FEASIBILITY OF GEOTHERMAL AGRICULTURAL PROJECTS AT THE BEGINNING OF XXI CENTURY

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SUMMARY

An intensive process of development of new technologies for direct application of low-temperature geothermal fluids in agriculture during the 70s has been significantly slowed during the 80s and nearly stopped during the 90s. However, that was a period long enough for development of a large number of commercially feasible technologies, offering a rather large field of use of low-temperature brines at the end of the previous century.

To plan for the possible development of geothermal projects with direct application in the beginning of this century, a review of the available technologies is made and proposals for their technical and economic consideration for use in different market conditions is presented.

Some of the conclusions have a broad interest. The most important one is that direct application projects are feasible in most of the regions where geothermal energy is available. Even under very stiff competition with fossil fuels, it appears that geothermal energy is going to consolidate its position as the best alternative resource in many regions of the world.

INTRODUCTION

The so called "energy crisis" of late 70s and early 80s showed that it was worthwhile to develop an energy source available just below our feet. This offers the advantage of being independent of the international market of fuels, where powerful countries are playing a game that does not always benefit the small ones with weak economies.

Unfortunately, favorable conditions for geothermal development were too short to enable a real and wide introduction in all possible life sectors where it is available. Today the lowered exploration activities in many developed countries are discouraging development. However, development has not stopped. Slowly and continually, the number of improvements, new uses and new sources are increasing. This is probably the last of the so-called "alternative energy resources" which can be and in many cases is economically competitive with the cheap fossil fuels of today.

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

POSSIBLE USES AND LIMITATIONS

Theoretically, the number of possible uses of geothermal energy is large. Where hot or warm fluids, or steam are required, geothermal water or steam can be used for agricultural production in protected conditions, aquaculture, mushroom growing, heating of dwellings and animal farms, washing, pasteurization, sterilization, etc.

Unfortunately, a number of limitations discourage development:

The first and most important is of an economic nature. Rather high investment costs influence the composition and kind of users for a known resource. 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 large capital investment that is necessary to develop the final project.

The second limitation is the multidisciplinary character of the problem. A rather high level of knowledge of different scientific disciplines is necessary to provide an economic and easy technical solution to development.

The third limitation is the characteristics of the energy resource site, as it controls the location and composition of the users.

The fourth limitation is the need for a high level of organization (i.e., users have little freedom to choose the way and terms of energy use) which is particularly true for small users.

The fifth (and not the least) 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 around the world, but the problems can be resolved.

These limitations are one of the major reasons for the application of very simplified solutions to projects all over the world. They give short-term benefits to the users, but are not always favorable to the long-term development of geothermal energy as a viable energy source. The public remembers an unsuccessful experience more than a positive one.

REAL EXPERIENCE

Without pretending to be complete, the list below illustrates the commercial geothermal experience gained in:

- Electricity production;
- Heat pumps use in combination with different uses of geothermal energy for heating purposes;
- Drying of wood, fish and agriculture products (rice, tobacco, etc.);
- Milk and vegetable processing;
- Paper production and other industrial uses;
- Heating of greenhouses;
- Heating of animal farms;

- Heating of dwellings, hotels, offices, hospitals and other public houses;
- Heating of hot beds;
- Heating of aquaculture farms;
- Hot irrigation;
- Heating of thermal and public swimming pools; and
- Open field heating, heating of streets, parking lots and sidewalks.

Most of the listed uses were known during the previous periods of development, but the difference now is that it is possible to speak about commercial development, and not just research and development.

Not all the problems are solved, but a certain level of technological development has already been achieved. The problem at the moment is that the concentration of knowledge and production possibilities is in a very limited number of countries; unfortunately not always where the geothermal possibilities are abundant and where they are needed. A number of developing countries could derive significant benefits from a wider use of geothermal energy in agriculture, but up to now, the situation was not very satisfactory. The main constraints can be attributed to the lack of knowledge, money, and organizational problems.

TECHNICAL ASPECTS

Heat Exchangers

Probably the most important advances in the use of low-temperature geothermal waters during the recent years are in heat exchangers. They are characterized by a variety of new configurations and materials, closely adapted to the requirements of users. The most common, economical, versatile, and simplest type is the plate heat exchanger.

Greenhouse Heating

Greenhouse heating is among the most interesting and widespread application of geothermal energy as a heat source. Over 300 ha of glasshouses and plastic houses were geothermally heated in Europe in 1986 (Duda), with a continuous increase by tens of hectares each year. That is somewhat surprising, because it is a rather poor heat consumer when considering the annual heat load factor. The explanation lies probably in the possibility to install the projects near the geothermal sources, without disturbing the organization of the production and marketing of the products.

The large introduction of cheap plastic materials for the distribution of geothermal brines and heat exchangers is the most significant development of the last ten years for this particular energy use. Thus, direct use is possible, as the corrosion problem is eliminated, which is very convenient for small artesian wells; and where it is difficult to justify the installation of expensive equipment and materials such as for heat exchangers, etc.

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

Soil heaters: Usually made of smooth or corrugated plastic pipes (Figure 1), located 30-50 cm below the ground level for cultivation in soil or directly in the concrete floor for soil-less or cultivation in pots. It is convenient for a rather low-temperature heating medium and for base heating. The large inertia of the soil material will not allow a precise regulation to follow the changes of outside climate. However, it is a good energy-saving technique, having a large influence on plant development, but it cannot be taken as a unique system to cover the total heat demands, particularly in cold climates.

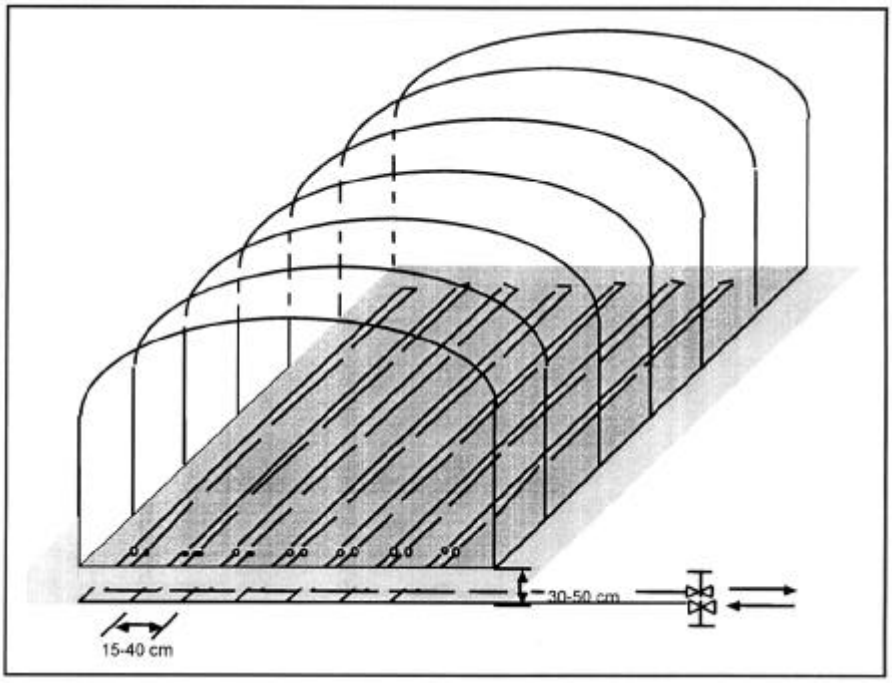

Figure 1. Soil heating installation for greenhouses.

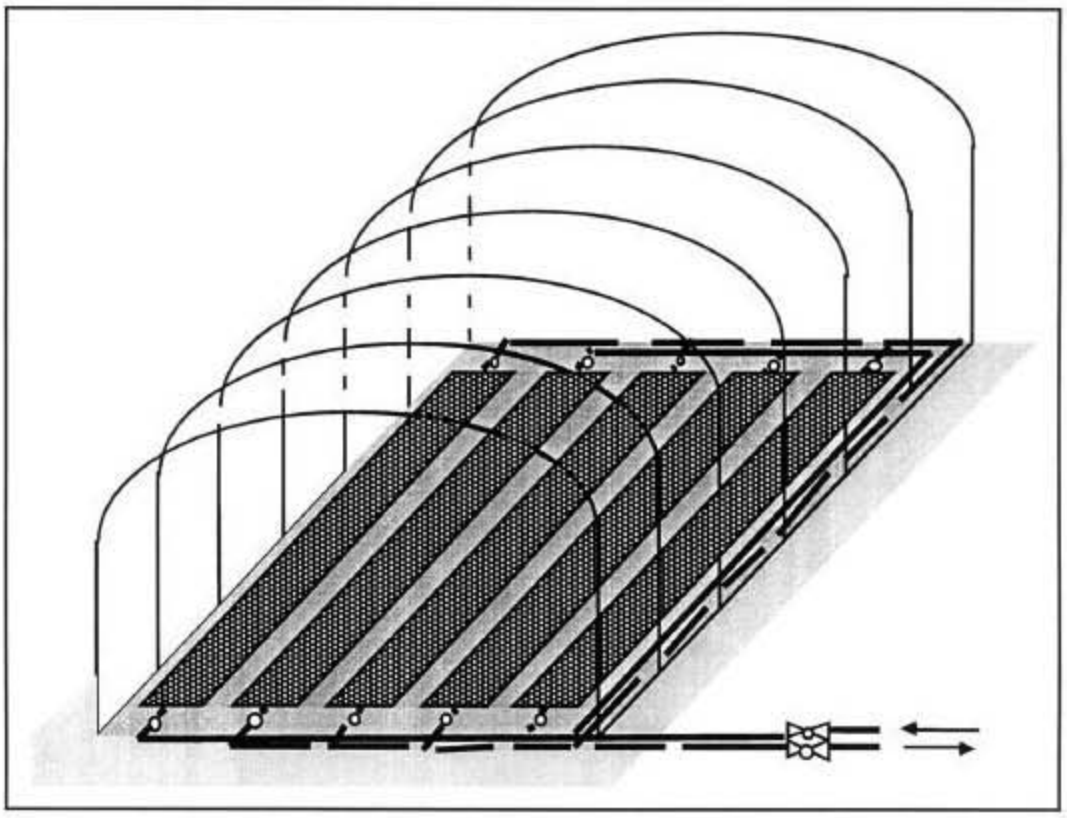

Figure 2. Heating installations laid on the ground.

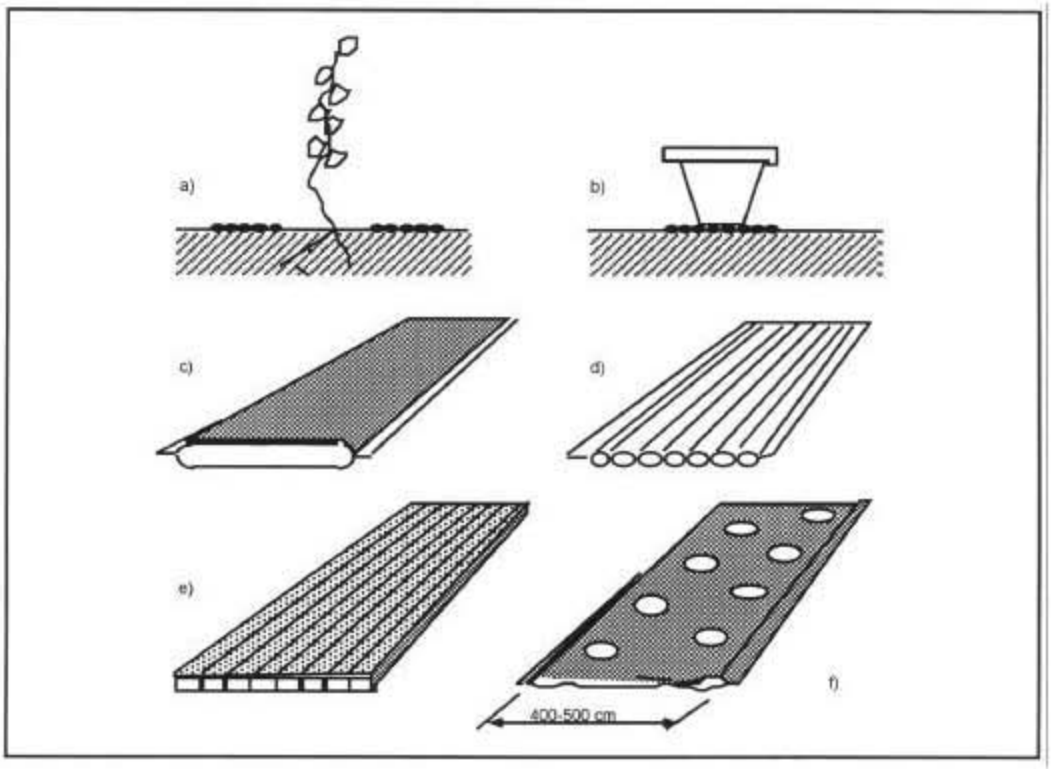

Figure 3. Different heat exchangers for ground surface heating installations.

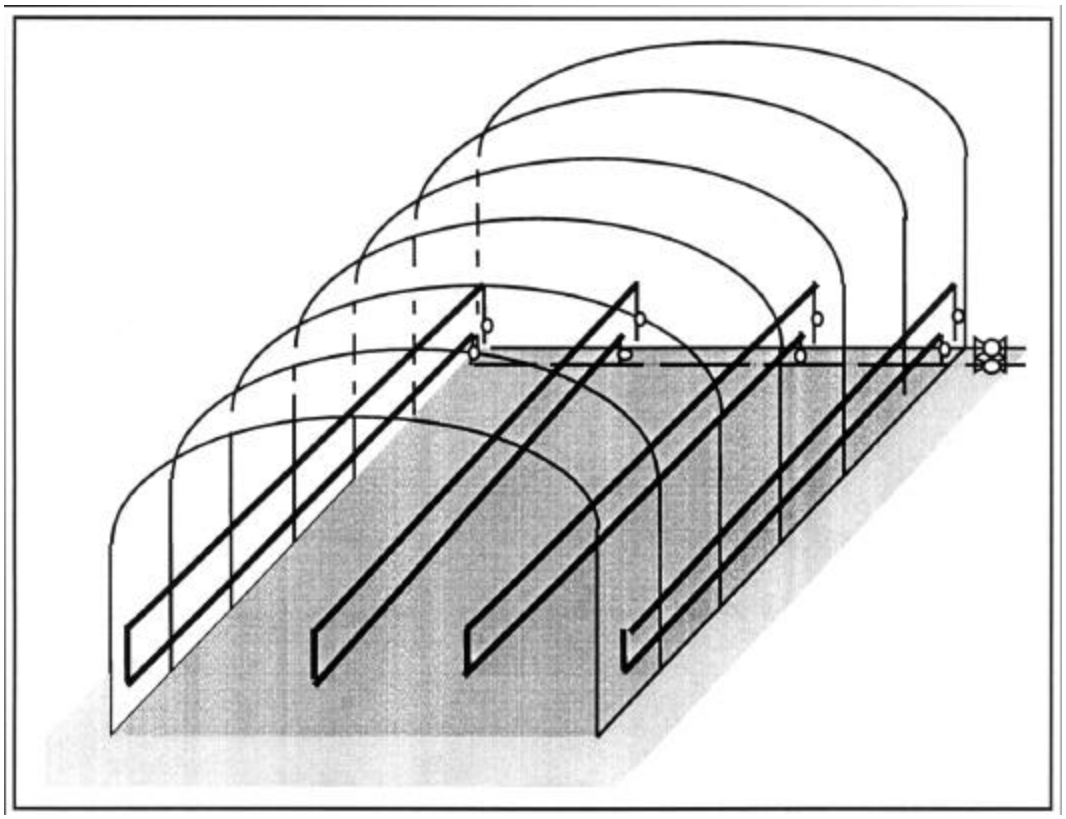

Figure 4. Free convection pipe heating installation.

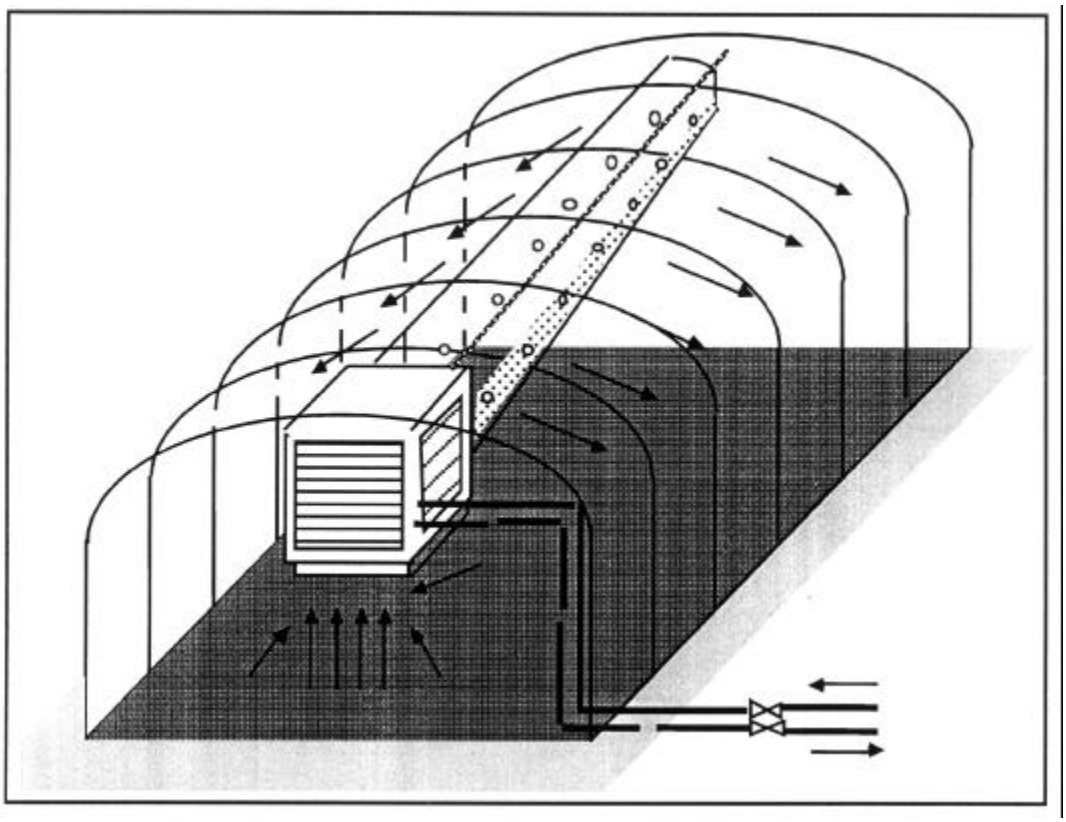

Figure 5. Fan-jet heating installation.

On-the-soil-heaters: They play two roles: to heat at the same time the soil and the air in the greenhouse (Figure 2). Excellent influence on the inside climate and production results in combination with low price; easy and simple installation, making this type of heating the most popular in Mediterranean countries in recent years. Mainly thin-pipe heating and large-plastic tube heating is widely used, as also are plate-type heat exchangers (Figure 3)(El Golli).

Free convective air heaters: This is generally the oldest type of heating installations for greenhouses, with the difference that for low-temperatures new finned pipes and special profiled aluminum pipes have been introduced (Figure 4). New experiments have improved the characteristics of heating elements in greenhouses. In addition, many good references are available (Popovski; and De Murtas). High investment costs hamper their wide spread use in countries with mild climates. In the central European, this type of installation is in wide use (Karrai: Popovski; and De Murtas).

Convective air heaters with forced air movement: the classical "fan-jet" system (Figure 5) is still in wide use, although the negative side is poor temperature distribution in the heated space. Using warm air distribution tubes solves this problem. New convector units ("hortitherm") along the sides of the greenhouses (Figure 6) are very promising. Excellent results are achieved even with a very low temperature roof heating source (Figure 7). Positive and negative sides of the various types of heating installations are the reason for using them in combinations depending on the types and placement of crops.

Heating of Animal Farms

Surprisingly enough, farm heating with geothermal energy is experienced only in two countries (Hungary and Serbia). Simple air heating installations are reliable and are often combined with greenhouse's heating (Figure 8). The relatively small demand explains probably why this type of use is not common in other countries.

Aquaculture

Some aquaculture plants heated with geothermal energy have been already tested in geothermally developed countries. The best known are the simple technical solutions in Hungary and Bulgaria (already at commercial stage).

The technical characteristics of these installations show that this type of use can be the last step in geothermal cascading, thus reducing the thermal pollution of the

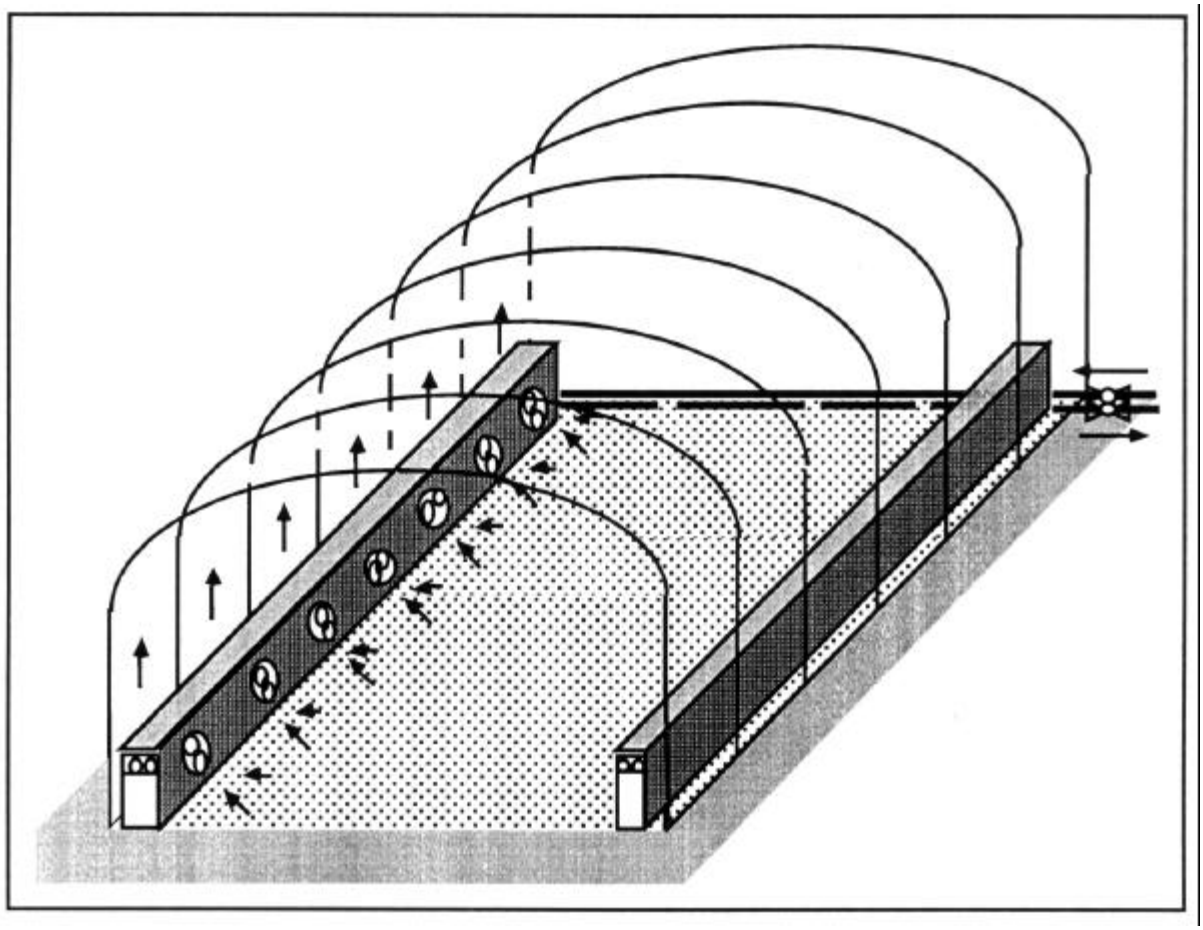

Figure 6. Hortitherm heating system.

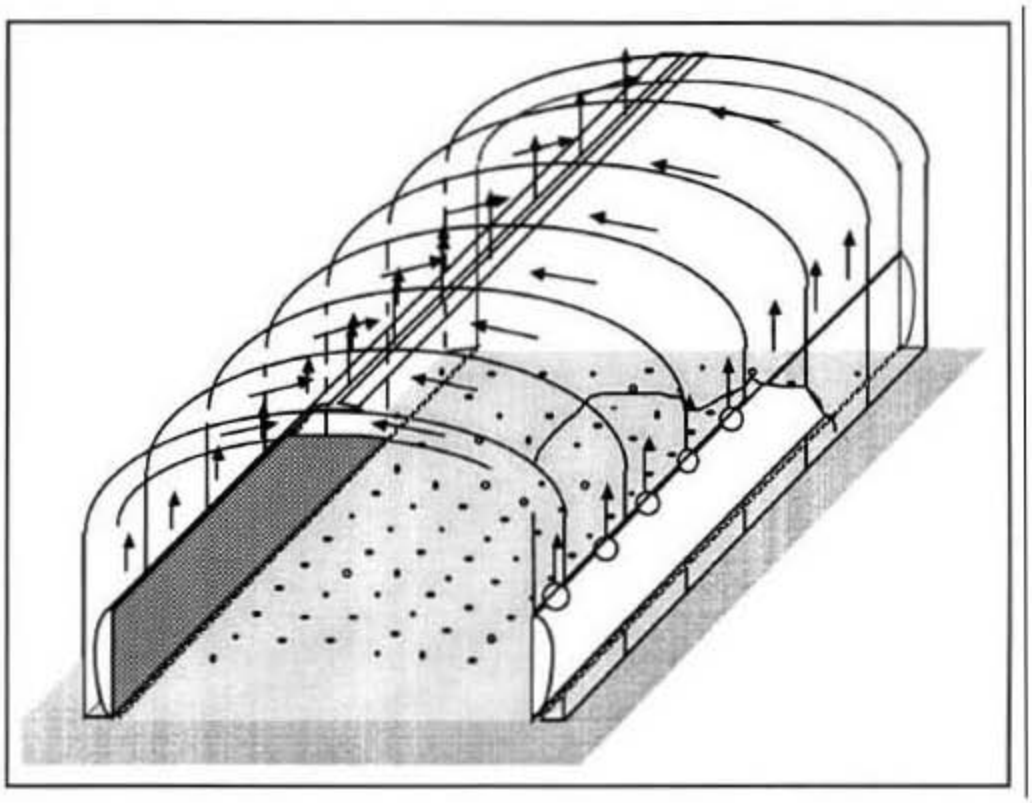

Figure 7. Low-temperature roof heating system.

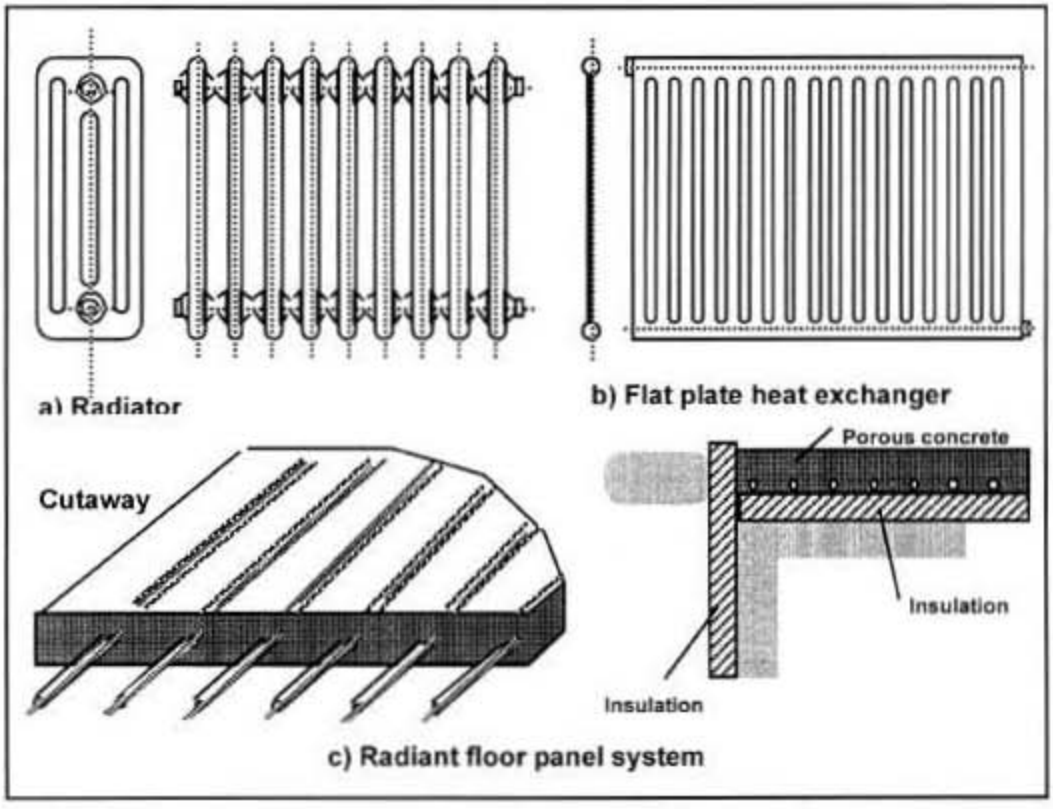

Figure 8. Elements of room heating installations for animal farms.

environment. Simple, very often hand-made heat exchangers placed in the ponds are the "heart" of the installations, offering easy exploitation and quick return on investments.

Irrigation

Two types of irrigation are of interest. One is so called "hot irrigation" for plants cultivated in protected conditions, the second is the normal irrigation in dry areas (El Golli). For the latter use, additional measures should be taken to cool the water to the proper temperature (by greenhouse heating, special cooling towers, etc.).

The Ministry of Agriculture in Tunisia, using simple corrugated plastic pipes hanging in series has developed an interesting and effective technical solution.

Other Agricultural Applications of Geothermal Energy

The 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 the food processing industry, but there is still no technical data, except for drying of agricultural products (rice, tobacco, etc.) (Figure 9) and the paper industry.

ECONOMIC ASPECTS

The changeable situation of the fuel market and of the world economy during 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 10 years ago. In spite of this, geothermal use has survived and continues to contribute to the energy mix. Depending on the composition of energy users, the nature of the geothermal source locally, the climate, technical, economic and social conditions; two types of development approaches gave positive economic results during the recent years. These are:

- The orientation towards a greater simplification of all the elements of a geothermal plant and the use of cheaper plastic materials. Users estimate the optimal inside climatic condition better and, this is more significant than other technical improvements. As a result, investment costs are minimized and the economics even favors poor managers.

  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. Principally, the task is not the total conditioning of the inside climate of the greenhouse, but its optimization. Excellent results are reported in Tunisia, Greece, Spain and Israel.

- 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 minimizing their influence on the price of used heat (Figure 10). Peak load can be covered by reject heat users (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 for a very high level of multi-disciplinary knowledge, centralized management, and resource development, which can be very difficult to be obtained in most of the developing countries. The influence of stable market conditions should not be minimized in relation to the risk for high investment costs. A stable market can be difficult for developing countries.

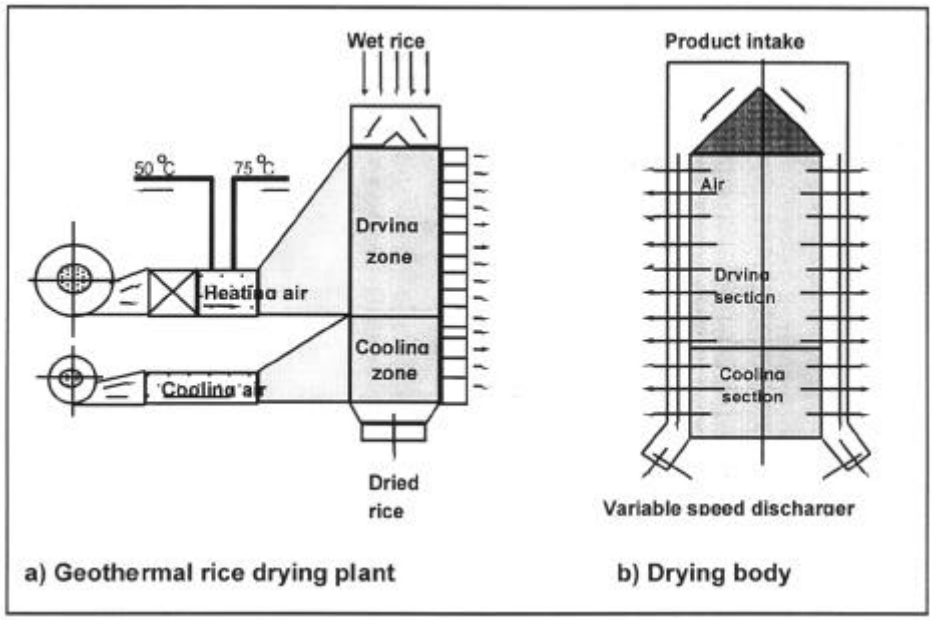

Figure 9. Geothermal rice drying plant in Macedonia.

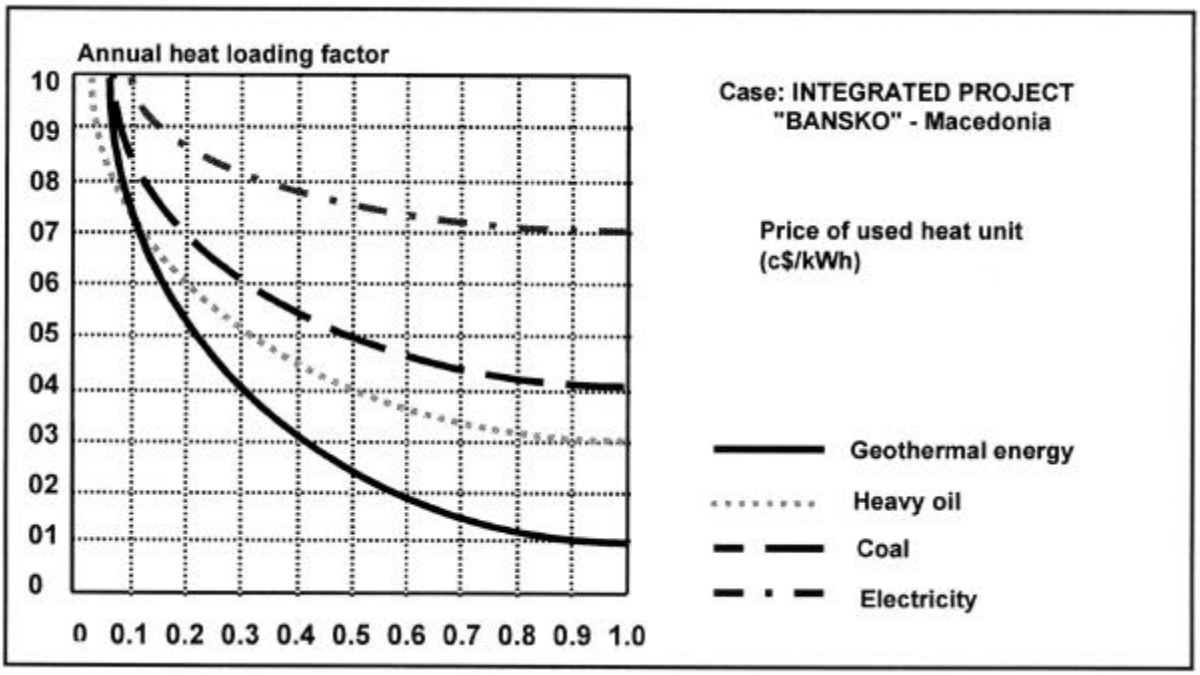

Figure 10. Changes of the used heat price depending on the annual heat loading factor.

During the last 10 years, a combined approach became predominant (i.e., the use of simple elements) where possible and justified (in order to minimize the investment costs) but also combinations of heat users in order to lower the price of the energy. That was made possible by the introduction of high productive technologies in the greenhouses of southern countries, which enabled repayment 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 initially obtaining strong support from 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 their 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 available) may results in expensive mistakes and negative impacts on the project.

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 not every-where, at least in a number of countries. The field of appli-cation has been significantly enlarged, particularly for direct applications. Design of different combinations of users is feasible and has improved the competitive with other energy sources improved in comparison 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 energy source in the world economy. Unfortunately, at least at this stage of development, it is still more useful to ask questions than to provide conclusions. We are still far from having a firm grip on this energy source because:

First: it is known that there is no common technology for geothermal energy application as each case is unique. If economy is desired, each case should be treated separately and in a multi-disciplinary 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 and confirmed that an international exchange of information and experience is extremely important for the establishment of high-level (and local) "know-how." Many international organiza-tions are actively engaged in providing technical assistance.

Third: a number of technical advances are available for all the links of the geothermal energy use technology chain, providing excellent accommodations to the local climatic, economic and social conditions.

In how many countries is the above really understood? If the State supports the development of geothermal energy in its own economy, does this support relate to all the parts of the total factors influencing the economy of geothermal energy use? How many countries

have really defined the strategy for the development of geothermal energy use with the necessary legal, economic and organizational support?

A list of similar questions can be put anywhere in the world. Although there are differences in the treatment and approach to development of geothermal energy use between countries, in no one are all the answers available. One should not be misguided with the rather good situation in some countries (Italy, Iceland, New Zealand, etc.). They are also faced with serious problems.

As the final conclusion, it should be underlined that it is already confirmed and proved that geothermal energy can be commercially competitive with other energy sources in many locations in the world. It can be of a strategic importance for many countries of the world.

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