GEOTHERMAL ENERGY UTILIZATION FOR TOMNATEC (TIMIŞ COUNTY) GREENHOUSES HEATING

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KEY WORDS: heating greenhouses, reconstruction, finances.

Completion, testing and exploitation of **100** wells allowed the delineation of 8 hydrothermal Systems, five located in West Romania and three in the Southern part of the country.

In those areas, the temperature of geothermal waters is comprised among **40** and **125°C** and production among **20** to **90** m^3/h (artesian flow). In **1994, 137 MWt/h** are installed corresponding to annual energy savings of **35,000 ton oil** equivalent (toe).

Geothermal energy is used for various purposes such as heating for more than **3,000** conventional flats, several administrative buildings and commercial spaces, and **47** ha of greenhouses. Water is also utilized in **10** industrial plants and for manufacturing of domestic hot water in **16,000** flats.

There are also **15** localities where geothermal water is used for balneology and/or for recreational center.

ABSTRACT

S.C. FORADEX S.A. is exploiting **14.5** ha of existing **greenhouses** in Tomnatec (Timiş County - West Romania) near the Hungarian and Serbian borders, in the Panonian Basin. Artesian geothermal water coming from **5** deep wells represents an installed power of **7** MWt used to grow vegetables and flowers. Since **1992,** the improvement of geothermal water production by means of pumping equipment and bettering of heat production and distribution is intended to produce a full scale exploitation of this agricultural complex.

1. INTRODUCTION

At the beginning of the **1970's** Romania intensified the efforts to replace some of the conventional energy resources with geothermal strongly evidenced by the geological research.

In the last **32 years, more than** 200 wells have been drilled for geothermal water production.

The geothermal heating of the **47** ha of **greenhouses** is ensured using **22** geothermal wells. These wells are usually exploited without pumping equipment: one well equipped with a Pleuger submersible pump, **6** wells in *Arad* County with air lift and the remaining **15** by artesian flow.

Due to exploitation without reinjection during a long period **(10 - 15** years) some geothermal fields are now strongly depleted and it should be necessary first to install electrical submersible pumps for further deeper exploitation and second to design doublet schemes.

After the **1989** Revolution and the new economy implementation, S.C. FORADEX **S.A.** that was only a geothermal water producer decided to extend its activities in order to exploit not only the geothermal wells but also the surface installations. One of the first *step* was to buy these **14.5** ha of greenhouses in Tomnatec. The decision was taken based mainly on the fact that for **almost** 10 years, the greenhouses were supply with geothermal energy from the FORADEX wells and that it was necessary to control the whole process in order to optimize energy savings and greenhouses' production.

2. TECHNICAL DESCRIPTION OF THE PLANT

2.1. GEOTHERMAL WELLS

Geothermal boreholes were drilled between **1980** and **1984,** tapping the water from the Pontian sands (complex I, 11, III).

The reservoir, being made up of sand-banks and clays of *sandy* origin, is exploited between **1,560** m and **1,985m.**

The completion includes a **7"** perforated liner; characteristics of the reservoir and production results are:

- net pay of aquifer: **45** up **to 103m,** productivity Index **= 5** up to **10 l/s** bar;
- physico-chemistry: **3.32** up to **4.54** g salt per liter;
- combustible gases content (mainly CH_4): Gas water ratio **(GWR) = 1.00 - 1.36** Nm^3/m^3;
- actual artesian restricted flowrate: between **32.4** and **50.4** m^3/h well **(Table 1);**
- wellhead temperature (artesian flow): between **78** and **83 °C (Table 1);**
- static level: **-25** m (I Complex), **-15** m (11 Complex), **-10** m **(III** Complex);
- submersible pumping: possible only in wells having a surface casing of $13^3/_8$" (wells **1564,1566** and **1567).**

N.B. a) disposal of used geothermal water, at **30** °C, is realized in open channels, going directly in *the* Mureş river;

b) a shallow new reinjection well and opportunity of resuming reinjection tests have been put forward;

c) due to the salt concentration, severe scaling problems appeared in first years of exploitation when Ca CO_3 precipitated in the upper part of the production **4 %"** tubing. Scaling was entirely prevented, by injection with a dosimetric pump at -80 m depth, of **5** *mg* triples polyphosphates of sodium per liter of geothermal water produced.

2.2. GLASSHOUSES INSTALLATIONS AND EXPLOITATION PROBLEMS

Tomnatec greenhouses were built in **1970** (Dutch type).

There are 4 main modules: **3** of **4** ha and one of **2.5 ha,** total **14.5 ha,** oriented NW-SE and grouped into two sections of **7.25** ha each. The modules consist of greenhouses with **202** m x **68** m or **176 x 68** m dimensions **(12,524** m^2**)**, equipped with a spray irrigation system of plastic pipes. More than half of the greenhouses are in an overall *good* condition, however it is to be noted that there are still some obsolete wood frames.

The heating is carried out by way of an aerial radiant *smooth* steel pipe, positioned along the side walls and in the plant canopy. Initially it was a **2** pipe distribution *system,* the heating requirements being satisfied with steam provided by oil fueled boilers. Later, at the beginning of **1980,** when geothermal water was discovered and up **to 8** wells were drilled in the vicinity **(Figure 1),** one well being devoted to reinjection, if possible, in order to maintain a sufficient pressure in the aquifer, a **4** pipe distribution system was adopted, **by** increasing with **30%** the existing length pipes. Today the mean length of **1½ "** smooth steel pipes is **14** to **18** km/ha and about **75%** is operational.

Geothermal water is used directly inside greenhouses, through the aerial 1½ " smooth steel pipes system; there is **no** secondary loop circuit. Because of eventual pipes' corrosion – due to the direct utilization of geothermal water – some leaks have **been** shown **,** the soil being affected (causing pH problems). Also, the old venting ***system*** of geothermal gases accumulated into the pipes, causes troubles sometimes, by local decreasing the pipes' temperature.

Util 1994, during the cold **season** (mid November – mid March), the geothermal water temperature was increased with the steam, produced with **2** gas fueled boilers, passing in counterflow through the water – water heat exchangers. Obviously there **was a** very poor heat transfer, due to both the allowable low pressures into the heat exchanger passes, and the fact that the heat exchangers were not of "steam – water" type.

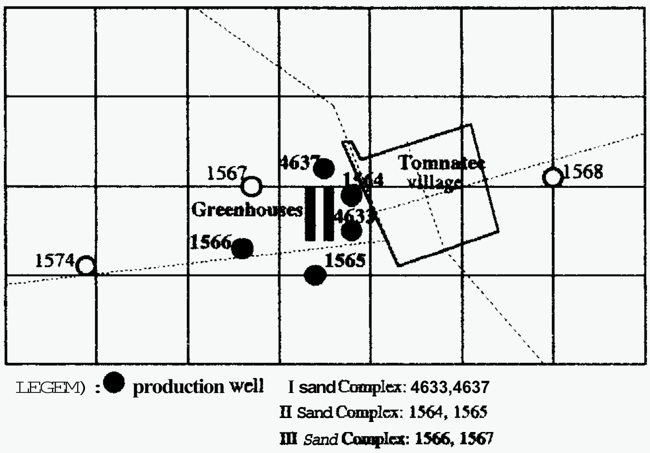

Figure 1: Tomnatec greenhouses and geothermal field.

<u>2.3. ORGANIZATION</u>

<u>There **are** 4 main buildings</u> **–** two of them **(30** m **x 18 m)** serving **as** headquarters, workshop and warehouse, the tbird one serving **as** Geothermal Heating Distributor (GHD) and the last one as Peak Load Heating Station (PLHS), both of **34** m **x 20 m.**

<u>2.4. HEATING **NETWORK**</u>

<u>The GHD includes</u>:

•- one storage tank of 120 m^3 (regulating basin), receiving the geothermal water from the **5** production wells (direct connection – open loop system), which **assure** the adoption, of both the flowrate and the pumping, at the needs of greenhouses, but not of a daily regulation;

•- *six* circulating centrifugal pumps (50 **m^3/h,** with **7.5** up to **15 kW** electrical motors);

•- a **1 0** geothermal water distributor, which allows the geothermal water distribution to the **greenhouses,** at an average of **1.5** bar pressure, through:

•- four old "shell and tube" water **–** water heat exchangers **(70.8** m^2 exchange surface each), **during** the peak load hours.

<u>The PLHS includes</u>:

•- **2** gas fueled **boilers,** each of **2.30 MWt/h,** supplying **4 t/h** of steam **(120°C),** at a very low **pressure,** due to the **type** of heat exchangers;

•- one water treatment facility, for the boiler's needs.

3. HEAT REQUIREMENTS

<u>**3.1.** CALCULATIONS</u>, for **a** minimum internal temperature of **15°C** and outdoor temperature of **– 18°C,** typical *figure* for Romanian winter conditions, gave a total heat loss for the **peak** load conditions of **36 MWt/h,** and a heat loss, for the average external air temperature during heating **season** (2 - 3°C), of **12 MWt/h.**

<u>*3.2.* **ACTUAL HEAT SUPPLY**</u>

3.2.1. Geothermal production: currently **223.2** m^3/h, with a mean temperature of **80°C,** giving for a AT of 40°C about **10.7 MWh.**

3.2.2. Steam supply: because of **poor** heat transfer, about **3.5 MWh,** less than 2 x **2.3 MWh (two** gas fueled boilers).

It should be noticed that the actual heat supply **(14.2 MWh)** **sustains** the heat requirements of **14.5** ha for **no** less than an outdoor temperature of **+ 1°C.**

In conclusion for temperatures of less than **+ 1°C,** about **65%** of **14.5** ha of Tomnatec **greenhouses are** not heated and only **5** ha **are** cultivated without risks during the cold season!

4. MAIN CROPS

The temperate climate conditions in Romania permit two annual crop cycles.

In Tomnatec greenhouses the main crops consist of: tomatoes (40 **– 50 t/ha),** cucumbers **(110 – 130 t/ha),** carnation **(50,000 –** 75,000 flowers/ha), mild pepper **(30 – 40 t/ha),** cabbage and cauliflower (30 **– 40 t/ha).**

5. IMPROVEMENTS REALIZED SINCE 1990

Because of poor local management and low productions' record, the former manager was replaced with two experienced agricultural engineers and a new mechanical chief engineer was appointed.

A lot of money was granted **to** pay the old accumulated debts, to **finish** the **second** gas fueled boiler, **to** invest in some new tractors and greenhouse tools, and to construct a concrete wall around **the greenhouses.** The discipline was reinforced and workers **are** much better paid than before the take–over.

All these factors created a new attitude towards the interests of the Company!

<u>**TECHNICAL PRINCIPLES TO BE HARNESSED**</u>

To achieve the maximum use of the geothermal energy we **had** to look upon some basic principles:

aj. <u>Regulation of the heat supply</u>: foreign **experience** and calculations made, determined **the** necessity of extending **the** actual capacity of the storage **tank (120** m3) to include a compensation pool (or larger storage tank) of **1,500** m^3, storage by day, **to** be used when **normal** power requirements **are** exceed at night **(12** hours continuos flow, 93 m^3 for each ha of the **14.5** ha surface greenhouses);

b). <u>Decisions taken in the **geothermal** production sector</u>: based **on** the Company Reservoir **Engineering** and production Divisions estimates, we decided that the output from the **5** wells should not **surpass:**

Table 1: Characteristic of the 5 geothermal wells.

Well No.	Flow	Temperature	Sand complex	Length of prod. tubing	Tubing diameter
–	m^3/h	°C	–	m	in
4633	46.8	83	I	150	4½
4637	32.4	81	I	275	4½
1564	46.8	80	II	225	4½
1565	46.8	79	II	225	4½
1566	50.4	78	III	225	4½

Table 2: Combined system, artesian and submersible pumping, 210 days of production each year.

Well No.	Flow	Temperature	Sand complex	Length of prod. tubing	Tubing diameter
–	m^3/h	°C	–	m	in
4633	46.8	83	I	150	4½
4637	32.4	81	I	275	4½
1564	130	84	II	Drawdown: – 90 m	
1566	130	78	III	Drawdown: – 100 m	

– In artesian mode, for 10 years' production life, 210 days of production each year (Table 1):223.2 m^3/h, the energy supplied to the greenhouses being about 10.7 MWt/h.

– For a combined *system*, artesian and submersiile pumping, 210 days of production each year (Table 2): 314 m^3/h, the energy supplied to the greenhouses being about 14.6 MWt/h.

N.B. A prediction of the reservoir behavior under a given extraction scheme, but not considering reinjection of waste geothermal water, was done using the general purpose geothermal reservoir simulator MULKOM (developed at LBL – Pruess, 1982).

The simulation to forecast the future behavior was carried out for 25 years, considering that the requirement of the greenhouse is for 41 kg/s water during winter (October – February) and 29 kg/s during March – April.

The results show that the drawdown in the productive layers does not exceed 5 bars for the 25 years simulated period, which means that if the reservoir is exploited with these extraction rates it is not necessary to change the extraction system, i.e., to downhole pumping.

c).Up-to-date combination of geothermal energy with another heat *source:* **Starting 1992, meetings with French specialists, Mr.** Jean LEMALE from Ademe – Paris (Agence pour l'Environnement et la Maîtrise de l'Energie), Mr. Christian BOISSAVY from C.F.G. – Orléans (Compagnie Francaise pour la Géothermie), also expert of the XVII Directorate of the E.E.C., and Mr. Alexandre KELMAN from Cabinet KELMAN – **Paris, gave us the possibility of preparing together a common report.**

The REPORT has two solutions: a Provisional one and the Complete solution.

The Provisional solution ($ 70,000 worth - Figure 2), to be in use for no more than 2 years, indicates the necessity of changing all the 4 old water – water heat exchangers with some better type (VICARB plate heat exchangers), for 4.6 MWt, the replacement of the actual centrifugal circulating pumps, eventual replacing the geothermal water in the piping heating system with a secondary treated water loop, and the procurement of 1 – 2 Byron–Jackson, or similar, submersible pumps, for 130 m^3/h output.

The Complete solution of the REPORT shows that an investment of no more than **$ 1,000,000,** mainly in the heating supply sector, i.e. two new oil/gas fueled boilers, each of 18 MWt/h with MONARCH type burners (producing hot water with 95°C), new titan heat exchangers, 3 - 4 circulating pumps of 200 m^3/h each, regulations, etc., is economically feasible, the project offering a good return:

- internal rate of return: 18%;
- anticipated payback period on investment: 5 - 8 years.

The geothermal water production, in the combined *system* - artesian and downhole pumping - has to be no less than 300 m^3/h **(Table 2).**

To increase the energy saving, with more than 1,500 toe/yr., reducing correspondingly the payback period, a geothermal fish farming, using water with 25°C, is to be taken into consideration.

d) Uu-to-date use of appropriate heat exchanger *systems* in the greenhouses enabling the geothermal energy extracted to be used with maximum efficiency: an overall Technical Project for Tomnatec greenhouses is to be realized util the end of 1994.

e). Two "in depth" agricultural reports, realized by a neutral expert, in 1992 and 1994, gave us some more information and necessary support for the next steps to be taken to increase the gross yield agricultural production.

6. STATE OF ADVANCEMENT AND CONCLUSIONS

In the spring of 1994, the company *still* not has a positive answer for the financial assistance required through the PHARE Program; **decision was taken to further extend our own financial efforts, to implement for 7.25 ha the Provisional solution (Figure 2).**

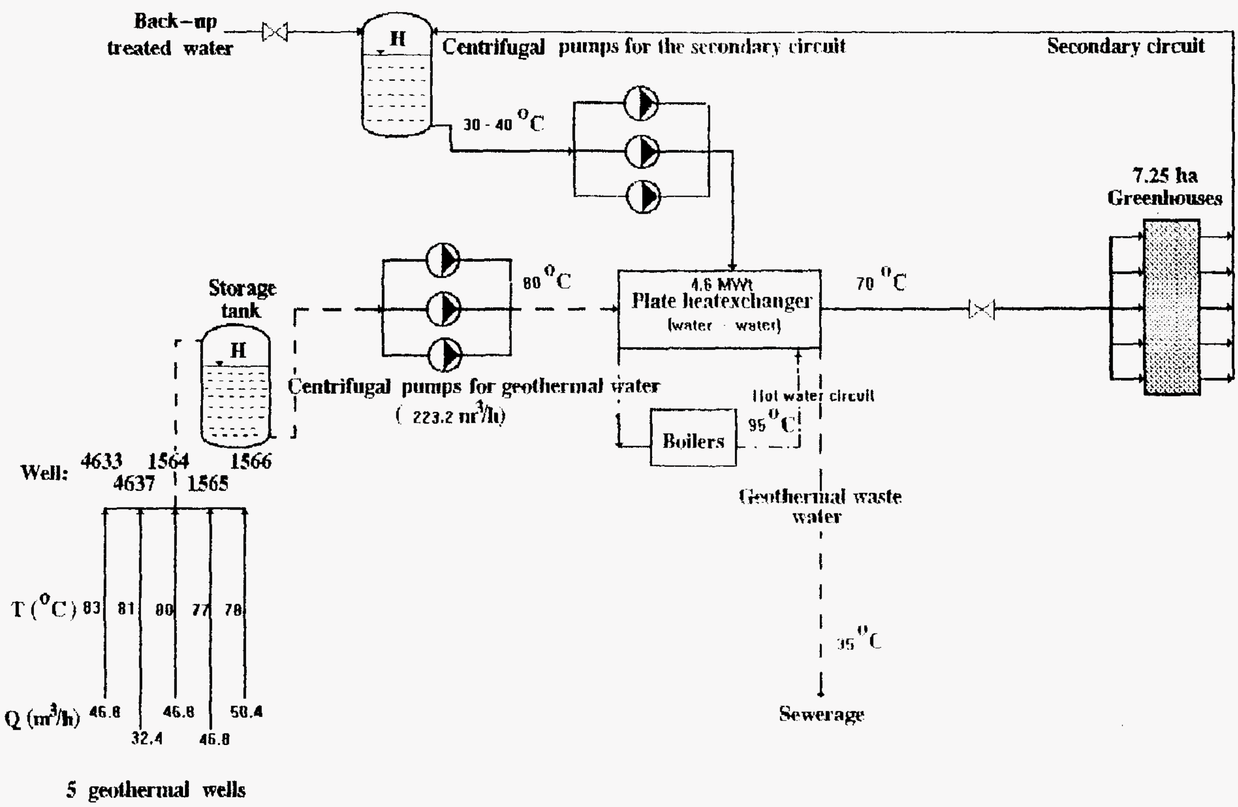

Figure 2: Tomnatec Greenhouses - Provisional solution

We have already obtained, as a donation from France, some geothermal equipment, such as: geothemal plate (iox arid Titanium) heat exchangers, for up to 200 m^3/h, several circulatings KSR and Salmson type pumps, a 130 m^3/h Byron–Jackson submersible pump, 2 low pressure gas fueled burners, Cuenod type, for 1.60 MWt/h, regulations, a.o.

The first two plate heat exchangers, VICARB and APV Raker water-water type, 200 m^3/h each, are mounted on site.

The final work to amend the first gas fueled boiler to produce hot water instead of steam is to be completed. Providing that the results will satisfy, we. shall continue to amend the second boiler and to construct a new one.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support and assistance being rendered by S.C. FORADEX S.A. and French specialists, especially Mr. Christian BOISSAVY, in preparing this paper.

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