TECHNICAL FEASIBILITY OF GEOTHERMAL PROJECTS IN AGRICULTURE AT THE END OF XX-th CENTURY

Kiril Popovski
Faculty of Technical Sciences
St. Kliment Ohridski University of Bitola
97000 Bitola, Former Yugoslav Republic of Macedonia

Key Words: Direct Application, Agriculture, Technologies

Abstract *Intensive process of development of new technologies for direct upplicaiion of low-temperature geothermal fluids in agriculture during the seventies, has been significantly slowered during the eighties and nearly slopped during the nineties. However, that was a period long enough for development of a large number of commercially feasible technologies, offering rather large field of use of low-temperature brines at the end of this century.*

For the need of planning the possible development of geothermal projects with direct applicaiion in the begin-ning of the next century, a review of the technologies on disposal is niade in this paper and a trial for iheir techno/economic estimation for the me in different market conditions.

Some of the conclusions are of wider interest. The most important one is that direci appliroiion projects in agriculture are feasible in most of the regions where geothermal energy is available. Even under very sharp competition offossil fuels, it looks that geothermal energy is going io consolidate its position as the besi alternaiive resource in many regions of the world.

1. INTRODUCTION

The so called "energy crisis" of late 70-ies and early 80-ies allowed to find out that it was worthwhile to develop an energy source available just below our feet, offering the advantage of being independent of the international market of fuels, where powerful countries are playing a game which does not always beuefit the small ones with weak economies.

Unfortunately, convenient conditions for its development lasted too short to enable a real and wide introduction in all possible life sectors where it is at disposal. Now-a-days, the lowered exploration activities in many developed countries are discouraging a lot of less developed countries. However, the development is not stopped. Slowly aiid continually, the number of improvements, new uses aiid new sources is increasing.That is probably the last of so-called "alteruative energy resources" which caii be and in maiiy cases is economically competitive with the cheap fossil fuels of today.

An attempt is made in this paper to make a short description of important improvements of direct application of geotlieriiial energy in agriculture. achieved during the recent years, in order to stimulate further engagements and development of this particular energy source. It can be of major importance lor a number of developing countries in the world.

2. POSSIBLE USES AND LIMITATIONS

Theoretically, the area of possible uses of geothermal energy is very wide. Where hot or warm fluids or steam are necessary, geothermal water or steam can be used; agricultural production in protected conditions. aquaculture and mushroom growing, heating of dwellings and animal farms, washing, pasteurisation, sterilisation, etc.

Unfortunately, a number of limitations obstructs such wide possibilities:

- The first and most important is of an economic nature. Rather high investment costs condition the composition and kind of possible users for a concrete source. Sometimes gradual development is not possible because it results in great money losses during the initial years of exploitation and always presents a rather high level of risk during the same period. That is an obstacle for the high capital investment, necessary to organise the final plant composition.
- The second limitation is the multidisciplinary character of the problem.A rather high level of knowledge of different scientific disciplines is to be applied to enable economic and easy technical solutions in exploitation (and that is not everywhere possible or justified).
- The third limitation is the dictation of the energy source site, i.e. it dictates the location and composition of the users, too (and it is not to energy which can dictate it, even being important to nearly all kind of users).
- The fourth limitation is the need of a high level of organisation. i.e. users have no freedom to choose the way aud terms of eiiergy use. It is a hard limitation, particularly for the small users.
- The fifth (and not the last one) limitation is the need for environmental protection. For a long time, it has been considered as a clean energy, but it is not. Geothermal brines can pollute the environment both chemically and thermally. This limitation is not taken seriously in many locations round the world, but the problem appear after very short periods of use.

Unsolved limitations are one of the major reasons for the application of very simplified solutiolis all over the world. They are giving short-term benefits to the users, but are not always favourable to the long-term development of geothermal energy as a prospective energy source. Unsuccessful experience is impressing the public more than a positive one.

3. REAL EXPERIENCE

Without pretending to be complete, tlie list below shows the commercial experieuce gained in:

- Heating of greenhouses;
- Heating of animal farms;
- Heatiug of hot beds;
- Heatiug of aquaculture farms;
- Hot irrigation;
- Open field heating;
- Milk and vegetable processing;
- Drying of wood, fishes aiid agriculture products (rice,tobacco, etc.);
- Heat pumps use in combination with different uses of geothermal eiiergy for heating purposes.

Most of the listed uses were known during the previous periods of development, but the difference now is that it is possible to speak of conunercial use and not only of tlie positive results of experiments and investigations.

Not all the problems are solved but a certain level of technological developinent has been already achieved. Heatiug of dwellings and public buildings with geothermal energy is an usual technical feature, the list of new heat exchangers is so wide that there is hardly aiiy problem to create the necessary optimal indoor climatic conditions for auy culture in any climate and any type of greenhouse construction; the same holds true for hot beds, irrigatioii or dilfereut animal-farm heating.

Tlie problem at tlie monient is the concentration of knowledge and production possibilities in a very limited number of countries. unfortunately not always where tlie geotliermial possibilities are broad aiid where they are necessary. A number of developiug countries could derive significant benefits from a wider use of geothermal eiiergy in agriculture but, up to iiow, the situation was not very satisfactory. Main constraints can be located in tlie lack of knowledge and money, and organisational problems.

4. TECHNICAL ASPECTS

4.1. *Heat exchangers*

Probably tlie most important advauces for the use of low-temperature geothermal waters during the recent years.They are characterised by a variety of new constructions aiid materials, closely adapted to the requirements of users.

4.3.1. Greenhouse heating

Greenhouses are among the most interesting and widespread applications of geothermal eiiergy as a lieat source. Over 300 ha of glasshouses aiid plastic houses were geothermally heated only in Europe in 1986 (Ref.N° 19). with a continuous iucrease by tens of hectares each year. That is somewhat surprising, because it is a rather bad lieat consumer when consider ing the annual heat load factor. The explanation lies probably in tlie possibility to install the projects near the geothermal sources. without disturbing the whole organisation of the production aiid marketing of the products.

The large introduction of cheap plastic materials for the distribution of geothermal brines and heat exchangers is the most significant characteristic of the

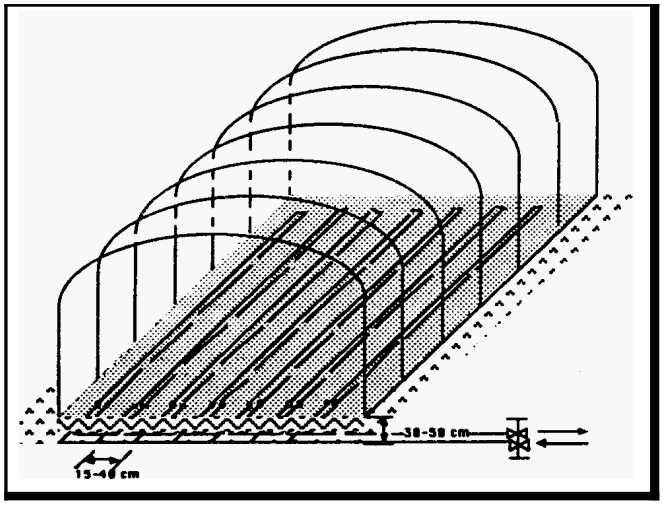

Fig.1. Soil heating installation for greenhouses

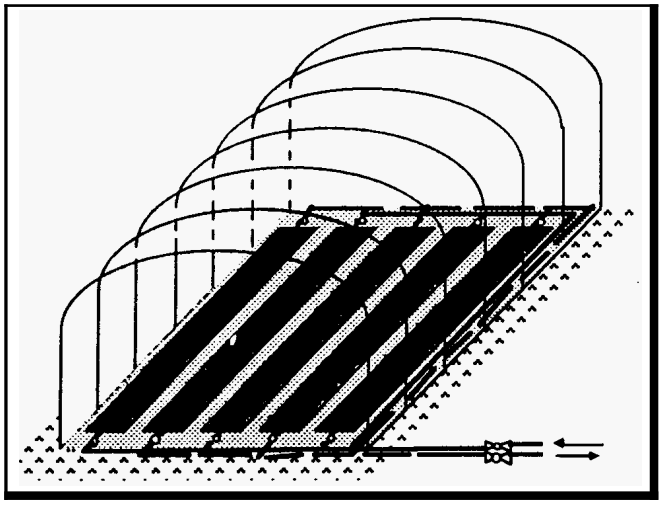

Fig2 Heating installations laid on the ground surface

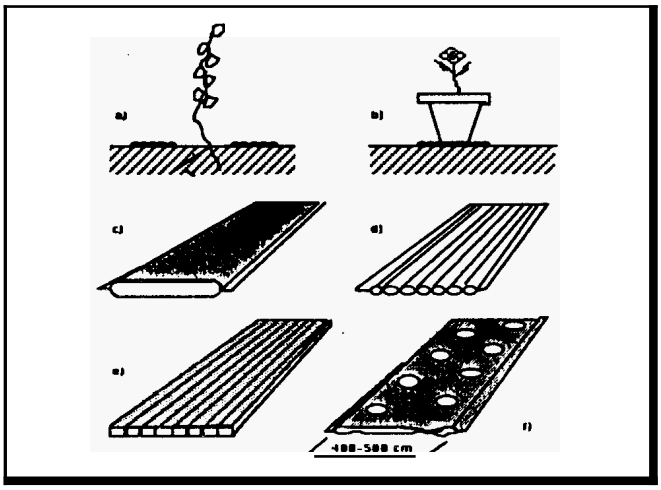

Fig.3. Different heat exchangers for laid on the ground surface heating installations

last ten years lor. this particular energy use. Thus, direct use is possible, i.e. the corrosion problem is eliminated, which is very convenient for small artesian wells; where it is difficult to justify the installation of expensive equipment, the use of expensive materials for heat exchangers, etc.

The rather wide variety of constructions can be divided into four main groups:

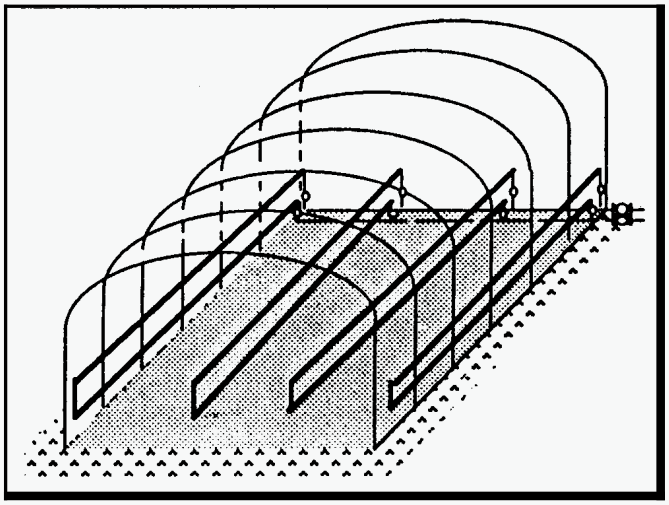

Fig.4. Free convection pipe heating installation

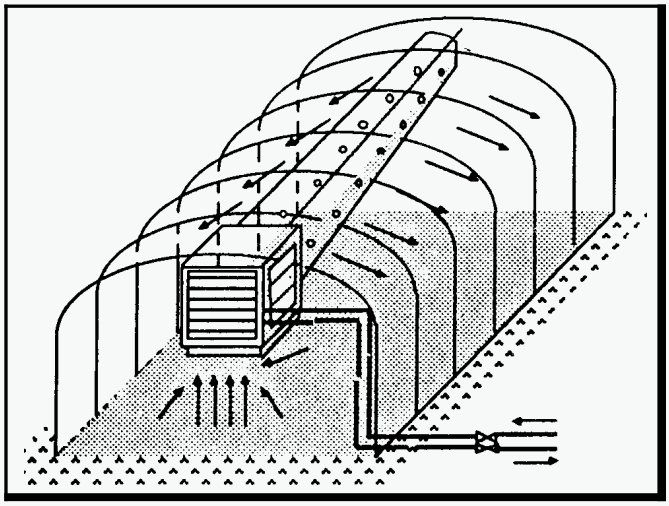

Fig.5. Fan-jet heating installation

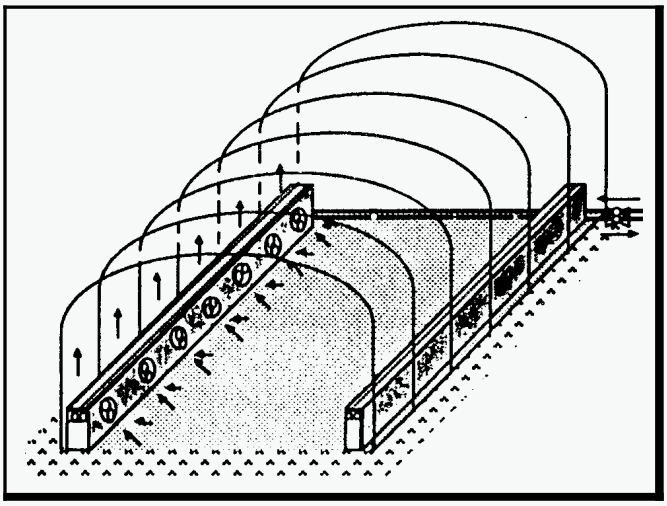

Fig.6. Hortitherm heating installation

- Soil heaters; usually made of smooth or corrugated plastic pipes (Fig.1), located 30-50 cm below the ground level for cultivation in soil or directly in the concrete construction for soil-less or cultivation in pots. It is convenient for rather low temperatures of the heating medium and for the base heatings. The large inertia of the soil material will not allow a precise regulation to follow the changes of outside climate. It is a good energy-saving technique, influencing positively total conditions for plant development, but it cannot be taken as a unique system to cover total heat demands, particularly in cold climates.
- On-the-soil-heaters; they are playing two roles: to heat at the same time the soil and the air in the greenhouse (Fig.2). Excellent influence on the inside climate and production results in combination with low price; easy and simple installation makes this type of heating the most popular in Mediterranean countries in the recent years. Particularly thin-pipe heating and large-plastic tube heating is in wide use, as also are plate-type (Fig.3) heat exchangers (Ref.N°7).
- Free convective air heaters; this is practically the oldest type of heating installations for greenhouses, with the difference that for low temperatures new finned pipes and special profiled aluminium pipes are introduced (Fig.4). New experiments enabled to improve the characteristics of heating elements in greenhouses. Evenmore, many positive references are at disposal (Ref.N°.18,20). High investment costs hamper their wide spreading in the countries with mild climates. In the middle European areas, this type of installation is in wide use (Ref.N° 11, 18.20).
- Convective air heaters with forced air movement: the classical "fan-jet" system (Fig.5) is still in very wide use. although the negative sides of bad temperature distribution in the heated space are known.

That is removed with the lower allocation of the warm-air distributive tubes. New convector units along heated greenhouses (Fig.6) are very promising. Excellent results are achieved even with very low temperature of the heating medium (Fig.7).

Positive and negative sides of different types of heating installations are the reason for using their combinations depending on the concrete culture requests.

4.3.2. Heating of unimul farms

Surprisingly enough, farm heating with geothermal energy is experienced only in two countries (Hungary and Serbia). Simple air heating installations are reliable and well combined with greenhouse's heating (Fig.9). The relatively small demand explains probably why this type of use is not so much spread out in other countries.

4.3.3. Aquaculture

Some aquaculture plants heated with geothermal energy have been already tested in geothermally developed countries. The best known are the simple techni-

cal solutiolis in Hungary (already at commercial stagc).

Technical cliaracteristics of installations show that this type of use can be the last step of geothermal combinations. thus preventing the environment from thermal pollution. Simple. very often hand made, heat exchangers sinked in pool are the "heart" of the installations, offering very easy exploitation and quick return from necessary investments.

4.3.4. Irrigation

Two types of irrigation are interesting. One is so called "hot irrigation" for plants cultivated in protected conditions. the second is the normal irrigation in dry areas (Ref.N°7). For tlie latter use, additional measures should be taken to cool the water to the adequate temperature (greenhouse heating, special cooling towers, etc.).

Interesting and effective technical solutions are developed by the Ministry of Agriculture in Tunisia, with the use of simple corrugated plastic pipes hanged in series at certain distances.

4.3.5. Other agricultural applications of geothermal energy

l'he list of users given in the introduction part of this paper does not exhaust the possibilities of geothermal energy applications in agriculture. It is reported that attempts have been made to introduce it also in food processing industry, but there is still no technical data. except for drying (Fig.11) of agricultural products (rice. tobacco. etc.) and paper industry.

4.3.6. Heat pumps

The application of heat pumps in geothermal projects is in direct connection with the increase of the annual lieat load coefficient. Up to 64% in comparison with 36% with heat exchangers are proved in European circumstances. However. that is not true for Southern climates arid niost of agricultural users.

A popular solution in developed countries at the time of high prices of fossil fuels, it became less popular during the recent years because of very high investment costs. Up to 30 years pay-back periods are out of questioii in the economic circumstances of to-

More careful determination of peak-load powers in concrete climatic conditions and for concrete uses allows more economic combinations of heating installations and users with use of simple and cheap light oils and gas boiler plants (Ref.N°19).

5. ECONOMIC ASPECTS

The changeable situation of the fuel market and of the world economy during the recent years influenced to a great extent the development of geothermal energy as a possible alternative energy source. The constant decrease of fuel prices, together with the constant increase of equipment prices totally changed the preconditions for its wider introduction of ten years ago.

The background of its successfull survival should be searched in the accommodation of technical possibilities to the changing economic aspects in different technical. technological, economic and social conditions.

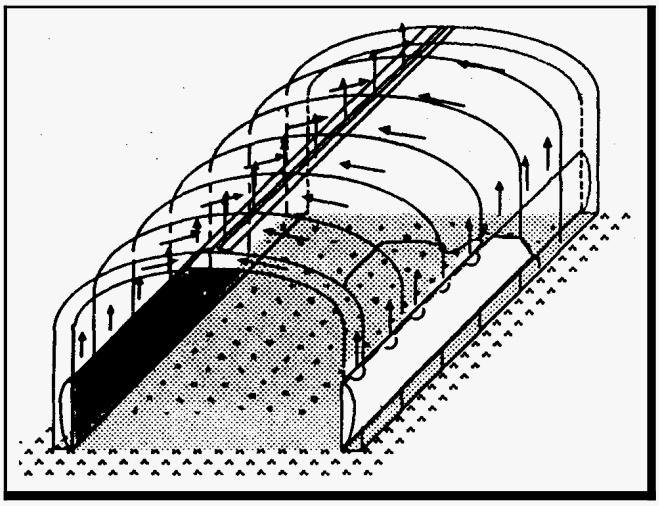

Fig.7. Low-temperature roof heating installation

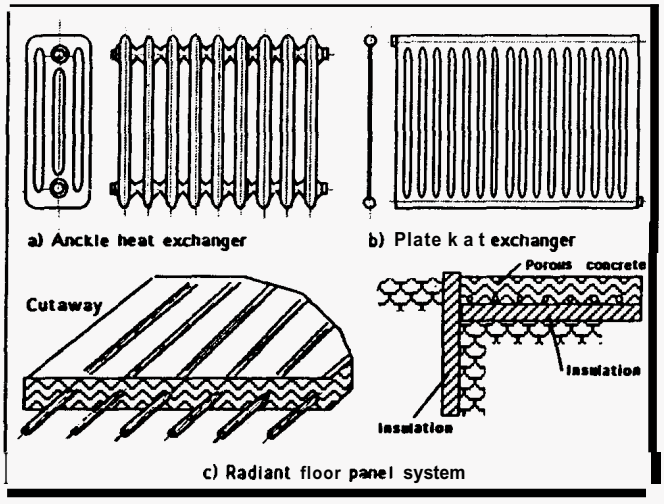

Fig8 Elements for room heating installations for animal farms

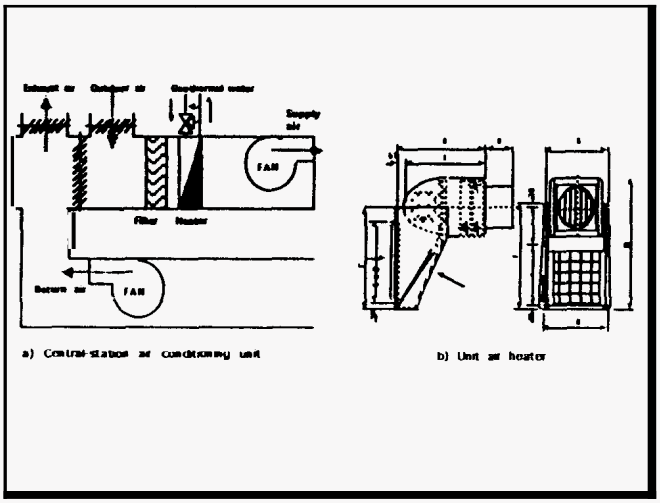

Fig.9. Elements for air heating with forced convection

Depending on the composition of energy users, the nature of the geothermal source and locally the climate, technical, economic and social conditions; two types of development approach gave positive economic results during the. recent years. These are:

(i) The orientation towards a greater simplification of all the elements of geothermal plant and the use of cheap plastic materials. The approximation to the optimal inside climatic conditions is realised more by means of ingenious solutions for concrete users than through technical improvements. Thus, investment costs are minimised and economy can be reached even for energetically very bad users.

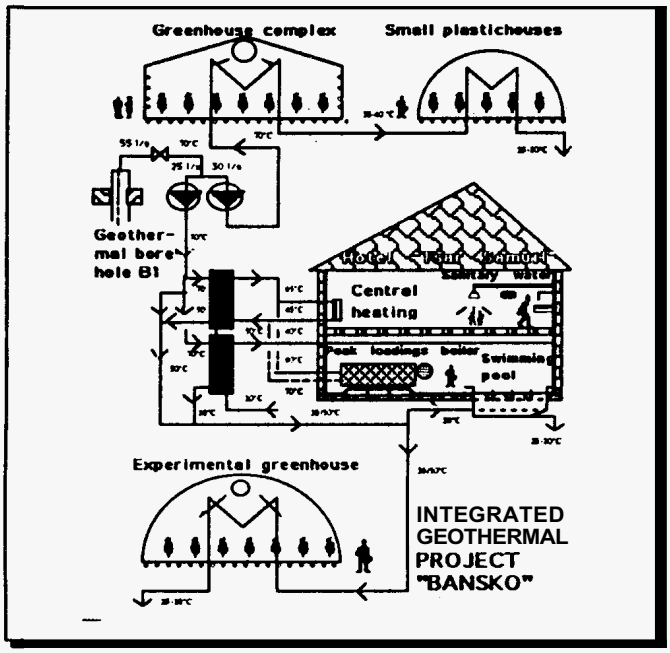

Fig.10. Integrated systems with different types of heating installations aid different daily and annual heat loading factors

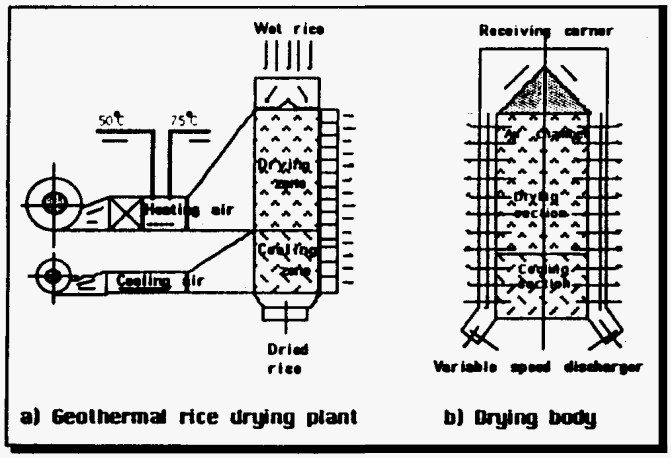

Fig. 11. Geothermal rice drying plant

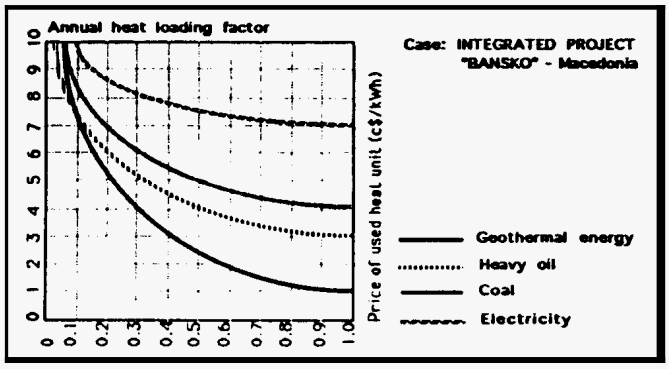

Fig12. Changes of tlie used heat price depending on the annaul heat loading factor

Greenhouse heating in Mediterranean countries is a typical example of such an approach to the problem. Mild climatic conditions allow the use of simple constructions and heating installations. Practically, the task is not the total conditioning of the inside climate of the greenhouse, but its improvement. Excellent results are reported in Tunisia, Greece, Spain and Israel.

(ii) The orientation towards the improvement of the annual heat load factor through the combination of different heat users. The rise of investment costs and the expensive exploitation of geothermal sources are compensated by minimisation of their influence on the price of used heat (Fig.12). Peak load can be covered by end heat use (accumulation of heat), careful composition of heat users and the use of cheap fossil-fuel boilers.

Typical examples of such an approach are the geothermal complex Bansko in Macedonia and combined heating schemes in Hungary.

The problems posed by such geothermal plants are the need of very high level of multidisciplinary knowledge, centralised management and development, and that is very difficult to be obtained in most of the developing countries. The influence of stable market conditions should not be neglected in relation to the risk for high investment costs, which is also a negative precondition for developing countries.

During the last five years a combined approach became predominant, i.e. the use of simple elements where possible and justified (in order to minimise the investment costs) but also combinations of heat users in order to lower the price of used heat. That was made possible by the introduction of high productive technologies in the greenhouses of southern countries, which enabled payment of higher investment costs, but also owing to the need to be competitive with cheap fossil fuels in northern ones.

When considering the introduction of geothermal energy as a possible energy source in many countries, it is necessary to stress the importance of initial strong support by the State.

Information exchange and international cooperation should also be underlined as extremely important economic aspects for the development of geothermal energy. The complex nature of this energy source entails a risk of making mistakes. Any money "saving" in this field during the initial period of development (when multidisciplinary "know-how" is not developed enough) results in expensive mistakes and negative effects for the project.

6. CONCLUSIONS

The main characteristic of geothermal energy direct application development during the recent years is that it has been introduced as a commercial energy

source, if riot everywhere, at least in a number of countries. The field of application has been significantly enlarged, particularly for direct applicatious. Desigu of differeut combinations of users is feasible and competitiveness with other energy sources improved in comparizon with the period before.

If the above statement holds true, it should be very easy to draw useful and important conclusions for an accelerated development and a much wider introduction of this euergy source in the world economy. Unfortunately, at least at this stage of development, it is still inore useful to put some questions than to bring final conclusions. We are still far from having a firm grip on this euergy source because:

First: it is known that there is no common technology for geothennal eiiergy application,but a changeable chain of dilfereut combinations of technologies of differeut fields of science and techniques. If wanting to reach economy. each case should be treated separately aud in a multidisciplinary way. In other words, the concentration of knowledge is the most important link in the technical chains for geothermal energy use in any possible field.

Second: it is known aiid confirmed that an international exchange of information and experience is extremely important for tlie establishment of high-level (and own) "know-how" Many international organisations are actively engaged to set up it on a non-commercial basis and tlie most acceptable way for tlie users.

Third: a number of technical advances is realised in all tlie links of the geothermal energy use technology chain, enabling excellent accommodation to the local climatic, ecoriomic aiid social conditions. Unfortunately, that is iiot the economics of a concrete use which only influences the technical solution of the geothermal plant. Technical solutions of the users, marketing of tlie products, etc. influence it too.

And. in how many couiitries the above said is really understood'? If (very rare in necessary size) the State supports the development of geothermal eiiergy introduction in its own economy, does this support relate to all the parts of the total composition of factors influencing the economy of geothermal energy use? How many countries have really defined tlie strategy for the development of geothermal euergy use with the necessary legal, economic and organisational support?

A list of similar questions can be put anywhere in the world. Although there are differences in the treatnient and approach to development of geothermal energy use between countries. in no one all the necessary answers are given. One should iiot be misguided with the rather good situation in some couutries (Italy, Iceland, New Zealand, etc.). They are also faced with serious problem.

As the final conclusion to this paper, it should be underlined that it is already confirmed and proved that geothermal energy can be commercially conipetitive with other energy sources in many locations in the world. It caii be of a strategical importauce for many countries of the world.

6. REFERENCES

(1) Esder, D.: The Studies on the Possibilities of Non-Electrical Uses in Seferihisar Geothermal Field (EP/DSEM.14/R.9);

(2) Kaya. A.: Cooling of Balcova Establishment by Using Geothermal Energy (EPISEM. 14/R. 12);

(3) Ozbek, T.: Interpretation of AnkaraKizilhamam Geothermal Area (EP/SEM. 14/R.15);

(4) Ozbek, T.: Interpretation of Nevsehir-Kozakli Geothermal Area (EP/SEM. 14/R. 16);

(5) Yilmazar, S.: Studies to Define Potential of Balcova Geothermal Field and Down-Hde Exchange Application (EP/SEM.14/R/24);

(6) Spiteri, P.: L'Etude des materieaux pour la centrale geothermique de Bouillante (EPISEM.14/R2.26);

(7) El Golli, S.: Utilization des sources geothermique pour la serriculture en milieuxsemi-aride (EP/SEM.14/R. 17);

(8) Allegrini. G., Cozzani, M.. Sabatelli. F.: Thermodynamical Analysis of the Optimum Exploitation of Water- Dominated Geothennal Field With High Gas Content (EP/SEM.14/R.-35);

(9) Ceppatelli. L.. Fioresi. G.: Experience gained during the Installation and Operation of theNew Standardised Geothermal Units (EP.SEM.14/R.40);

(10) Schneider, H.: Use of Geothermal Resources in the German Democratic Republic (EP/SEM.14/R.41);

(11) Karrai, J.: Automatic Thermal Water Heating with Elimination of Scale Crust (FAOIWS.1IR.l.b.);

(12) Aires Barros, L.A.. Forjaz. V.H.: Economic Impact of Ribeira Grande Geothermal Field on Food and Agriculture of Azores Islands (FAOIWS.1/R.1.c.);

(13) Paskalev. V., Novkovski, T.: Geothermal Energy Exploitation Development and Utilization in SR Macedonia (FAOIWS.1/R.1.d.);

(14) Arenas Cuevas. M.: The Present Situation and Prospects for the Use of Geothermal Energy in the Spanish Agricultural Sector (FAO/WS.1/R.-1.e.);

(15) Segal. I., Rosental. E.: Exploitation of Geothermal Sources for Irrigation and Agricultural Purposes (FAO/ WS.-1/R.-1.g.);

(16) Martzopoulous, G.G.: Geothermal Heating Systems for Greenhouses in Eleochoria (FAOIWS.1IR.l.j.)

(17) Zabeltitz, Chr. von.: Geothermal Energy in the Federal Republic of Germany (FAO/WS.1/R.l.l.);

(18) Campiotti, C.A.. Taggi, R.. Picciurro. G.: Use of Hot Water for Greenhouse Heating (FAO/WS.1/R.111.d.)

(19) Popovski. K.: The Economy of Geothermal Energy Use in Agriculture (FAO/WS.1/R.111.g.)

(20) Duda, M.: The Possibilities of Utilization of Geothermal Energy for Soil Heating of Plastic Houses (WS/C.1/R.5.);

(21) De Murtas, I.: La situation de l'aqua culture thermique en Italie (FAO/C.1/R.6.).