THERMIE LANGADAS GEOTHERMAL PROJECT

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ABSTRACT

The project concerns the utilisation of geothermal energy for the heating of Municipal energy users in the Municipality of Langadas, approximately 20 km NNE from the city of Thessaloniki. At the spas of Langadas, subsurface water of temperatures 22-40ºC is encountered at shallow depths (100-200m). Wells drilled in the area yield 40 to 75 m^3/h of water each. The project, which is funded by the Municipality of Thessaloniki, and is also supported by the EU THERMIE programme, concerns: (i) production of tepid to warm groundwater from 3 wells located near the spas, (ii) collection of the groundwater in the main tank at the spas of Langadas, (iii) its transport to a series of tanks placed in cascade, located either at the vicinity of the spas, or in the town of Langadas at approximately 2 km distance from the spas, (iv) delivery of its energy to secondary loops of hot water (45ºC) via water source heat pumps, (v) the hot water distribution networks to the energy users, (vi) transport of groundwater to the reinjection site after use and (vii) groundwater reinjection at 6-10ºC.

1. INTRODUCTION

The project concerns the heating and cooling of selected energy users, namely one greenhouse and several public buildings including a hotel, a hospital, and schools, using warm/tepid water from the shallow bores and heat pumps, within the municipality of Langadas, which is located approximately 20 kilometres NNE from the city of Thessaloniki. It includes the construction of three production and one reinjection boreholes, the groundwater collection piping network, the groundwater transmission and disposal lines, the provision and installation of underwater pumps, centrifugal pumps, variable speed drives (inverters), automatic flow control valves, electromechanical equipment and computer controls, the provision and installation of heat pumps and the energy distribution piping network.

The project has been mainly financed by own funds of the Prefecture of Thessaloniki and by the European THERMIE programme. The wells have been designed by the Aristotle University of Thessaloniki and have been drilled by local contractors. The piping network has been designed and supervised by the Centre for Renewable Energy Sources (CRES) and the Hellenic Company for Thermalism (HE.CO.THE.), and has been constructed by local contractors. The specifications for the heat pumps systems have been prepared by CRES and HECOTHE. The provision and installation of the heat pumps, as well as the interventions to the schools required to accommodate low temperature systems are undertaken by the Prefecture of Thessaloniki.

2. PRODUCTION AND REINJECTION WELLS

Well G-2: This ~70m deep well was already operating before the project commencement, which feeds the greenhouse with 36ºC geothermal water via a buried polyethylene pipe. The groundwater outflow from the greenhouse is delivered to the heat pumps with a flow rate of 20 m2/h and temperature of 10-20 ºC.

Well GP-1: This well was drilled in ~25m distance from the previous well in 1999, in order to cover both peak thermal loads during winter season and the needs of the spas for warm water. It reached a depth of ~125m and delivers 45 m_/h of warm water with the aid of a submersible pump. It has a production casing/liner of 8". After two years of operation, the production water temperature dropped from its initial value of 40ºC and stabilised at 36ºC.

Well GP-2: This well was also drilled in 1999, approximately 250m away from previous wells, in order to serve as the main production borehole for the project. It reached a depth of ~175m and delivers 90 m_/h of 28ºC water with the aid of a 40 HP submersible pump. It has a 8" production casing/liner. It produces a water mixture from cool shallow permeable horizons (22ºC) and from warm deeper horizons (40ºC).

Well GP-3: It was drilled very close to previous well (at 10m distance) in 2001, in order to tap the shallow cool permeable horizons only. Its role in the project is to deliver cooler water used in the heat pumps during summer season. It reached a depth of ~92m and delivers 90 m_/h water of 22ºC with the aid of a 30 HP submersible pump. It has a 8" casing-liner.

Well GP-4: This well will be drilled at ~1 km distance from the production wells, reaching a depth of ~200 m, and will serve as the reinjection borehole for the disposal of the groundwater after its use at the heat pumps. It will be drilled in the vicinity of a nearby stream, which will serve as an alternative surface disposal agent of the groundwater. Reinjection will take place with gravity, with two centrifugal pumps as a back-up.

3. ENERGY USERS

The energy users which will be connected to the heating-cooling network at first stage are shown in table 1, while the ones which may be connected in the future are shown in table 2.

Table 1: Energy users connected to the heat pumps at first stage

Energy User	Heating Power, KW	Energy Use
Municipal Greenhouse	880	Heating
Spa Hotel	350	Heating & Cooling
Health Centre	160	Heating & Cooling
2nd Primary School	160	Heating
High School	600	Heating
Administration Building	300	Heating & Cooling
Total	2.450	

Table 2: Future potential energy users connected to the heat pumps

Energy User	Heating Power, KW	Energy Use
Spa Building	160	Heating
Old Revenue Service	70	Heating & Cooling
Police Department	80	Heating & Cooling
New Elderly House	250	Heating
Old Town Hall	85	Heating
New Town Hall	170	Heating & Cooling
1st Primary School	175	Heating
Total	990	

4. ENERGY NETWORK

The project flow chart is presented in figure 1. The whole network has been designed in order to minimise electricity consumption and in order to achieve sustainability by minimising groundwater use. The overall useful thermal power delivered to the energy users, not including the greenhouse, amounts at 1570 kW. The system as is, can accommodate additional 800 kW of energy users. If it is fed by 100% warm water of 36-40 ºC, rather than 20-36 ºC, it can accommodate further 1200 kW, raising its total thermal power to over 3,5 MW. A modification of the reinjection well to a production one, adds an additional amount of 1800 kW of thermal power, available to the town of Langadas.

4.1. Groundwater collection network

The groundwater collection network includes:

i. The main water collection tank, where the groundwater is collected, before it is conveyed to the town of Langadas. This tank, also serves as a water source and sink for the heat pump which heats and cools the spa hotel.
ii. Water collection from production wells GP-1, GP-2 and GP-3. The groundwater is delivered to the surface with the aid of submersible pumps, and is conveyed within buried polyethylene piping of 3rd generation (HDPE 100, MRS 10, _ 80), _280, 10-12,5 atm, buried at ~1,5m depth, until the main collection tank. Well GP-1 is connected to the _280 pipe with a _110 3rd generation buried HDPE pipe of 12,5 atm and an on-off automatic flow control valve. Wells GP-2 and GP-3 are connected to the _280 HDPE pipe with 4_" steel piping.
iii. Water collection from the outflow of the greenhouse. It is conveyed to the main collection tank via a buried HDPE piping of 3rd generation, _110, 10 atm.
iv. Submersible pumps, the flow rate of which is controlled by a variable speed drive (frequency converter or “inverter”), according to the water level in the main tank. For this purpose buried cables have been placed connecting the main tank with the wells.

Polyethylene piping was selected in order to completely eliminate groundwater leakages. In order to encounter thermal expansion and contraction of the piping, the pipes have been anchored at their edges by enclosing them in concrete, and the connections with the steel piping are made with flanges. In order to minimise heat losses, polyethylene pipes are buried and steel pipes are insulated.

The flow within the main tank is smoothened by using different chambers for water inflows and outflows. In addition, the piping is bevelled at 45º angle within the tanks. Water level control is achieved with the aid of water level electrodes and central computer control. The whole space planning of the installations was determined by the land use allocation within the premises of the spas.

4.2. Groundwater transmission line

It includes the two centrifugal pumps, the fittings and the piping conveying groundwater from the main collection tank to the cascade tanks located in the town of Langadas at a distance of approximately 2,2 km.

The centrifugal pumps are rated of 10 HP each, delivering 45 m_/h at 3 bars head each. The pumps are controlled by a frequency converted or variable speed drive (“inverter”) in order to maintain constant pressure of 3 bars at the transmission line.

The transmission line is a _280 HDPE pipe, of 3rd generation (PE 100, MRS 10, _ 80), 12,5 atm, buried at ~1,6m depth beneath the road connecting the spas with the town of Langadas, enclosed in sand. It has been designed for water flow rate of 90 m2/h and water temperature of 40ºC, and for road loads corresponding to 40 tons trucks with a safety factor of 1,8. The pipe has been anchored every 8 meters by its enclosure in concrete in order to encounter thermal expansion-contraction. Its connection with the steel piping at both ends is made with flanges.

Water flow regulation is performed by a proportional control valve, depending on the temperatures prevailing at the cascade tanks in Langadas, controlled by a central computer system. Thermal losses along the line, which is not insulated, have been estimated at approximately 2,5 ºC maximum.

4.3. Cascade groundwater tanks of Langadas

The chemistry of the groundwater exhibits neither corrosive nor scaling tendency. For this reason there is no need for intermediate heat-exchangers for the protection of the heat pumps from scaling or corrosion. Instead, three tanks have been constructed, placed in cascade (series), so that the overflow of each tank feeds the next one.

The tanks have been constructed above the ground in order to simplify the mechanical equipment feeding the heat pumps with groundwater, and the construction works. They are insulated and made by reinforced concrete with two chambers per tank, one for inflows and another for outflows. The tanks are supplied with temperature sensors and water level electrodes.

The water from the main transmission line is fed to the first tank, which overflows to the second, which in turn overflows to the third one. That way a water temperature escalation is achieved within the tanks. The heat pumps connected to the first tank are fed with higher water temperature and as a result operate with higher energy efficiency. The flow rate of the incoming groundwater is regulated by the control valve, so that temperatures prevailing in each tank are higher than 16ºC, 11ºC and 6ºC respectively during winter, and lower than 28ºC, 31ºC and 34ºC respectively during summer.

The heat pumps use the same tank as both water (and heat) source and water (and heat) sink. That way, on the one hand they require simplified design and control of the water hydraulics, and on the other they pump only heat from each tank simplifying overall system controls.

The control of water flow rate and temperature within the tanks allows the maximisation of the temperature difference between water inflow and water disposal, leading to the maximum possible energy extraction from a given flow rate of groundwater. As a result the necessary flow rate is minimised, leading to electricity savings at the water pumps, as well as to the sustainability of the subsurface geothermal system.

4.4. Waste groundwater line

It includes a _280 HDPE pipe of 3rd generation (PE 100, MRS 10, _ 80), buried at ~1,6m depth beneath the road connecting the town of Langadas to the spas until midway to the premises of the forestry and along the northern boundary of the forestry premises until the stream. Its nominal pressure is 12,5 atm beneath the road in order to be able to sustain high loads, and 10 atm within the premises of the forestry. It has been designed for both gravity and pressurised flow of 90 m_/h of 40ºC water. Two centrifugal pumps are standing by in case of emergency.

The pipe is enclosed in sand and anchored every 8 meters by local concrete enclosures, in order to encounter thermal expansion and contraction. Connections with steel piping at its ends are made with flanges.

The pipe will be connected to the reinjection well, which will be drilled to a depth of 200 meters approximately and will be cased with 8" casing. The overflow of the reinjection well will be delivered to the nearby stream. The temperature of the reinjected groundwater is estimated at 6 to 10 ºC during winter and 30 to 34 ºC during summer.

One of the reasons the heat pumps in Langadas were placed in the same site, was the simplification of the water disposal network. That way a single pipe for gravity flow with stand-by pumps is sufficient. Locating the heat pumps in every building – energy user, would result in the need for additional tanks for the collection of the waste groundwater, additional pumps and long sewage piping network of larger diameter in order to comply with local regulations.

4.5. Energy distribution network

This comprises steel pipes delivering a closed circuit of either hot water of ~43ºC for heating during wither, or cold water of ~7ºC for cooling during summer. Each energy user (building) is served by a single pair of insulated pipes starting from a single heat pump corresponding to this building and ending to the boiler house of the building. That way, existing diesel fired boilers can serve as emergency back-up sources of heat during winter.

The pipes are anchored at their ends in order to encounter thermal expansion and contraction. They have been designed for the calculated thermal loads of the building they serve and for a maximum temperature difference of 6ºC between outgoing and incoming water current at the heat pumps. Temperature drop due to thermal losses corresponds to a maximum of 0,5ºC per pair of pipes.

5. HEAT PUMPS

Their specifications include water source heat pumps of high efficiency capable of delivering both heating and cooling. The market research performed indicated that such heat pumps with coefficient of performance (C.O.P.) of 4,2 are available by local dealers.

However, as the majority of them are designed to operate in heating mode with 18ºC maximum water inflow at the evaporator, while the available groundwater may have a temperature up to 40ºC, a special configuration of the evaporator piping is necessary. This includes a re-circulation of a proportion of the water exiting the evaporator, which is mixed with the incoming groundwater in order to produce 18ºC water.

The heat pumps will operate with output heating power between 180 kW and 370 kW each, having electricity consumption varying between 40 kW and 90 kW each. For the provision of electricity for the heat pumps and the other mechanical equipment (pumps, “inverters”, lights, computers, control valves, etc) two power sub-stations are necessary, one with rated power of 250 kW within the premises of the spas, and another with rated power of 500 kW in the town of Langadas.

6. HEATING AND COOLING SYSTEMS WITHIN THE BUILDINGS

They will correspond to low temperature heating systems, capable of delivering cooling as well. This implies that existing heating systems of high temperature radiators will be replaced by low temperature fan-coils. The only exception is the administration building, the new ball room of the spa hotel and the spa building itself, which are already equipped with fan-coils. Simple fan-coils available by local dealers will be used. The corresponding design for the schools has already been prepared by the Prefecture of Thessaloniki.

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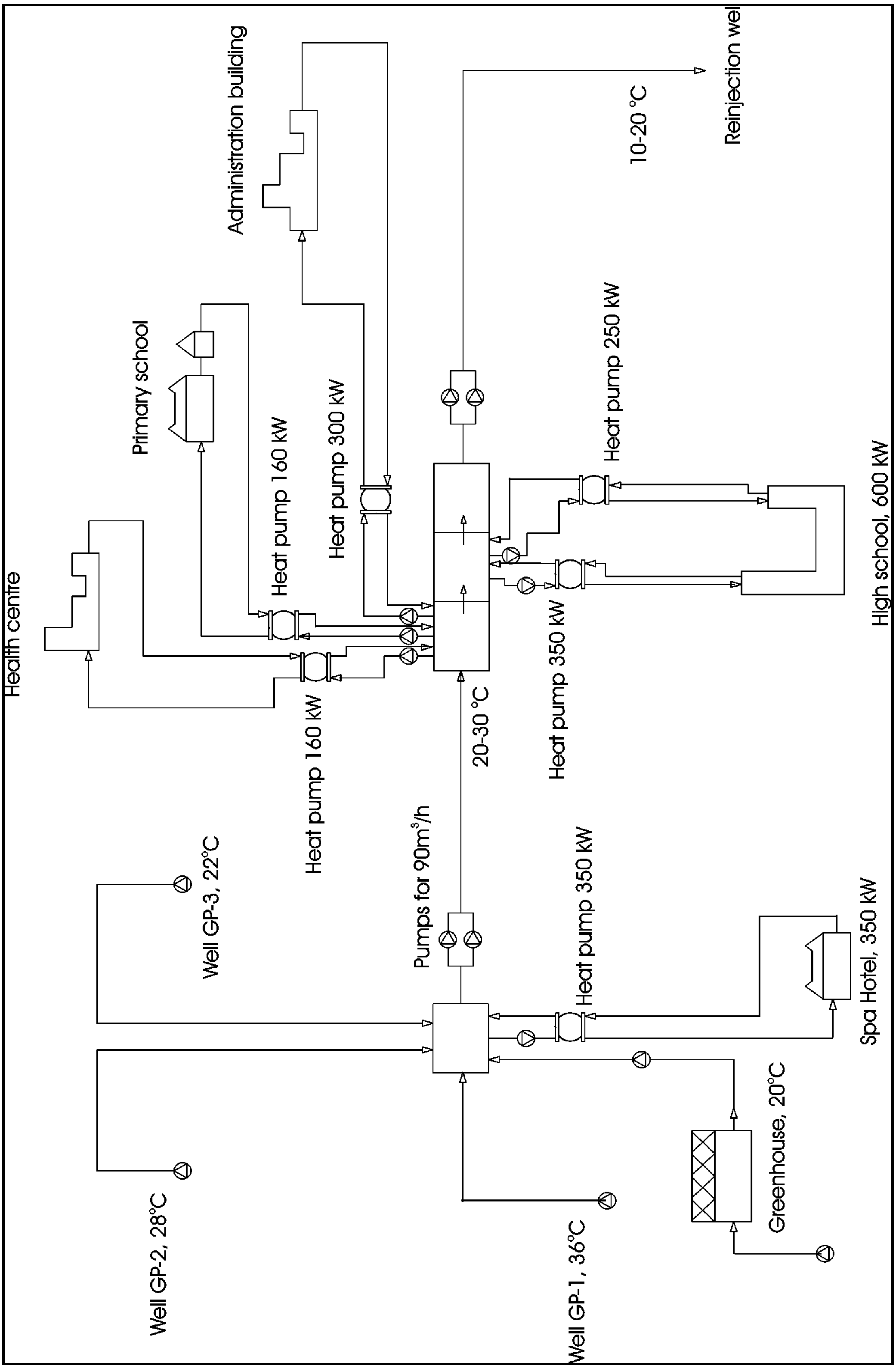

Figure 1: Langadas Cascade Scheme Flowchart