, application and monitoring of a range of technique, equipment and system are necessary, including better control of natural ventilation and automatically controlled mechanical sytems, that flexibly meets the varying user demands, operate simply and at low expenses. For this purpose, to start up further development, a comprehensive survey of the ventilation characteristics of the dwelling stock is required, and future trends in housing should be considered.

To respond the demand outlined above the monitoring technique acquired from the present project should be completed with two new sets of instrumentation:

- tracer gas technique for monitoring actual ventilation rates in buildings,
- pressurization technique for the determination of air permeability of several houses of the building stock.

Computer controlled monitoring must be regarded as immanent part of any research and development action in solar systems and applications, and in general building energy design and management. Only this method gives realistic and reliable information on the thermal characteristics, efficiency and operation of building energy systems.

It is suggested that a Solar Experimental Plant be established, where comprehensive, well instrumented and comparative studies of experimental solar systems could be carried out, making use of the monitoring systems acquired from the present project. The Szentendre Plant of the HIBS could provide favourable inputs for this purpose.

A promising field of solar space heating application is the greenhouses. Here a joint development is recommended with horticultural experts, to take into account their economical and technological aspects.

6.2./Recommendations for transfer of R+D results into the practice and for the development of the industrial background

Promotion of manufacturing solar collectors with copper-aluminium coupled coils and selective coating is recommended through purchasing licence or know-how from industrialized countries.

In order to make use of the advantages of heating cold supply water for DHW purpose directly by solar energy rubber or plastic collectors and reflexion-free glazing or plastic cover should be further developed, manufactured and applied. Systems with reduced flow rate of the heat transporter media should be prefered.

Manufacturing of long collector strips, taylored and assembled at the construction site should be developed (f.i.: MEGA type) for summer DHW production of district heated buildings. An enhancement of this type of collectors by the use of selective coating and transparent cover of decreased thermal conductivity would ensure the required 45-50 oC temperature level.

For space heating with solar systems transparent thermal insulations and hybrid solar systems should be prefered. These ensure the active storage and passive discharge of solar energy.

The further development of solar drying technology is recommended, with special regard to the improvement of food supply in the developing countries.This technology could be an important factor in preserving and storing aggricultural products.

The Hungarian manufacturers of ventilation equipment should be encouraged to renew and develope their scope of products. The favourable results from the Pilot Projects in this respect are encouraging and the close connection between the HIBS and the manufacturers facilitates a quick transfer of project results into the practice. A range of products is necessary that are applicable in any type of residential building for balanced ventilation with heat recovery.There exists an industrial background for manufacturing these equipments. To spread practical applications production and development of systems (and design manuals) aare necessary.

The simple venting structure that has been developed in the HIBS for the better control of natural ventilation of buildings and for the better distribution of the air in building with mechanical exhaust ventilation got to the threshold of being introduced in the practice. It needs no sophisticated manufacturing technology, and is accepted by a number of constructing companies.

6.3./Recommendations for the maintainance and development of the intellectual background

The professional knowledge, experience and education is an inevitable precondition to the technical development and must always preceed it. Therefore it is of vital importance to preserve all those personal and institutional contacts that originated from the present project. This applies to all the involved main and side fields.

It is therefore requested from the UNDP to provide a small budget for fellowship purpose, as a follow up of the project to promote to maintain and develop the knowledge and information level of the HIBS s researchers that had been obtained from the present project.

Establishment of another moderate budget is requested from the UNDP for the regular maintainance of the monitoring systems acquired by the present project.

It is recommended to the Hungarian governmental officials to consider and promote the membership of competent persons and research organisations in international organizations such as the ASHRAE and the Air Infiltration and Ventilation Center.

6.4 Recommendation for initiating a follow-up project

A new project is suggested on "Sick building diagnostics". This new project could be a follow-up of the present one. Its main objective would be the elaboration, organization and pilot applications of a mobile Sick Building Diagnosis Laboratory. The instrumentation might be partly based on the measuring technique acquired in the present project. The purpose of this mobile diagnosis laboratory is the quick investigation and quantification of building-diseases at the site with short term observations, giving the diagnosis and advise on the curing measures.

Figure captions:

Fig.5. 1 = Principal scheme of the system and measurement
2 = Outdoor pool heating
3 = Indoor pool heating
4 = Swimming pool I
5 = Swimming pool II
6 = Filter
7 = Heating distributor
8 = Heating collector
9 = Solar supply forward
10 = Solar return
11 = Pool water supply
12 = Pool water return
13 = Heating circuit forward
14 = Heating circuit return
15 = Valve closed or preset for the measurements
16 = N=0 Closed
17 = N=1.....5 adjusted to the given setting

Fig.6. 1 = Principal scheme of the system and measurement
2 = Helikon hotel, Keszthely
3 = Filter
4 = Rough filter
5 = Swimming pool
6 = Heating distributor
7 = Heating collector
8 = Automatic control line
9 = Solar supply forward
10 = Solar return
11 = Pool water supply
12 = Pool water return
13 = Heating circuit forward
14 = Heating circuit return
15 = Cold water mains
16 = DHW supply
17 = DHW circulation pipe
18 = DHW by-pass
19 = Valve closed or preset for the measurements
20 = N=0 Closed
21 = N=1.....5 adjusted to the given setting

Fig.7. 1 = Layout of the Annabella hotel and the solar system
2 = Drink bar, 1 storey
3 = Hotel block, 7 stories
4 = Indoor swimming pool (I)
5 = Outdoor swimming pool II)
6 = Heating center, pumps etc.
7 = Anemometer mast
8 = Swimming pool building, 1 storey
9 = Parking lots
10 = 24 pcs solar collectors
11 = street

Fig.8. 1 = Layout of the Helikon hotel and the solar system
2 = Hotel block, 10 stories
3 = Swimming pool building, 1 storey
4 = Heating center, pumps etc.
5 = Anemometer mast
6 = Parking lots
7 = 42 pcs solar collectors

Fig.9. 1 = Annabella hotel. The outdoor swimming pool and the surroundings

Fig.10. 1 = Annabella hotel. Solar collectors set on the roof of the swimming pool

Fig.11. 1 = Helikon hotel. Collector array on the roof of the swimming pool

Fig.12. 1 = Helikon hotel. Arrangement of the collectors.

Fig.12. 1 = Energy balance of the swimming pools in the Annabella hotel
2 = Auxiliary energy from furnace
3 = Solar pump performance
4 = Total solar radiation incidence
5 = Loss due to delay of the automatic control system in switching on solar pump
6 = Collector losses
7 = Loss from "thermosyphoning" fallout of solar heat exchanger
8 = Auxiliary energy used in pools
9 = Total utilized heat energy
10 = Utilized solar energy in pools
11 = loss from gravity circulation in solar loop when pump is off

Fig.13. 1 = Energy balance of the swimming pools and building in the Helikon hotel
2 = Auxiliary energy from furnace
3 = Solar pump performance
4 = Total solar radiation incidence
5 = Loss due to delay of the automatic control system in switching on solar pump
6 = Collector losses
7 = loss from gravity circulation in solar loop when pump is off
8 = Auxiliary energy used in pool
9 = Total utilized heat energy
10 = Utilized solar energy
11 = Auxiliary heat used in floor heating
12 = Auxiliary heat in DHW
13 = Loss from DHW leakage

APPENDICES

Appendix 1

Foreign experts involved in the Project

Name/Nationality	Post description	Affiliation
Prof.Dr.L. JESCH /English	international expert	University of Birmingham (UK) Solar Energy Lab.
Prof.P.K. JENSEN /Danish	international expert	Technical University of Copenhagen, Laboratory of HVAC
Prof.Dr.K. CENA /Polish	international expert	Environmental Phys. Institute Tech. Univ. of Wroclaw

Appendix 2

Hungarian experts involved in the project

Name	Post description	Qualification
Mr.K. BALAZS	senior researcher	Cert.Mech.Eng.
Dr.L. BANHIDI	scientific adviser	Dr.Tech.,C.M.Eng.
Mr.L. BORONKAY	researcher	Cert.Architect
Mr.G. FORRAI	researcher	Cert.Mech.Eng.
Mr.B. KOSZTOLANYI	senior researcher project manager	Cert.Mech.Eng.
Mr.L. KUN GAZDA	researcher	Cert.Mech.Eng.
Dr.G. KUNSZT	scientific adviser	MSc.,Cert Arch.
Mr.G. PÉNZES	senior researcher	Cert.Mech.Eng.
Dr.G. SZABO	scientific adviser	MSc.,C.M.Eng.
Mr.Z. SZALAY	senior researcher	Cert.Mech.Eng.
Dr.T. TÖMÖRY	scientific adviser	MSc.,C.M.Eng.
Prof.Dr.A. ZÖLD	nationally recruited project professional expert	Dr.Tech.C.M.E.

Appendix 3

Fellowships awarded

Name of fellow	Host organization	From - To
Mr.L. KUN GAZDA	University of Birmingham, UK, Solar Energy Laboratory	03.84.-05.84.
Mr.L. BORONKAY	- " -	04.84.-05.84.
Mr.L. KUN GAZDA	Chalmers University of Gothenburg, Sweden Measuring Centre for Energy Research	04.86.-05.86.

Appendix 4

List of major items of equipment provided by UNDP

Item no.	Qty.	Description	USD equivalent
3	1	Series 3 Analogue Scanner	9.537
1	1	HP-85 Desktop Computer Incl. 82936 ROM, 00085-15003 I/O ROM,82937 HP-IB Interface	4.809
1.1	1	82903 16 kb add. memory modul	269
1.2	1	Matrix ROM 00085-15004	200
1.3	1	Advanced Programming ROM	200
1.4	1	00085-15007 hp85 Assembler	407
1.5	1	82928 System Monitor	407
1.6	1	82929 Programable ROM Drawer	269
2	1	3478 HP-IB Digital Multimeter	1.651
1	3	Kipp+Zonen Pyranometers	1.676
3	6	R.M.Young Propeller Anemometers	2.582
4	1	Digital I/O Unit	4.738
4	5	Differential Pressure Sensors	1.589
1	1	Scanner Box Assembly No. 3325	1.807
2	3	Scanner Module Assembly No. 3326	1.807
2	10	Resistance Humidity Sensors	1.232
	5	Resistance Humidity Sensors	657
	1	HP85B Personal Computer with integrated screen, printer	4.536
	1	HP 82937 HP-IB Interface	553
	1	HP 3478 Programable Digital Multimeter, HP-IB	1.713
	1	HP 7470 2-pen Graphics Plotter	1.441
	1	HP 9121 Dual Floppy Drive 540 kb	1.751
	1	HP Compatible Dot Matrix Printer	1.149
	1	Basic Assembly IEEE-488 I/O Unit	3.191
	1	16-ch Digital Input Module	429
	1	8/8-ch Digital I/O Module	429
	3	K3675 Cuproswem Thermosensor	170
	7	Combimeter T3	1.645
	1	Combimeter T30	1.020

Appendix 5/1

List of relevant publications

K. BALAZS: R+D project for new space heating concepts for large industrial workshops /in Hungarian, co-authors: G. MAKARA, K. BIRO/
Energiagazdalkodas /3/, 1985. No.3.

K. BALAZS: Untersuchungen zur Bestimmung des Lüftungswarmebedarf /in German, co-author: A. ZÖLD/
Heizung Lüftung Haustechnik 1985. No. 10.

K. BALAZS: Filtration heat demand of multistorey residential buildings /in Hungarian, co-author: A. ZÖLD/
Energia és Atomtechnika /4/, 1985. No.2-3.

K. BALAZS: Case studies of calculating heat losses of buildings /in Hungarian, co-authors: A. ZÖLD, B. KERESZTY/
Techn. Univ. of Budapest, Coursebook for postgraduate students, 1985.

Dr.L. BANHIDI: Increased performance floor heating /in Hungarian, co-authors: dr.K. HAMVAY, I. SIMON/
Épületgépészeti Technika, 1985/2

Dr.L. BANHIDI: Energy saving floor heatings /in Hungarian, co-authors: dr.K. HAMVAY/
Proc. of III. ER Colloqium, Székesfehérvár, 1985.Vol.3

Dr.L. BANHIDI: Low temperature high performance floor heating /in Hungarian, co-author:dr.K. HAMVAY/
Épitésügyi Müszaki Gazdasági Tájékoztato, 1985/4.

Dr.L. BANHIDI: Prediction of thermal comfort in a building during a cold spell /co-authors: A. SOMOGYI,L. FABO/
Energy and Buildings /8/ 1985.

Dr.L. BANHIDI: Effect of the water mass flow rate on the perfomance of new radiators /in Hungarian, co-author:

Appendix 5/2

List of relevant publications /continued/

L. PONGRACZ/
Épületgépészet, 1983/5-6.

Dr.L. BANHIDI: Technical economical principles of dimensioning run-around heat recovery systems /in Hungarian/
Épületgépészet, 1983/5-6.

Dr.L. BANHIDI: Study of the control characteristics of TR heating systems /in Hungarian, co-authors: L. PONGRACZ, B. KOSZTOLANYI/
Épületgépészeti Technika, 1985/4.

Dr.L. BANHIDI: Practical cases of simultaneous free and forced flows /in Hungarian/
Épületgépészet, 1985/4.

B. KOSZTOLANYI: Thermal performance of RADAL radiators /in Hungarian, co-author: G. FORRAI/
HIBS Report, 1986

B. KOSZTOLANYI: Study of national cost-efficiency of different energy carriers /in Hungarian/
OMFB Study 1-7801/L-T, Budapest 1983/9

B. KOSZTOLANYI: Low temperature heating systems /in Hungarian/
Épületgépészeti Technika 1984/3

B. KOSZTOLANYI: Comparative study of consumer side equipments of communal heat supply systems /in Hungarian, with co-authors/
OMFB Study 1-8302/Et , Budapest 1984/5

L. KUN GAZDA: Monitoring system for HVAC equipments
III. ÉI Conferenc,Budapest, 1983, April

L. KUN GAZDA: Passive solar house in Budapest /co-authors: L. PONGRAcZ, G. BORONKAY/,GATE Conf. Budapest,1983

Appendix 5/3

List of relevant publications /continued/

L. KUN GAZDA: The Székesfehérvár Solar Energy Project
Swedish-Hung. Monitoring Seminar,Budapest 1983

dr.T. TÖMÖRY, L. KUN GAZDA: The Csákvár Solar DHW Project
Swedish-Hung. Monitoring Seminar,Budapest 1983

dr.T. TÖMÖRY, L. KUN GAZDA: In situ measurement of a thermosyphon DHW solar system
HIBS Report, 1983, Oct.

L. KUN GAZDA: Development of modelling method for aerodynamics and thermal processes /in Hungarian, co-author: Z. SZALAY/
HIBS Report, 1983. Nov

L. KUN GAZDA: How to form measuring systems for monitoring of HVAC equipments /in Hungarian/
Épitésügyi Müszaki Gazdasági Tájékoztató, Budapest, 1983/12.

L. KUN GAZDA: Up-to-date thermal energy research of buildings and HVAC systems /in Hungarian/
II. Symp.on Thermo-Techn Measurements, Budapest, 1984

dr.T. TÖMÖRY, L. KUN GAZDA: In situ measurement of a wall collector solar system /in Hungarian/
HIBS Report 1984

dr.T. TÖMÖRY, L. KUN GAZDA: Generalizing measured data of a solar system
INTERSOL Congress of ISES, Montreal,1985

dr.T. TÖMÖRY, L. KUN GAZDA: Computer aided design for solar water heating systems /in Hungarian/
3th OÉEK, Székesfehérvár,1985

Appendix 5/4

List of relevant publications /continued/

dr.T. TÖMÖRY, L. KUN GAZDA: Case study for solar water heating system of camping sites /in Hungarian/
CIB Conf. Budapest, 1985

L. KUN GAZDA: New computer simulation program and operation method for the ventilation system of the Budapest Underground /in Hungarian, co-author: L. MOLNAR/
HIBS Report, 1985. September

dr.T. TÖMÖRY, L. KUN GAZDA : Operation experiences of a building equipped with wall-panel solar collectors
/in Hungarian/
Épületgépészet, 1985/4.

L. KUN GAZDA: In situ measurement of DHW solar energy system connected to a district heating system
/in Hungarian/
HIBS Report, 1985. November

dr.T. TÖMÖRY, L. KUN GAZDA: Examination of a solar warm water system
/in Hungarian/
Épületgépészet, 1985/4.

dr.T. TÖMÖRY, L. KUN GAZDA: Solar energy systems developmant with monitoring and computer simulation
CIB Conference, Washington D.C.,1986. June

dr.T. TÖMÖRY, L. KUN GAZDA: Low energy house in Budapest
PLEA 86 International Conference, Pécs, 1986 September

dr.T. TÖMÖRY, L. KUN GAZDA: Examination of glass tile solar collector covers
/in Hungarian/
HIBS Report, 1986. September

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List of relevant publications /continued/

dr.T. TÖMÖRY, L. KUN GAZDA: Process water heating with solar energy
/in Hungarian/
HIBS Report, 1986. September

dr.T. TÖMÖRY, L. KUN GAZDA : Development of rubber solar collectors
/in Hungarian/
HIBS Report, 1986. November

dr.T. TÖMÖRY, L. KUN GAZDA: Ördögszikla hybrid solar project
/in Hungarian/
HIBS Report, 1986. September

G. PÉNZES: Ventilation methods of residential buildings
/in Russian/
Ventilation Conf.,Prague,1984.

G. PÉNZES: Possibilities for energy saving in the operation of residential buildings /in Russian/
Energy Conservation Conf., Bratislava, 1985.

G. PÉNZES: Means of air supply in residential buildings
/in Hungarian/
Épitésügyi Müszaki Gazdasági Tájékoztató, Budapest, 1985

G. PÉNZES: Ventilation of residential buildings
/in Hungarian/
OÉEK, Székesfehérvár, 1985

G. PÉNZES: Devices of air supply in residential buildings
/in Hungarian/
Épületgépészet,1986

G. SZABO: Energetical aspects of housing policy
/in Hungarian/
Épitésügyi Szemle 1983/3

G. SZABO: A model and modification possibilities of energy used by the habitants
/in Hungarian/
Épületgépészet,1983/3

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List of relevant publications /continued/

G. SZABO: Energy aspects of windows
/in Hungarian/
Magyar Épitőipar 1983/9

G. SZABO: Energy flows through windows and glazing in the heating period /in Hungarian/
Energia és Atomtechnika 1984/3-4

G. SZABO: Effect of solar radiation on the heat flows through windows in the heating season /in Hungarian/
Energia és Atomtechnika 1985/2-3

G. SZABO: Principles of creating buildings for rational use of energy /in Hungarian/
VATI Study, Budapest, 1984

G. SZABO: Energy losses of solid walls in the heating season /in Hungarian/
Épületgépészet,1983/3

G. SZABO: Rationalizing the energy consumption of buildings Ideas - Facts - Tasks /in Hungarian/
Magyar Épitőipar 1984/10

G. SZABO: Analysis of energy flows of windows /in Hungarian/
OÉEK, Székesfehérvár, 1985

G. SZABO: Basic data for passive solar dimensioning /in Hungarian/
ÉTK Publication, Budapest,1986.

G. SZABO: Energy consumption model of the population and possibilities to change it
SBI-HIBS Seminar in Copenhagen 1986

Z. SZALAY: Complementary venting structure for airtight windows
Windows in Building Design and Maintainance
Sweden, Gothenburg 1984. june 12-15.

Appendix 5/7

List of relevant publications /continued/

Z. SZALAY: Wind loads on an industrial building
6th Colloqium on Industrial Aerodynamics, Aachen, 1985

Z. SZALAY: The influence of occupants behaviour on indoor air quality - a case study
7th AIC Conference 1986, Stratford upon Avon

Appendix 6

List of short-term study tours

Name	Country	Time
Mr. B. KOSZTOLANYI	Switzerland, FRG	Dec. 86
Mr. K. HAMVAY	Switzerland, FRG	Dec. 86
Mr. Z. SZALAY	Austria,Switzerland	Dec. 86
Mr. B. KOSZTOLANYI	Austria	Nov. 86
Ms. E. SZIGETI	Austria	Nov. 86
Mr. K. BALAZS	U.K.	Sep. 86
Mr. Z. SZALAY	U.K.	Sep. 86
Mr. B. KOSZTOLANYI	FRG	May 86
Mr. G. SZABO	FRG	May 86
Mr. G. PÉNZES	Denmark	May 86
Mr. L. BANHIDI	FRG	May 86
Mr. B. KOSZTOLANYI	Austria	March 86
Mr. G. FORRAI	Austria	March 86
Mr. L. KUN GAZDA	Sweden	Arpil 86
Mr. B. KOSZTOLANYI	U.K.	June 84
Mr. Z. SZALAY	Sweden	June 84
Mr. G. KUNSZT	U.K.	March 83
Mr. B. KOSZTOLANYI	USA	Jan. 83