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Benedikt Geothermal Heating System, Stage I

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ABSTRACT

In spring 2004, geothermal well Be-2/03 has been drilled in the Benedikt place, Benedikt Municipality, north-eastern Slovenia. Two thermal aquifers were tapped: the first one at a depth of 1492 m having lower yield, and the second one at depths from 1848 m and 1857 m, respectively, where the well terminated. The Na-HCO_3 dominated water is classified as a CO_2-rich healing mineral water suitable for drinking, bottling and balneology. The free degassing gas is almost pure CO_2 (99.9 %). The major ion composition is dominated by sodium (1750 ppm) and by bicarbonate (4700 ppm).

Owing to very high investment costs that could not be carried by the municipality itself, and very poor engagement of the responsible governmental institutions, the municipality council decided in the beginning of the year 2006 to make a contract with the company Gejzir Consulting from Ljubljana. The Benedikt Municipality is the well owner and ensured an uptake of 5 liter/sec of thermal water to Gejzir Consulting for construction of the first stage of district heating.

The whole project of district heating is characterized by 3.3 MW power and annual production of 4200 MWh.

The first stage is already built and put into testing operation. District heating encompasses public dwellings – the municipality building, gymnasium, primary school and kindergarten that consume 20 % of total municipality consumption. Heat station has the power of 700 kW and is foreseen to produce 600 MWh annually. Gas separator and heat exchanger are located at the production well in order to simplify the system operation. Energetically used thermal water is cooled in a nearby temporary pool.

The inflow of thermal water from the production well is regulated automatically with respect to the outflow temperature from the heat exchanger which is constant and amounts to 40 ºC. The water undergoes further cooling in the pool and has the temperature of less than 30 ºC when is disposed into a small creek. After the enlargement of district heating network and erection of a recreation center, energetically used thermal water will be supplied in the recreation center along with additional amounts of thermal water from the well, and the temporary cooling pool will not be needed any more.

1. INTRODUCTION

1.1 Geothermal well Be-2/03

Benedikt is located on the northern flank of the Murska Sobota Swell, and in the southern slope of the Radgona Depression (Kralj 2001). The Be-2/03 well has been drilled in winter 2003/04. Final depth amounts to 1857 m (Kralj 2005). Thermal water has been captured at a depth of 1492 m, and between a depth of 1848 m and the final depth of 1857 m (Figure 1). The water belongs to sodium-bicarbonate hydrogeochemical facies. Total dissolved ions (TDI) amount to 7.4 g/L. The thermal water contains 14 g/L of dissolved CO_2 gas.

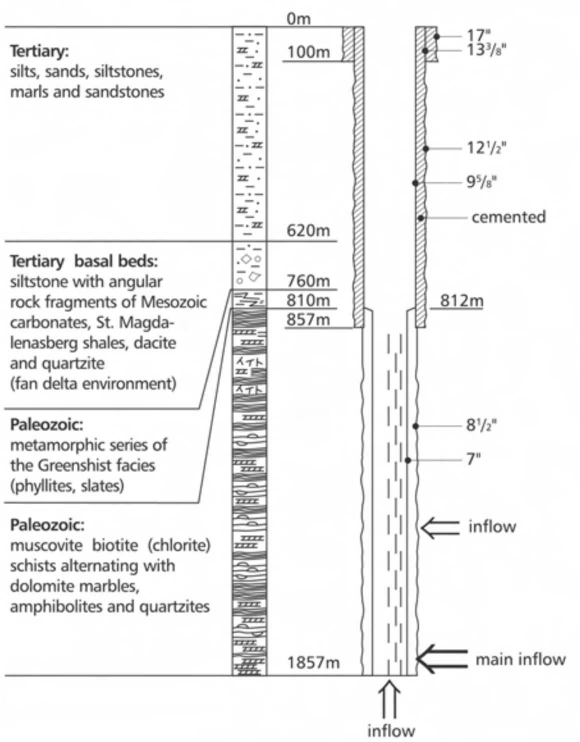

Figure 1. Geological and technical profile of the geothermal well Benedikt-2/03

1.2 District heating system - principle of operation

The object of this investment is to outline heat demands in the area of Benedikt place as a whole. District heating distribution network is designed to assure the connection of all public buildings, private detached houses and apartment buildings, etc. Heat demands of all consumers connected to the district heating network will amount to 3.3 MW_{th}, with the potential of 4200 MWh/annum.

Until now no district heating system is present at the Benedikt Municipality. The district heating system designed and presented here is a novelty inside this community.

Geothermal district heating system construction is intended to proceed in four stages (Figure 2)

Stage I: The construction of a district heating system will encompass public buildings inside the center of Benedikt (the kindergarten, public elementary school, municipality and multipurpose hall) with an estimated heat demand of 550 kW.

Stage II: Stage I will be expanded to the center of Benedikt and to the new buildings in the north-east of Benedikt, and on the right side of the public road Benedikt – Sv. Trojica. Inside this stage the following buildings will be connected: parish with church, public inn, culture hall, fire brigade building and 93 private houses.

Stage III: Construction inside this stage encompasses the north-west part of Benedikt; approximately 75 private houses will be connected.

Stage IV: The connection of buildings to the heating system is predicted in the south-western part of Benedikt. According to the urban plans 25 to 35 individual (detached) houses will be connected, too.

A stable consumption of heat is foreseen for the system. The heat demand is constant and depends only on weather conditions (the outside temperature).

2. THE CONSTRUCTION OF GEOTHERMAL DISTRICT HEATING SYSTEM – STAGE I

2.1 Scope and objectives of the project

The project's Stage I aim was to complete the boiler room in the multipurpose hall so that the heating system is equipped to operate either by geothermal energy from the well, or by the existing boiler inside the existing boiler room with a power of 400 kW.

The operation is automatic, for thermal water heat exchange at geothermal well side and distribution to the boiler room, as well as in the existing boiler room. Preparation of thermal water is achieved by a degasifier, a heat exchanger, frequency modulated pumps and pipelines connecting the well and the boiler house. The system construction at the geothermal well is shown in Figure 3. The new constructions must fulfill heat demands and the regulatory body conditions.

Because of that facts, the following equipment should be installed:

Geothermal water preparation for exploitation:

- Plateau with a fence for degasifier positioning, and a fence around geothermal well,
- Degasifier with appurtenant pipeline connections and valves,
- Geothermal water – water heat exchanger of the district heating system,
- Pipeline connection of the heat exchanger and temporary cooling pool,
- Temporary cooling pool,
- Cooling pool – creek pipeline connection,
- Exploitation well – boiler house pipeline connection,
- Pumps in the district heating system,

District heating system is composed of:

- Heat exchanger,
- District heating system pumps,
- Pipeline connections and valves inside the boiler room,
- District heating network pipelines with connections to the buildings,
- Heat stations for separate buildings,
- Return pipeline from the boiler house to the heat exchanger at the geothermal well, with a connection to the heat exchanger,
- Water preparation system for the district heating system, and
- Necessary civil engineering works for the district heating pipeline and temporary cooling pool construction.

2.2 Technical data

Stage I comprises the connection of public buildings with a heat demand of 550 kW, and total energy consumption of 600 MW_{th}/annum.

Heat exchanger parameters with heat exchange potential of 700 kW are:

T_{geo} –inlet = 80ºC

T_{geo} – outlet = 45ºC

Q_{geo} = 5 liter/s

$T_{dalj.}$ – inlet = 70ºC

$T_{dalj.}$ outlet = 42ºC

$Q_{dalj.}$ = 6,0 liter/s

dt log = 7.6ºC

Temperature control of the district heating system water inlet and return is attained by frequency modulated pumps which assure dt =30ºC, regardless of the heat consumption in building heating system, in the boiler house inlet and return distribution headers.

The water from the district heating is the same as in the boiler house, what means that we have a direct system of district heating in a chain: heat exchanger – pipeline to boiler house frequency modulated pumps – distribution header at the boiler house – a pump for each building pipeline to the building – radiators – pipeline to the boiler house – boiler house collector of return water – pipeline to the heat exchanger and then back to the boiler house.

The Stage I. of district heating system is constructed and designed in such a manner that can cover not just the present demands, but also the demands of the following stages. At this stage of the project only 20% of the whole heat demand is installed in the main system pipelines and boiler house.

Heat exchanger is designed for Stage I with an extension possibility to cover heat demands of all four stages of the district heating system expansion by installation of additional plates to the heat exchanger.

The use of thermal water for the purpose of heating and connection to the boiler room is not suitable because of high content of total dissolved solids. Therefore a heat exchanger with degasifier was installed close to the well.

On side of geothermal well there is sufficient over pressure of the geothermal water to prevail over pressure drop through degasifier and heat exchanger. Therefore there is no necessity for pump installation inside geothermal well.

3. EVIRONMENTAL IMPACTS AFTER GEOTHERMAL DISTRICT HEATING SYSTEM CONSTRUCTION IN THE MUNICIPALITY BENEDIKT

The use of geothermal energy for district heating purposes will have benefits to the environment because of the reduction of emissions to the environment.

After the replacement of fossil fuels and wood with geothermal energy, theoretical stage with practically no emissions to the environment inside the center of Benedikt can be achieved if we connect all buildings, and the redundant boiler house is not used any more.

In the next stages, a reinjection well is foreseen, and practically all energetically used intact thermal water can be returned in the parent aquifer. The CO_2 gas from geothermal water which is practically 99.9% pure, can be used for alimentary production.

In the Table 1, the foreseen lower impact to the environment owing to declined emissions from wood and fossil fuels is shown. The data is based on the assumption that geothermal energy is used for heating and preparation of hot sanitary water in the Benedikt area in the existing buildings, and in the buildings that will be erected in the future.

The sources of energy which will be replaced by geothermal energy (see Table 1).

In the Table 2, emission reduction data for the Municipality Benedikt are given for existing stage and for utilisation of geothermal energy inside the center of Benedikt (for 100% conversion and replacement of other fuels with geothermal energy). In the vicinity there are 40% of buildings or consumers with the existing system of heating.

The new buildings assumed to use the fossil fuel (Extra Light Fuel Oil - ELFO) were also considered in calculations presented in Table 2.

The major environmental impact will be experienced only during erection and construction campaign of the district heating system (Table 2). The difference between the existing and new technology is appreciable and the use of geothermal energy will bring a new quality of life to the residents of the Benedikt Municipality, and also new possibilities for environment friendly tourism and agriculture.

4. CONCLUSION

In 2004, geothermal well Be-2/03 has been drilled in the Benedikt place, and it yielded large amounts of thermal waters. Owing to a relatively high water temperature, the well could not have been tested in a reasonable financial framework. A possibility of partial hydrogeological well testing appeared with the construction of Stage I. of geothermal district heating. Testing results available at the present confirm that the energy capacity of geothermal well Be-2/03 far exceeds the present demands of the Benedikt Municipality.

Benedikt Municipality would like to solve energy supply in the area. With the construction of this district heating system the heating power will amount to about 3,3 MW with annual heat demand of 4200 MWh. The Stage I having the capacity of 700 kW is constructed in such a manner that allows expansion and the foreseen reserves for the following project phases.

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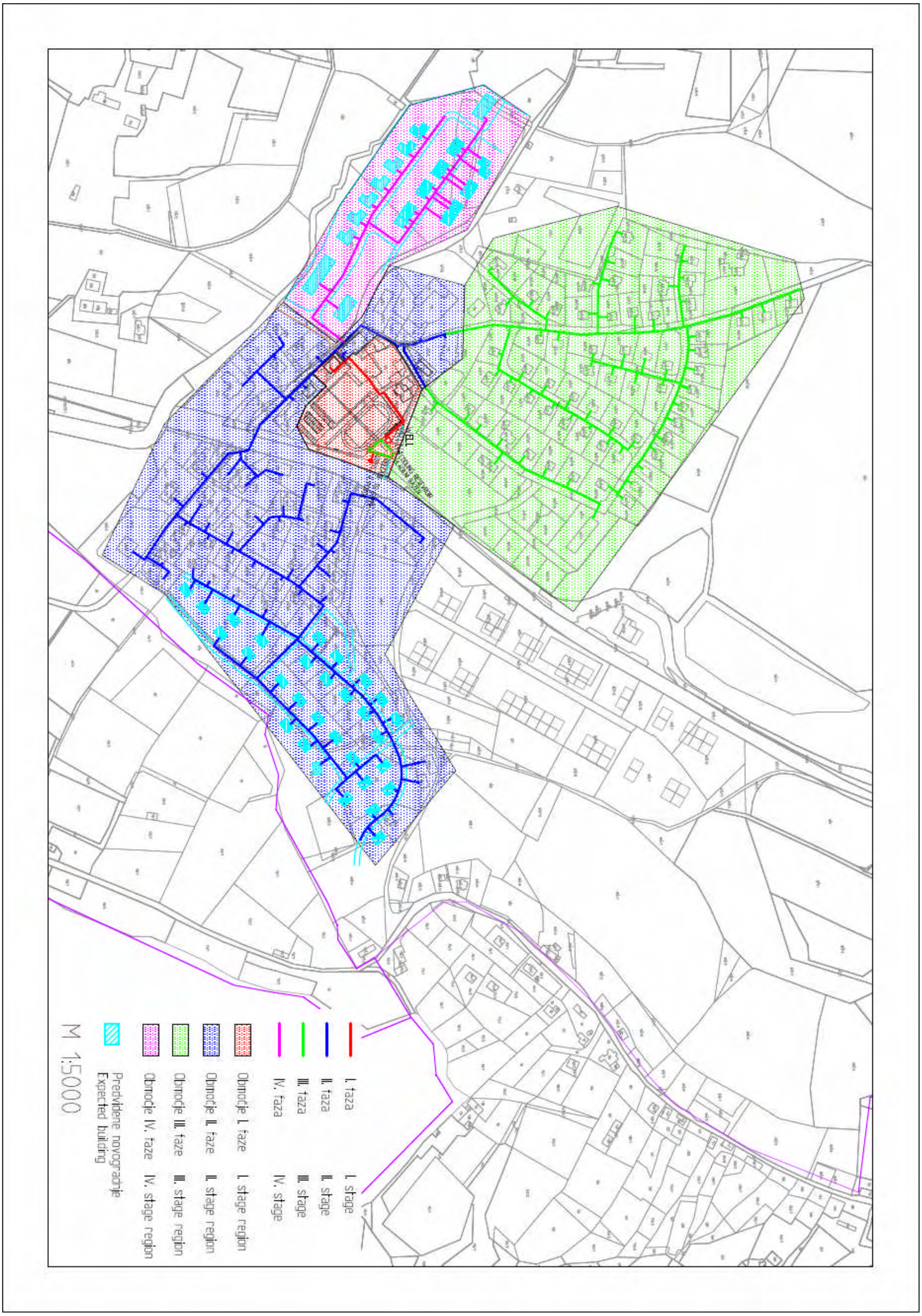

Figure 2: District heating system of Benedikt – The construction phases

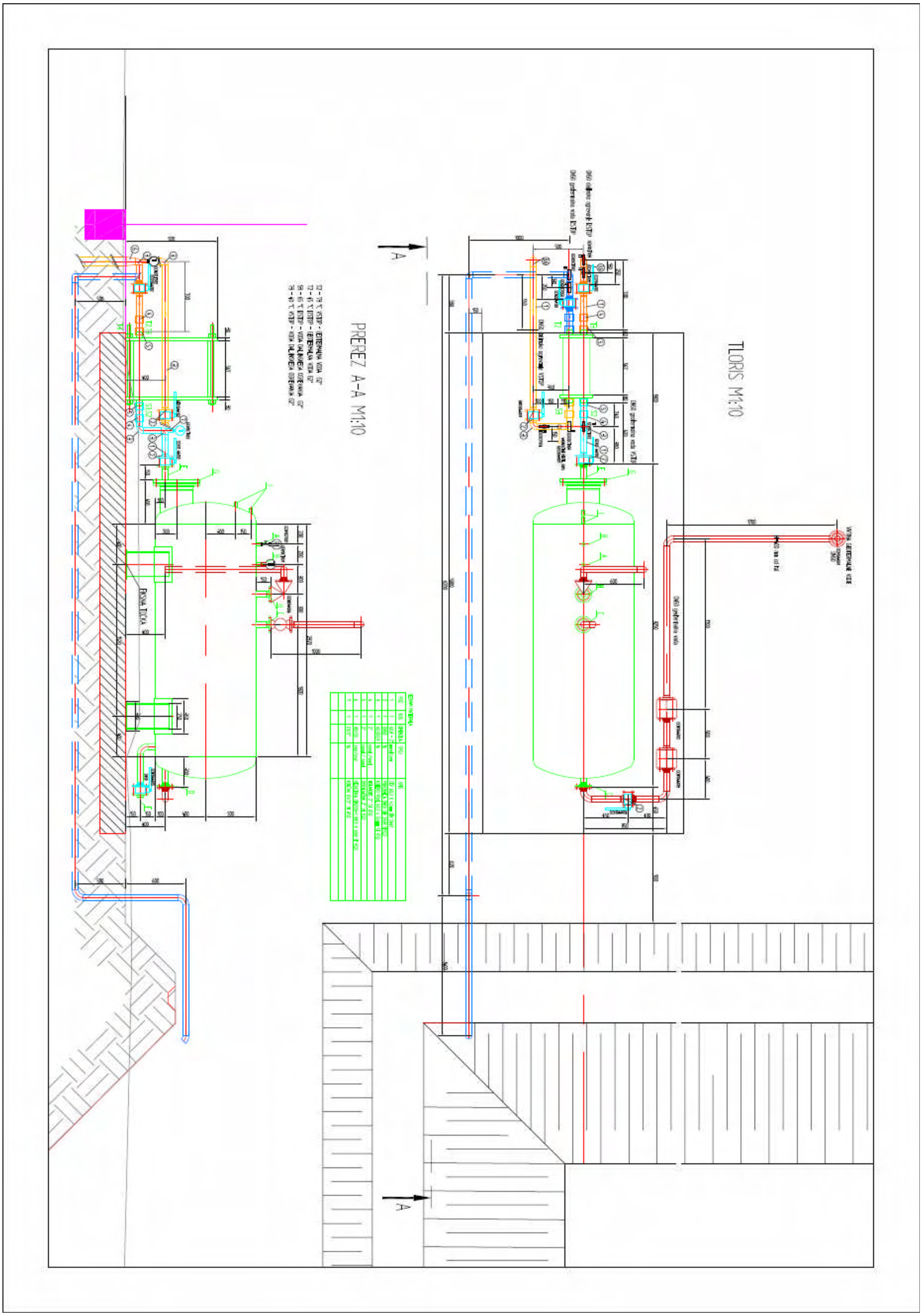

Figure 3: District heating system at geothermal well with geothermal water preparation and heat exchanger station

Table 1: Energy sources which will be replaced after the connection of buildings to the district heating system

Stage of project	Type of building	Estimation of the existing and planned (new buildings) usage of energy						
		ELFO	Wood	LPG	TOTAL	ELFO	Wood	LPG
		MWh/annual				liters	m^3	kg
Stage I	Public buildings	315	0	0	315	31.450	0	0
	Other non residential buildings	225	0	0	225	22.470	0	0
Stage I SUM		539	0	0	539	53.920	0	0
Stage II	Private houses, existing	284	412	59	755	28.350	196	4.596
	Public buildings	629	0	0	629	62.900	0	0
	Private houses, existing	136	197	28	361	13.568	94	2.200
	Private houses, planned	675	0	0	675	67.500	0	0
Stage II SUM		1.723	610	88	2.421	172.318	290	6.796
Stage III	Private houses, existing	648	943	136	1.726	64.800	449	10.506
Stage III SUM		648	943	136	1.726	64.800	449	10.506
Stage IV	Private houses, existing	126	0	0	126	12.600	0	0
	Public buildings	146	0	0	146	14.580	0	0
	Private houses, existing	470	0	0	470	46.950	0	0
Stage IV SUM		741	0	0	741	74.130	0	0
TOTAL		3.652	1.552	223	5.427	365.168	739	17.302

Table 2: Emission reduction owing to geothermal energy district heating system construction

	Existing	After project	Difference	
	(kg/a)	(kg/a)	(kg/a)	(%)
SO_2	1.506	462	-1.045	-69,3
NO_x	1.030	299	-730	-70,9
CO	58.142	23.060	-35.082	-60,3
Dust	808	309	-499	-61,7
C_xH_y	9.544	3.789	-5.754	-60,3
CO_2	2.032.613	593.404	-1.439.210	-70,8
TOTAL	2.103.643	621.323	-1.482.321	-70,5