DEMONSTRATION GEOTHERMAL PROJECT AT RIBEIRA GRANDE (AZORES, PORTUGAL)

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INTRODUCTION

The Azores Islands consist of nine volcanic islands in the middle of the Atlantic Ocean. Two of them are placed on the American Plate and others are aligned along a northwest-southwest tensional axis which runs from the mid-Atlantic ridge to Gibraltar after a directional change close to S. Miguel island. The youthfulness of the Azores archipelago makes it an attractive target for geothermal exploration and development. Of the discharging wells in operation, the liquid portion, are about 70-80% of the superheated geothermal fluid. Each 10-in. diameter borehole is able to produce 100-200 tons of fluid per hour. The amount of power which is available for direct heat uses is in the order of 9-19 MW per well. Up to now, only geothermal electricity production has been introduced. There are no direct application experiences on the islands.

Effluent water, from one of the existing power plants is 90°C (194°F) and flow of 8 L/s (127 gpm). The geothermal fluid is slightly aggressive and has a tendency to scale. The scaling problem is more characteristical at higher temperatures of the fluid (i.e., in the part used in the power production plant). The sustained heat potential of this energy source can be estimated for the temperature difference 90/25°C (194/77°F), which is technically feasible for many direct uses.

Since the islands are completely on the import of agricultural products from the continent and with the possibility to develop their own production based on the "free" geothermal energy, a demonstration project was proposed by INOVA- The Institute for Technological Innovation of Azores from Ponta Delgada in 1992. The proposal was accepted and financed by the EC Programme THERMIE of the DG-XVII and the Regional Government of Azores. It was completed in June 1997 and now measurements and investigations are being undertaken.

PROJECT COMPOSITION

The project consists of six (192 sq. m) + one (nursery of 96 sq. m) "family size" geothermally heated greenhouses for cultivation of the typically local crops, such as pineapple. Smooth Cayenne, Cape Gooseberry (Physalis Peruviana L) and melon, grown in different substrates of local origin ("bagacina," pumice and a locally made compost) and have fully automatic control of the inside greenhouse climatic condition (Figure 1), such as:

- One of the greenhouses is for growing gooseberry in local substrates, bagacina and pumice (6);
- Two of the greenhouses are for growing pineapples in locally composed substrates (4 & 5);
- One of the greenhouses is for growing melon in local substrate (bagacina)(3);
- One nursery with "virus-" and "insect-free" conditions for rooting the stocks and young plants in preparation for planting (7);
- Mini micro-propagation laboratory for pineapple and Cape-Gooseberry crops;
- Cold store for plant stocks, young plants and post-harvesting treatment;
- Store rooms for raw materials and spare parts, geothermal distribution station; and
- Working area.

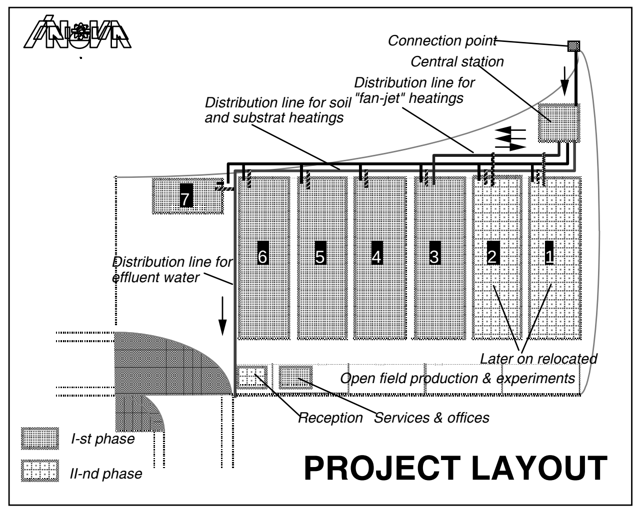

Figure 1. Planned project layout.

The second phase will consist of two additional greenhouses of 192 sq. m, for other cultures of interest for the Azorean agriculture development.

GREENHOUSES

The greenhouses are of rigid plastic covered construction of 8 x 24 m (26 x 79 ft), with foundations and design made of accommodated the local wind conditions. Both roof and side ventilation are provided (Figures 2 and 3) in order to provide strong ventilation of the greenhouses' interior, needed because of the small difference between the inside and outside air humidity.

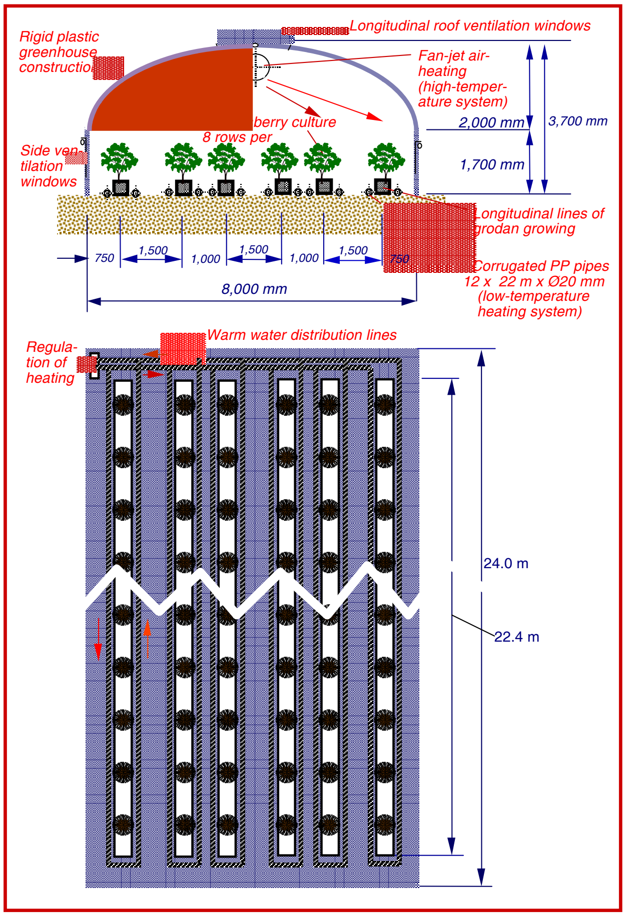

Figure 2. **Greenhouse for growing of cape-gooseberry culture.**

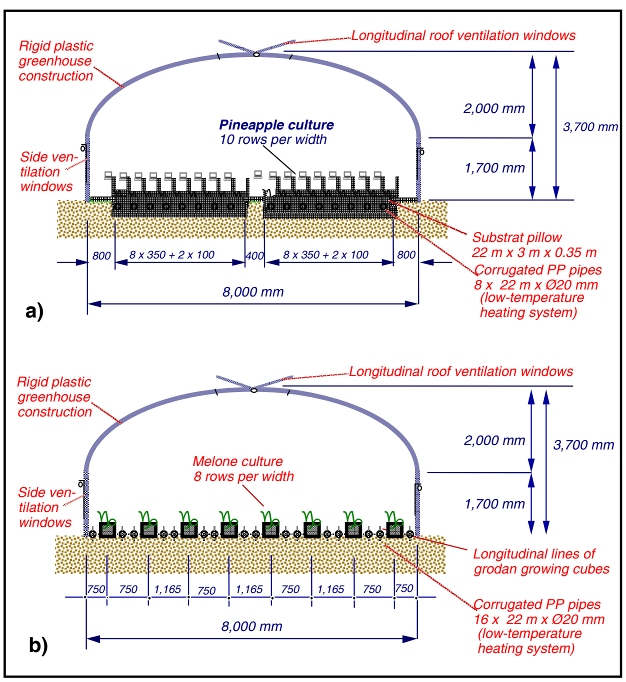

Figure 3. **Greenhouses for pineapple and melon cultures.**

PRODUCTION TECHNOLOGIES

As mentioned earlier, cultures are grown in local substrates or rockwool cubes (i.e., with so-called "soil-less" growing technologies [hydroponics]). That's allows full control of the irrigation and fertilization of the plants. Distribution of the growing rows for different cultures is presented in Figures 2 (Cape-Gooseberry) and 3 (pineapples and melons). Each plant row is equipped with a drip irrigation line, which enable programmed irrigation of every piece of the plant separately. Composition of the fert-irrigation solution and irrigation of the plants is programmed and performed by means of a computerized fert-irrigation unit, placed in the central station of the project.

GEOTHERMAL ENERGY RESOURCE

The effluent water of the power plant is pumped through a line made of concrete pipes which passes through the west part of the site. For peak heating (for the external design temperature conditions), about 3 L/s (48 gpm) of water is necessary for the project; however, the real flow is variable and depends on the combination of the external air temperature and intensity of solar radiation.

The regulation of the flow rate of the heating water is controlled by means of the central regulation station (Figure 4) and by local ones located in each one of the greenhouses (Figure 5). "Fan-jet" heaters are supplied directly (i.e., with water temperatures of 90ºC (194ºF), and the low-temperature heating systems with 35-40ºC (95-104ºF)by means of mixing the return (25-30ºC)(77-86ºF) with the fresh geothermal water (90ºC)(194ºF). Depending on the differences of internal temperature changes in each one of the greenhouses, an "on/off" temperature control provides for the programmed (different) internal temperatures (Figure 5). The low-temperature heating systems are set for so-called "base heating" (i.e., to work more or less continuously, with "fan-jet" heatings for "peak loadings" (i.e., below certain external air temperatures), when the first ones cannot cover the heat energy requirements of the greenhouses. In such a way, a better annual heating loading factor is reached (i.e., more or less equalized use of the available flow rate of the geothermal water). That opens the possibilities to introduce new energy users with different heat requirements and more intensive use of the available heat.

HEATING SYSTEMS

The heating systems are adjusted to the technological and temperature requirements of the cultures in greenhouses. For instance, pineapples requires stagnant air and control of the root temperature. Therefore, only the low-temperature substrate heating system is installed, made of corrugated plastic pipes 32 mm in diameter, located below the roots (Figure 3a).

The Cape-Gooseberry culture requires controlled temperatures of the air and roots, and prefers a slight vertical streaming of the warm air along the plants. Therefore, the so-called " "vegetative" heating system made of corrugated plastic pipes is installed along the plant rows. Taking into account

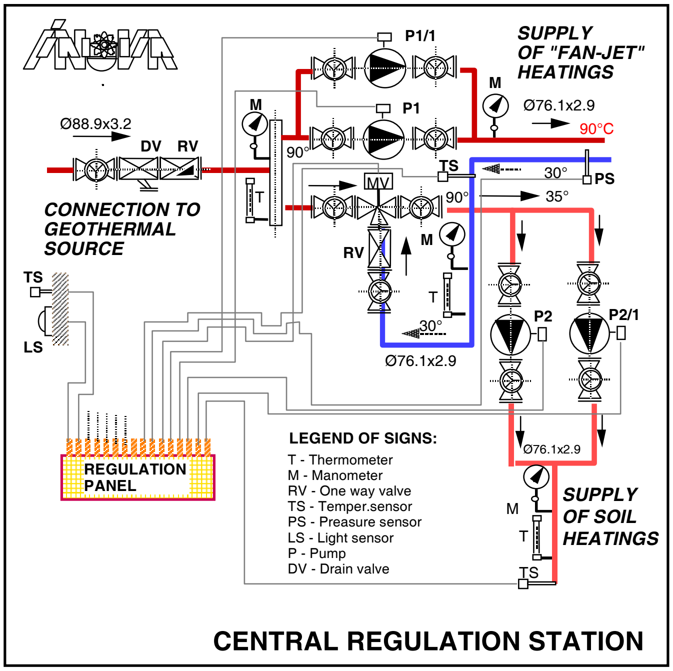

Figure 4. Central control station.

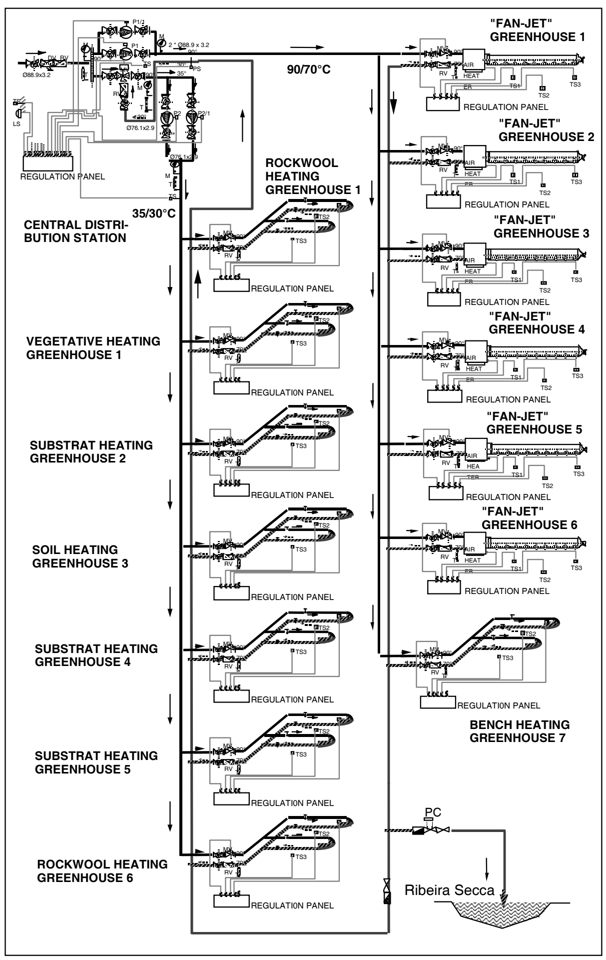

Figure 5. Geothermal water and control system.

that their heating requirements are larger than the ones which can be supplied by this system, an additional "fan-jet" air heating system is installed in order to cover the peak loadings, when external air temperature drops below minimum (Figure 2). Finally, the melon culture requires control of the soil and lower parts of the air temperature in the greenhouse. Therefore, again the "vegetative" heating system made of corrugated plastic pipes (32 mm) is installed (Figure 3b), positioned along the plant rows.

Total installed heat capacity of the systems is 52 kW (for the substrate, rockwool and bench heatings) + 120 kW (for the "fan-jet" heatings) = 172 kW.

BENEFITS OF THE USE OF GEOTHERMAL WATER

The main task of this demonstration project is to illustrate future benefits for producers of growing vegetables and fruits in the Azores. They can be summarized as follows:

- Protected crop cultivation enables control of the climate and other influencing factors for plant development. In that way, much higher productivity and quality of fruits can be obtained;
- Protect crop cultivation enables protection of the crops from external climate factors, such as the heavy rains, strong winds, etc., which are characteristic of the Azorean climate and makes it very inconvenient for growing of most of the vegetables and fruit cultures outside;
- Internal climate control also enable shortening of the normal growing period of the plants and "controlling" the time of harvest. Both provide much better economy of the production, the first one by lowering the costs of exploitation and the second one by "catching" the part of the year when the market offers the best prices for products; and
- the use of the "free" effluent water from the geothermal power plants by providing the heat requirements for protected crop cultivation allowing covering of the higher costs of production in comparison with the open-field production.

FIRST RESULTS

Taking into account that only the first set of measurements has been undertaken, it is too early to make any final conclusion about the confirmation of the initial suppositions. However, some initial indications show that a positive result can be expected, such as:

- Young plants develop much quicker than under the external climate conditions;
- Crop is much more uniform than the one grown in non-heated greenhouses and under the external climate conditions; and
- Crops look much more healthy than the ones grown in other conditions and with a better balance of the leaf mass.

The above listed results indicate that better productivity and higher yield can be expected than in the greenhouses without controlled internal climate conditions or with the open-field production. The real measure of the differences and their economic evaluation will be made during the next two growing seasons (1997/1998).

CONCLUSIONS

The agricultural geothermal project RIBEIRA Grande at Azores has been established in order to demonstrate possibilities for new family businesses in the Azores, based on the "free" geothermal energy, which up to now has not been used for direct heat application.

It is very much in accordance with the need to develop their own production of vegetables and fruits, which has up to now been totally imported from the continent because the local climate is not very convenient for open-field production (mild temperatures, but high humidity and strong winds).

The first results are very encouraging. A high production of high quality products can be expected, which can be competitive to the imported products--the latter which are rather expensive because of high transportation costs.

REFERENCES

Popovski, K.; Rodrigues, A. C.; Campiotti, C. A. and S. Popovska- Vasilevska, 1992. "Feasbility Study for Establishment of a Demonstration Project for Family-Sized Protected Crop Cultivation at Azores," INOVA, Ponta Delgada.

Rodrigues, A. C. and K. Popovski, 1994. "Technical Documentation for Production Technologies," INOVA, Ponta Delgada.

Popovski, K.; Rodrigues, A. C. and S. Popovska-Vasilevska, 1994. "Technical Documentation for Connection to Geothermal Source," INOVA, Ponta Delgada.

Popovski, K.; Rodrigues, A. C. and S. Popovska-Vasilevska, 1994. "Technical Documentation for Heating Systems," INOVA, Ponta Delgada.