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GEOTHERMAL ENERGY AS SUSTAINABLE ENERGY RESOURCE IN AGRICULTURE

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ABSTRACT

Geothermal energy resources are largely distributed in Europe and in the Mediterranean basin. They are utilized in electricity generation and in some direct-uses in agriculture, of which the most important one is represented by the greenhouse heating sector. According to the nowadays EU policies on environmental control and renewable energy as well, the potential market of geo-thermal energy as sustainable heat production could attract attention for commercial applications in agriculture. At present, a number of financial opportunities exist in the European programmes concerning the promotion of indigenous and local energy resources for productive applications in rural and isolated agricultural communities. The new EU objectives and the Agricultural Policy (CAP) include actions in favour of Member and non Member States, and this strongly increases the role and prospects to which geothermal energy resources could aspire given their high existing potential in Western, Central and Eastern countries of Europe and in the Mediterranean Basin.

1. INTRODUCTION

Over recent years, a number of CEE directives on the environmental protection and minimization of emissions to tackle the Climate Change Issue across industrialized countries, have lead to a recognised new interest on renewable resources as fundamental elements for developing their use at regional and local level.

At this purpose, the EC (European Commission) has launched a general policy addressed to reduce the emissions of CO_2 and other pollutants as NOx and SOx (which are emitted in smaller or greater amounts from fossil fuels). Thus, it has been adopted a negotiating position of 15% greenhouse gas emissions reduction target for industrialized countries by the year 2010 from the 1990 level. To meet this challenge, the 1997 EC-White Paper on energy policy includes a target of 12% for renewable energy's supply in the Community's energy mix by 2010, compared to its current level of less than 6% (EC-White Paper 1997).

In this context, it should also be envisaged the potential contribute of geothermal energy, which, while not strictly considered renewable, fits the criteria of a non – GHG such are: CO_2 N_2O (nitrous oxide), CH_4 (methane), HFC_S (hydrofluorocarbons), PFC (perfluorocarbons) and SF_6 (sulphur hexafluoride), emitting and decentralized resource either as energy for electricity production or as geothermal heat for direct uses (Devin and Dessus, 1991). Table 1 reports the general data on CO_2 emissions from different energies.

According to 1996's OECD figure, renewable energy in terms of total primary energy supply accounts in the IEA (International Energy Agency) countries for 178.3 Mtoe (million tonnes of oil equivalent) of which 32.1 by geothermal energy (IEA, 1996). However, the pattern of direct heat utilization from geothermal sources across the world is reported to be of about 4600 MWt with a thermal energy production equivalent to about 1.6 Mtoe for space heating, greenhouses, balneology and industry which represents about 11% of the total world thermal capacity installed and energy (EC-Blue Book on Geothermal Energy, 1998).

Of this thermal energy application, the direct energy consumption in the agricultural sector as a proportion of national energy consumption varies from 2-6% and the specifically the overall fuel greenhouse consumption for heating and cooling in the EU accounts for not more than 2% of Europe's total energy budget (Fabry and Williams, 1989; von Zabeltitz; Kocsis, 1990). Although influential factors on the energy price in agriculture vary from country to country, we can say that averagely the cost of the heat energy represents about 30% of the overall operational cost of a greenhouse, which most often has proved prohibitive, not permitting to growers the use of heating systems with negative impacts on the quality, quantity and cultivation time of the plant products (Campiotti, 1988, Segal, 1989).

Consequently, it would be reasonable to support the choice of geothermal energy as heat for greenhouses according to a general policy which privilege the advantages of this natural and clean energy in respect to the quality of the environment since geothermal heating could effectively contribute to the control of sulphur and nitrogen emission by reducing the fuel consumption of traditional greenhouse heating installations.

Furthermore, according to its lower emissions of carbon dioxide and of energy saving aspects, the geothermal energy use can becomes more competitive if the financial evaluation takes also account of other factors such as the "shadow costs" and the so-called "externalities", which greatly improve its economic value (Brown, 1995; EC-Blue Book on Geothermal Energy, 1998).

2. APPLICATION OF GEOTHERMAL ENERGY IN AGRICULTURE

It is generally medium-to-low temperature geothermal fluids (T<150°C) that can be successfully exploited in direct heat uses in agriculture, e.g.: greenhouses and aquaculture applications, plant drying), while high enthalpy geothermal fluids (T>150°C) are utilized to produce electric energy (Barbier, 1997; Dickson and Fanelli, 1997). However, although geothermal resources are rather widely distributed in the Mediterranean basin, it has been estimated very few commercial geothermal factories in operation in the Mediterranean regions (mainly in Italy, Greece, France) and in the central and eastern European countries (mainly in Hungary, Romania, ex-Yugoslavian Republics).

The application of geothermal energy in agriculture throughout the world is very limited and even the most common application as heat energy in greenhouse heating, however, accounts only for less than 700 hectares in the world. USA, China, Hungary, Italy, France, Iceland, New Zealand, Greece represent the countries with the most important installations of geothermal greenhouse plants. For the other Mediterranean regions (specifically those situated along the northern areas of the African continent), only for Tunisia, Israel and Turkey it has been reported of some commercial activities aimed at using this resource as water for thermal irrigation and as heat for greenhouse heating (Popovski and Campiotti, 1990). At this purpose it should be outlined that the European agricultural sector provides employment for 14 million people and on the CAP accounts for almost 50% of the Community budget. As regards use of the land and countryside, European farmers directly manage and maintain 44% of European land as utilized area. However, agriculture is overall responsible for 8% of greenhouse gas emissions while the technology introduction and the production-oriented logic which have characterized the sector of European agriculture, meanly in the EU, has led to an increase in the volume of traditional energy inputs used per hectare and a raising concern regarding the environ-mental impact associated with the application of technologies with high traditional energy demand.

From general data, European countries utilize about 18,000 GWh/y (1,6 Mtoe) of geothermal energy for direct uses of which greenhouse heating and aquaculture represent only a percentage of 14% and 11%, respectively (data from: Kocsis, 1989; EC-Blue Book on geothermal energy, 1997). Nevertheless, in the light of the new EU policy on energy and environment, the geothermal energy could play a significant role in contributing to develop local and regional power supply and to reduce energy and carbon intensity and hence CO2 emissions. Particularly, the use of the geothermal resources appears to be particularly suitable for rural areas which are an important part of the EU's regional policy instruments, the Structural Fund, and are included in specific, territorially regional objectives in most countries of the Mediterranean basin. As such, the market for direct uses of geothermal heat in agriculture and rural areas presents a great opportunity to develop either traditional agribusiness (horticultural geothermal greenhouses and/or aquaculture) or new applications, e.g.: thermal irrigation, production of algae, herbs and medicinal plants by thermal hydroponics (Verlodt H., Hady-Ali A., 1990; Dickson and Fanelli, 1997; Fournadzieva et al., 1999). Table 2 reports data on current and future heat production from renewables.

3. GEOTHERMAL HEAT FOR GREENHOUSE HEATING

It was estimated that the area covered by greenhouses (glasshouses and plastic houses) in 1990 resulted to about 25,000 ha in Europe and to about 50,000 ha in the Mediterranean basin (Campiotti et al., 1990). To keep a greenhouse inside temperatures from 15 to 24°C data from experimental investigations have shown that in South Europe 5-12 litres of fuel are needed per year to heat 1 m^2 of greenhouse area compared to the 60-80 litres of fuels which are required in North Europe (von Zabeltitz, 1989).

These plant systems are high energy demanding, and contribute in a large amount to the energy consumption of the agricultural sector (only for greenhouses, 0.7 MM TEP in France and 0.4 MM TEP in Italy). As such, the geothermal water at low-temperature is compatible with a wide range of heating system designs including forced-air distribution systems employing water-to-air heat exchangers, hot water radiator systems as plastic pipes and finned tubes, liquid-based radiant heat in the floor, bench-mounted-liquid based radiant heat, and direct soil heating. The geothermal heating can be classified into the following groups:

- *Soil heater*, made with smooth or corrugated plastic pipes buried in ground or in concrete. This system has a limited use for some flower species (gerbera, roses) and it has shown to be unable to cover the total heat requirements of a greenhouse, even in the mild climatic conditions typical of Mediterranean regions (it has seen that its heat flux to the ground surface results rather low with values from 10 to 40 W/m^2.
- *On-the-soil-heater*, systems made with smooth and/or corrugated plastic pipes directly laid on the ground and/or on benches. This technique permits partial soil temperature control and convenient vertical and horizontal air temperature distribution. It has practically shown to be able to produce an average heat energy ranging from 30 to 70 W/m^2 (plastic tubes with diameters ranging from 15 to 25 mm).
- *Free convective air heater*, systems made of steel finned pipes and new aluminium pipes installed at different levels above the ground (or bench) surface. This system effectively controls greenhouse air climate, even in sharp climates.
- *Convective air heater with forced air movement or fan-assisted convector*, which blow warm air through perforated plastic ducts. They provide a fast response to changes in outside climate and can cover even very large heat demands.

The advantages and disadvantages of these heating systems have been investigated by several experimentations, with a wide collection of data and results. There are roughly 20 different sub-types of the above four types of installation now in use, which gives an indication of the range of requirements, and of the different technical, technological and economic solution available (Rafferty, 1986; Dvoskin, 1988; Popovski, 1988; Campiotti and Picciurro, 1988, Baille, 1989; von Elsner, 1989; Segal et al., 1989). As general statement, we distinguish three approaches as geothermal greenhouse heating:

- *simple* installations, made of cheap plastic materials (polyethylene or polybutylene) with installations directly connected to the heat resource which has the main scope to increase indoor temperature during short, cold periods;
- *sophisticated*, solutions that can cover intensive production requirements in specialized greenhouses adapted for high

quality plant productions even for geographical areas characterized by severe climatic conditions;

- *in-between solutions*, that comply with costs, grower's experience and market.

Although the use of geothermal energy in greenhouse industry gives the chance to drastically reduce the annual fuel costs and consequently improve the profit margins, it should not be neglected the risks which may hindered the decision to utilize such heat resource in place of conventional energy forms. At this purpose, within the most important factors which influence the competitiveness of geothermal plant greenhouses are the following ones:

- The distance between the resource and the plant greenhouse must be as small as possible to reduce the costs of pipelines and avoid lost of temperature.
- The greenhouse plant should be designed sufficiently large and technologically adapted for plant productions to reduce the investments and to guarantee a long enough lifetime to pay back the initial high investment.
- The short-term applications makes geothermal energy application uneconomical because to achieve real benefits it must be used over a long period of the year and should be addressed to cover *base heat requirement* of the greenhouse energy load while *peek heat demand* should be meet with conventional heat technologies.
- The pay-back period for covering investment costs is strongly influenced by the type of the heating system solution which, however, depends on the greenhouse technology level, the local climate, the dimension of the greenhouse.
- The timing, the agro-techniques and the biological characteristics of the crops are of primary importance to achieve economical benefits with geothermal greenhouse.
- To achieve appreciable savings as well as an optimal utilization factor, it should be adopted an *integrated* scheme and/or a *cascade* heat system to simplify and to optimise the heat use from geothermal sources.

Last, it should be outlined the application of heat pumps for extracting energy from very low temperature resources (<20°C) and the managing option to integrate more energy users to decrease the price of used heat (Panichi, 1983; Campiotti et al., 1990). Both these solutions can make more attractive and competitive the exploitation of the geothermal energy in agriculture.

4. THE GEOTHERMAL ENERGY POLICY IN THE EU-AGRICULTURE

Over the past years, the EC has given economical support to a number of demonstration projects on geothermal energy use in agriculture and rural areas, and specifically for developing geothermal greenhouse plants. Recently, the EU strategies have assigned a great importance to the issues which deal with the environmental protection and control of chemical emissions (outlined by the Conferences held in Rio in 1991 and Kyoto in 1997). In this context of the EC-Sixt Framework Programme, the agriculture sector is considered a *key sector* for increasing the share of renewable energy sources with specific attention to the development of sustainable applications in agriculture and in rural areas.

Through the CAP, the rural development policy could support a number of initiatives in favour of local and natural energies environmentally friendly as could be the use of geothermal water at low temperature in rural and agricultural communities. However, there is a wide spectrum of opportunities among the other european energy actions, with specific reference to those included in the programme "Intelligent Energy for Europe "2003-2006. With this new energy action programme, the EU implements the strategy and the priorities already developed by the White Paper (1997) and by the Green Paper (2000) in the fields of sustainable technology, renewables and energy saving (Tables 3 and 4).

5. CONCLUSIONS

When considering the development of geothermal resources in rural areas and agriculture, it is important to outline that from a strict economic point of view, its use certainly is still not market competitive with conventional energy technologies, but due to the characteristics of the geothermal resource as local, decentralized and usable energy it can play a specific role in areas and regions not yet connected to modern energy supplies and distribution networks and with scarcity of fossil resources. Aware of these factors, the European Commission is promoting a number of programme in favour of renewables for rural areas and agriculture for meeting the objectives referring to the CO_2 emission reduction and to the energy saving and conservation energy policy at local, regional and national level. Therefore, the immediate future of geothermal energy for agribusiness consists on outlining its advantages as environmental friendly energy and linking its application to low-cost and soft technologies and only when both resource and demand are coincident. According to the current EU policy on both renewable energy and environmental protection, the geothermal resource is fully consistent with most scenarios of social and economic development inside and outside of its territory and this will continue over the coming decades.

Table 1–Carbon dioxide emission from district heating systems using different low-temperatureresources

ENERGY SOURCE	*Kg of CO_2/MWh*
Coal	310
Oil	250
Natural gas	176
Geothermal	ca. 0

Source: Blue Book on Geothermal Resources

Table 2 – Current and projected heat production (Mtoe) for 2010 from renewables

TYPE OF ENERGY	*ACTUAL IN 1995*	*PROJECTED BY 2010*
Biomass	38.04	75
Geothermal	0.4	1
Solar thermal collectors	0.26	4
TOTAL RENEWABLE ENERGIES	38.07	80
Passive solar	-	35

Source: White Paper for a Community Strategy and Action Plan - 1997

Table 3 – The new EC programme "Intelligent Energy for Europe"

€million	*2003*	*2004*	*2005*	*2006*	*TOTAL*
SAVE	21	18	18	18	75
ALTENER	23	21	21	21	86
STEER	4	11	9	11	35
COOPENER	2	5	7	5	19
TOTAL	50	55	55	55	215

Source: Directorate General for Energy and Transport, 2002.

Table 4 – European Commission Programmes for Energy

1998-2002	2003-2006
ENERGY	Intelligent Energy for Europe
ETAP: monitor markets and support studies.	ALTENER: new and renewable energies and diversification of energy production.
SINERGY: international energy cooperation.	SAVE: rational use of energy and demand management.
CARNOT: clean solid fuels technologies.	COOPENER: international promotion of renewables and energy efficiency.
SURE: cooperationin the nuclear sector.	STEER: energy aspects of transport.
ALTENER: promotion of renewables.	
SAVE: promotion of energy efficiency.	
OVERALL BUDGET: 175 millions €	OVERAL BUDGET: 215 millions €

Source: Directorate General for Energy and Transport, 2002.

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