PILOT PLANT GEOTHERMAL PROJECT FOR MULTIPLE INTEGRATED USE IN HUNGARY

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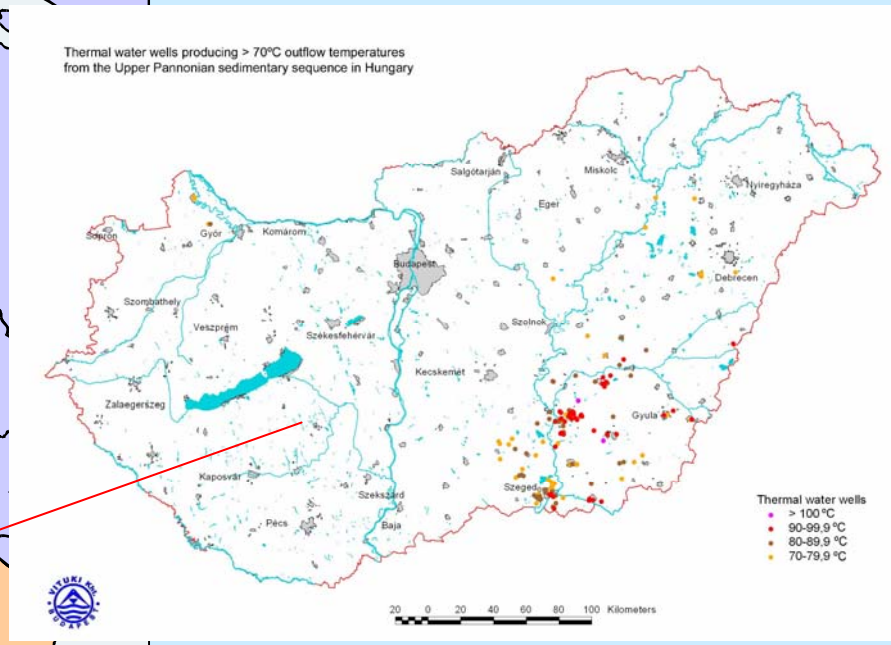

Thermal water wells producing > 70°C outflow temperatures
from the Upper Pannonian sedimentary sequence in Hungary
Salgótarján
Miskolc
Nyíregyháza
Eger
Sopron
Győr
Komárom
Budapest
Debrecen
Szombathely
Veszprém
Székesfehérvár
Szolnok
Kecskemét
Zalaegerszeg
Gyula
Kaposvár
Szeged
Szekszárd
Pécs
Baja
Thermal water wells
> 100 °C
90-99,9 °C
80-89,9 °C
70-79,9 °C
20 0 20 40 60 80 100 Kilometers

Hungary

Outline

Water resources
- thermalkarstic and sandstone porous sediments

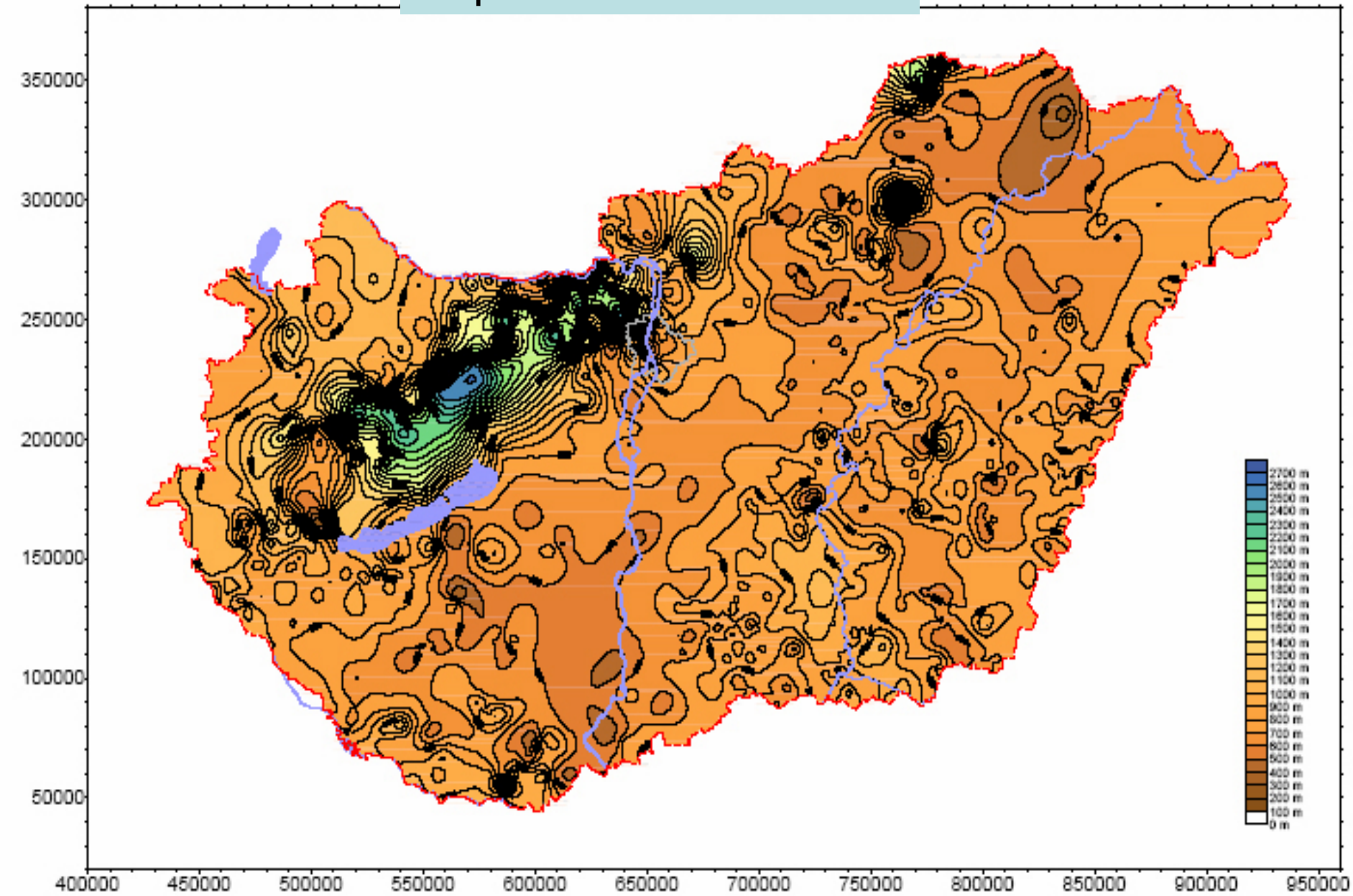
Utilization of thermal wells
- agriculture, secondary- multipurpose heat utilization

Energy sources (statistic)

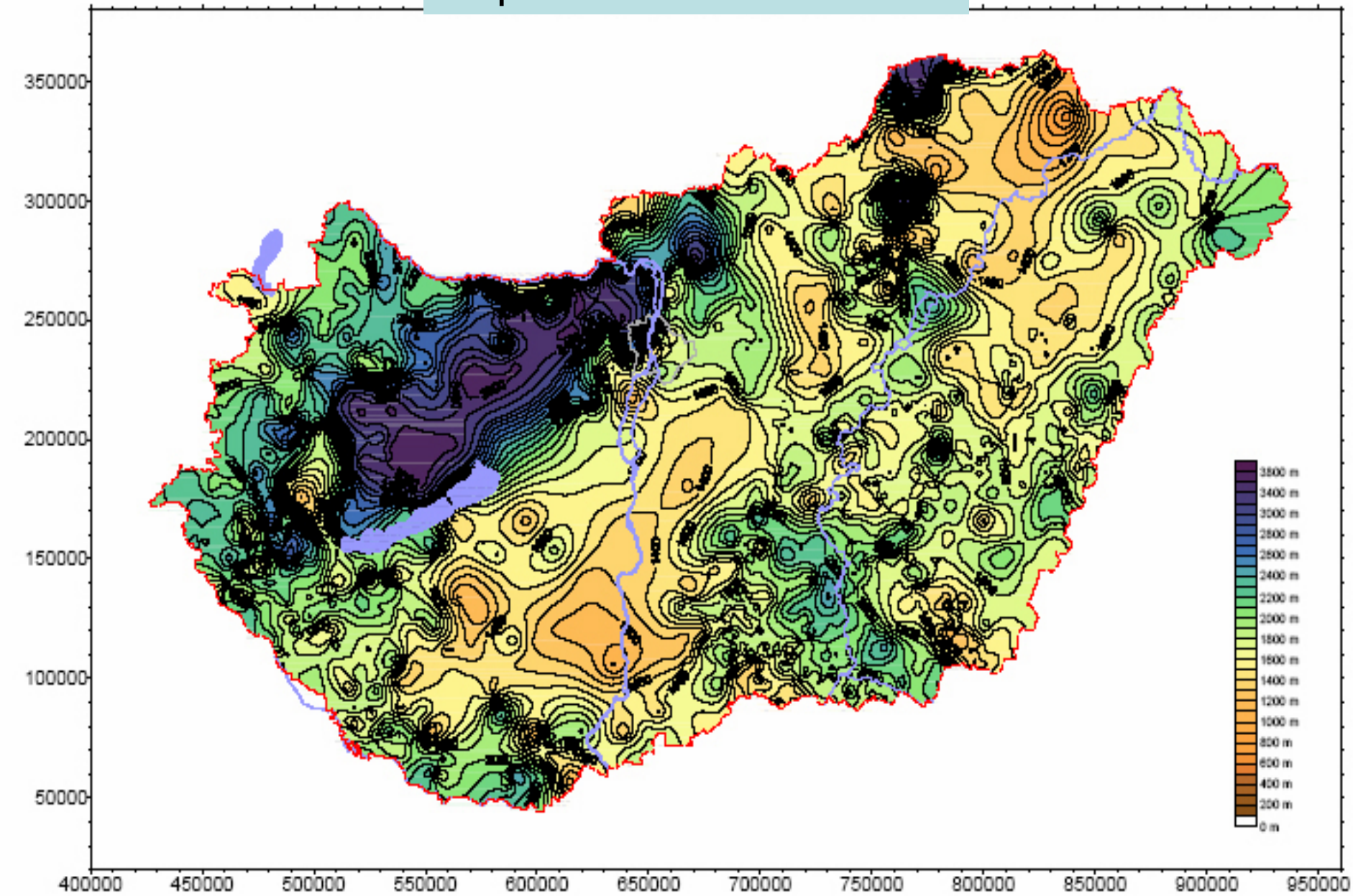
Pilot plant project

Future plan

Depth of 50 °C isotherm



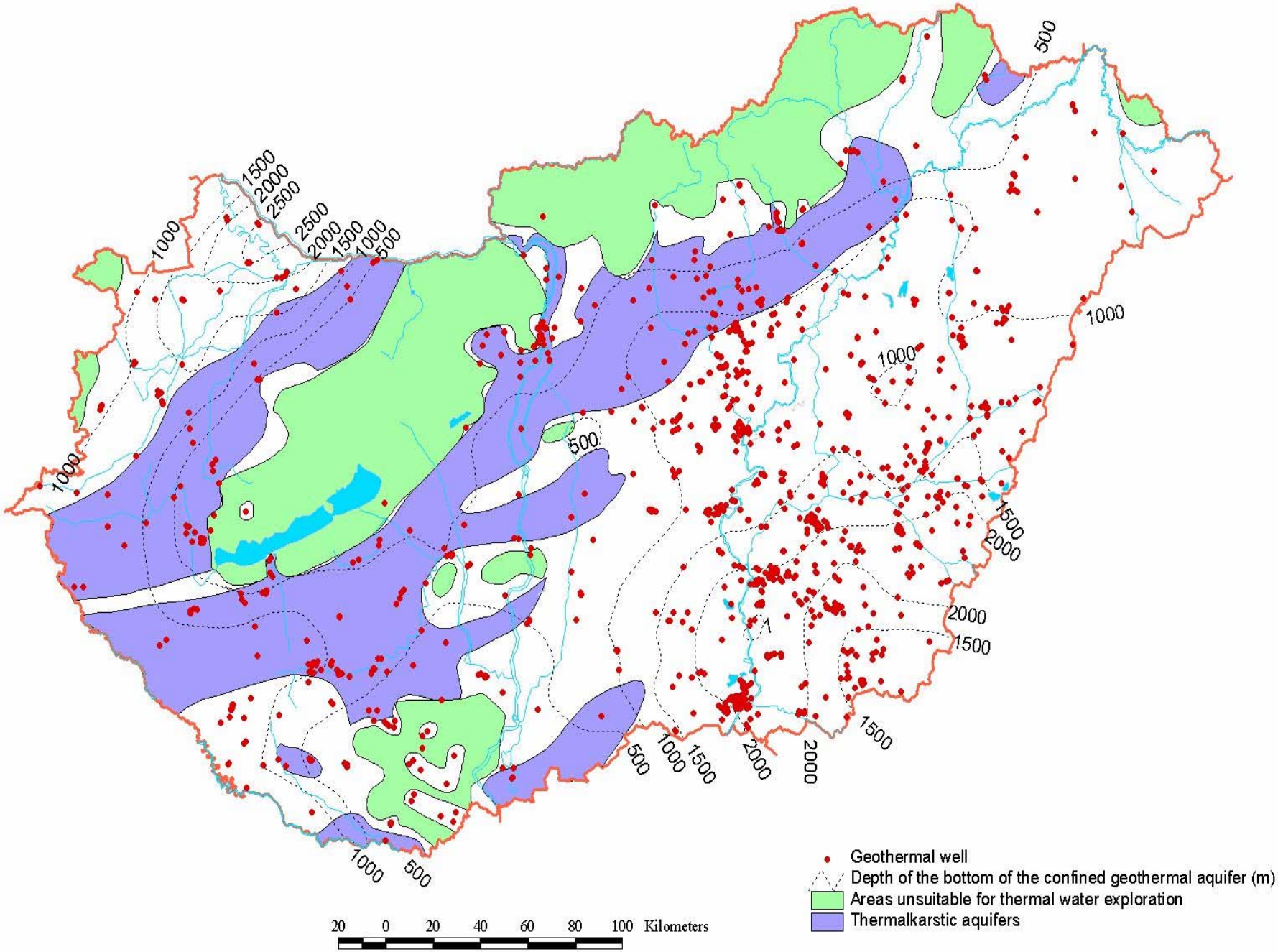
Depth of 100 °C isotherm



Hungary is well-known as a country of favorable conditions in terms of thermal and mineral water resources with a geothermal gradient higher than the World average.

As a consequence of the abnormally thin lithosphere the heat flux is above the average for the continent and the mean geothermal depth-step of 20 m/^{0}C is steeper than the normal 30–33 m/^{0}C value.

Hungary has one of the biggest underground water reserves and geothermal energy potential of low and medium enthalpy in Europe.


Geothermal well
Depth of the bottom of the confined geothermal aquifer (m)
Areas unsuitable for thermal water exploration
Thermalkarstic aquifers
20 0 20 40 60 80 100 Kilometers

The major geothermal reservoir (87% of the utilized thermal water resources) is located in the Upper Pannonian (Pliocene) sandstone formations, the depth of which reaches 2800 meters.

The temperature of the outflowing water obtained from this reservoir may have ranging from 30 to 99^{0}C depending on the aquifer depth and the local geothermal gradient.

The waters of the Upper Pannonian porous sediments are of alkaline bicarbonate type with low mineralization (in general the TDS less then 3000 mg/l).

Geothermal reserves and present utilization data for Hungary

The geothermal reserves of Hungary have been identified by geological exploration and by wells drilled for thermal water management and for hydrocarbon exploration. (over 85% of Hungary's drinking water comes from deep wells)

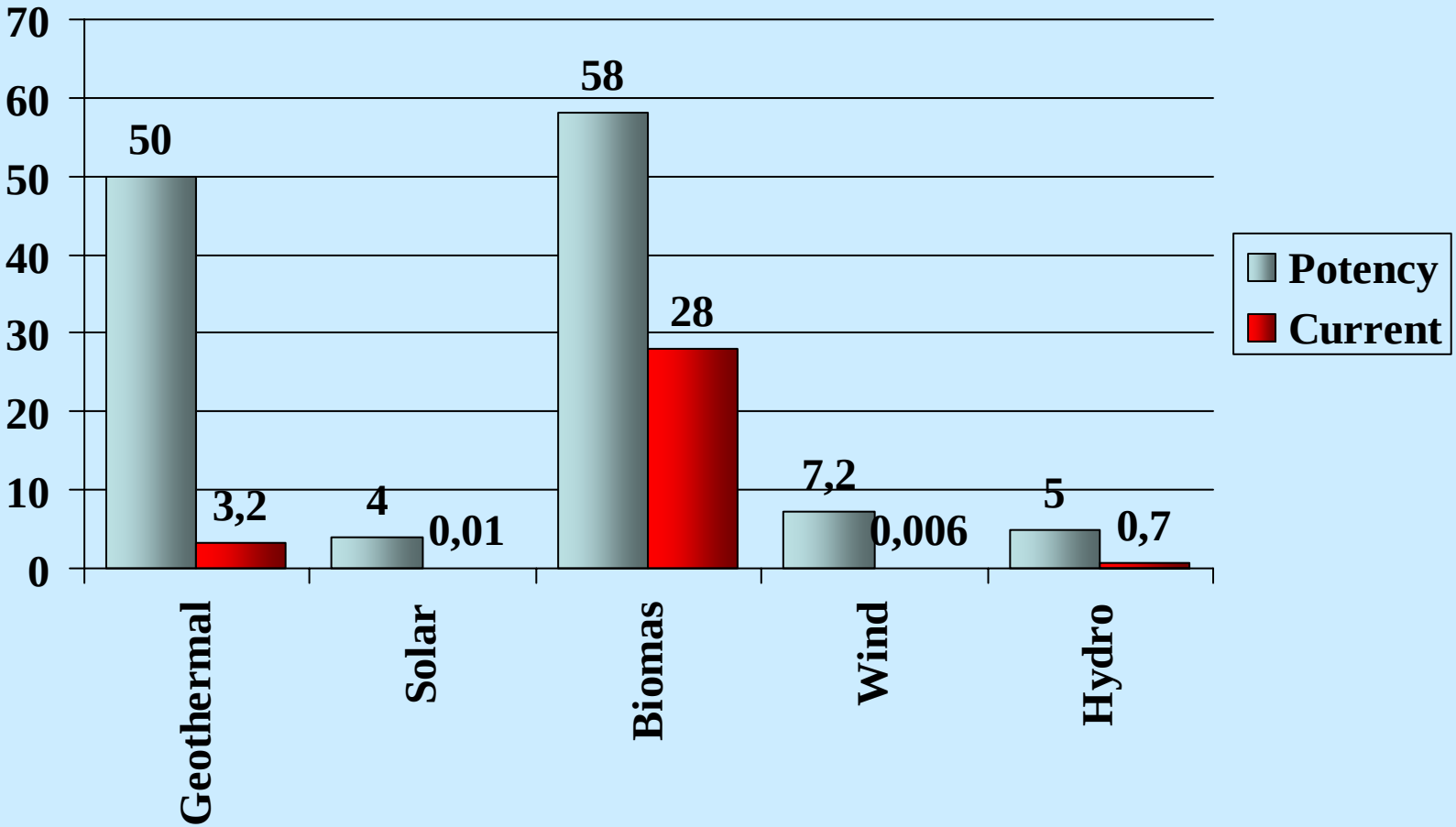
More than 1200 geothermal and approx. 10,000 oil and gas wells have provided reliable information on the existence of geothermal reserves.

In 2005 the production of geothermal fluids was >22 million m^3, **68%** of which is represented by thermal water with temperatures of **30–50°C utilized for health and recreational bathing and drinking water supplies,**

the remaining **33% being utilized for greenhouse heating, space heating, sanitary hot water supplies, etc.**

The summarized data relative to direct use in Hungary was slightly increased
utilization of geothermal heat was **decreased in agriculture** and **increased in communal heating and SHW supply**.

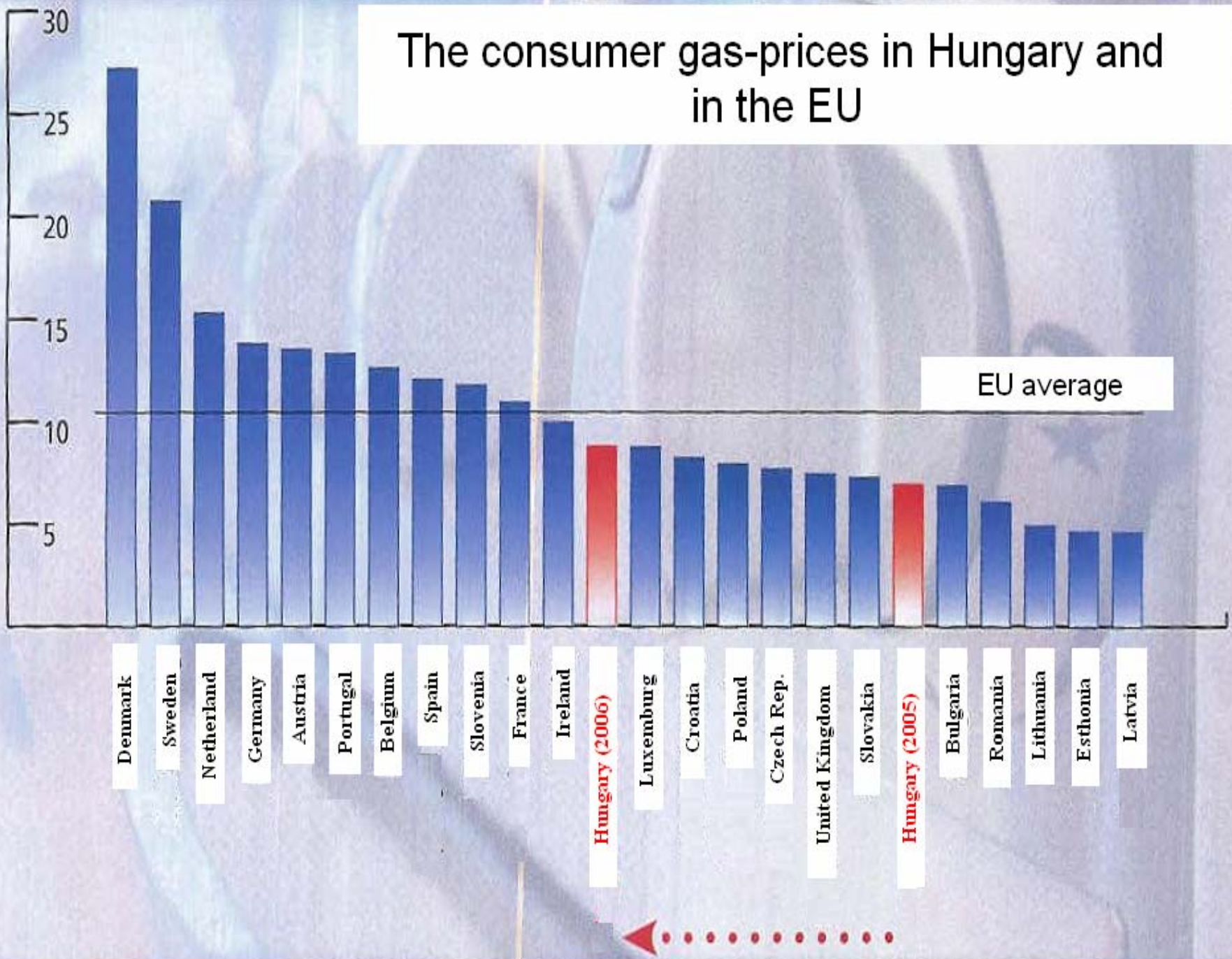
Renewable energy resources in Hungary (PJ/year)



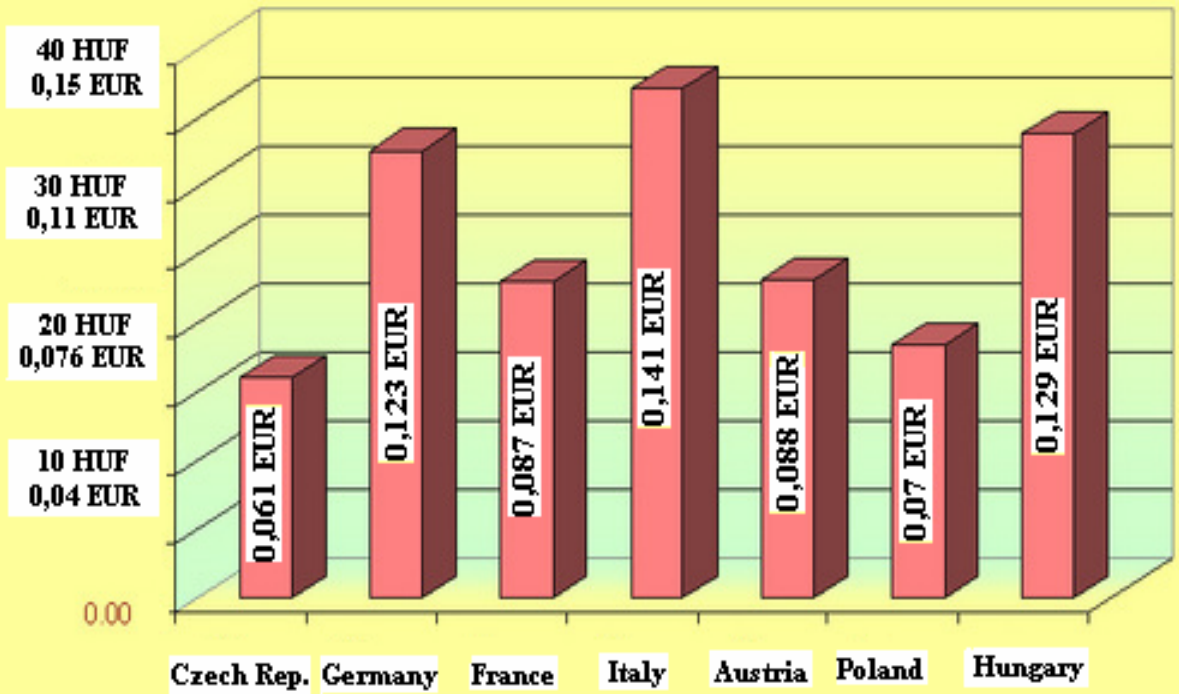
Percentage of renewable resources in the EU and Hungary

• Austria	24,3%	• Luxembourg	1,4%
• Belgium	1,0%	• Germany	1,8%
• Denmark	7,3%	• Italy	5,5%
• England	0,7%	• Portugal	15,7%
• Finland	21,3%	• Spain	5,7%
• France	7,1%	• Sweden	25,4%
• Greece	7,3%	• E U sum	5,3%
• Netherlands	1,4%		
• Ireland	2,0%	• Hungary	3,5%

The consumer gas-prices in Hungary and in the EU



Consumer electricity price in the EU (Euro cent/kWh)



Source: KSH (Hungary), 1st. July, 2005
7500 kWh/year
1EUR = 262 Ft

The Hódmezővásárhely PPP project's great success needed all the professional experiences, elaborate planning and continuous development

Development phases

1. SHW well (1994), heating well (1996) and distribution network: development of the public utility system

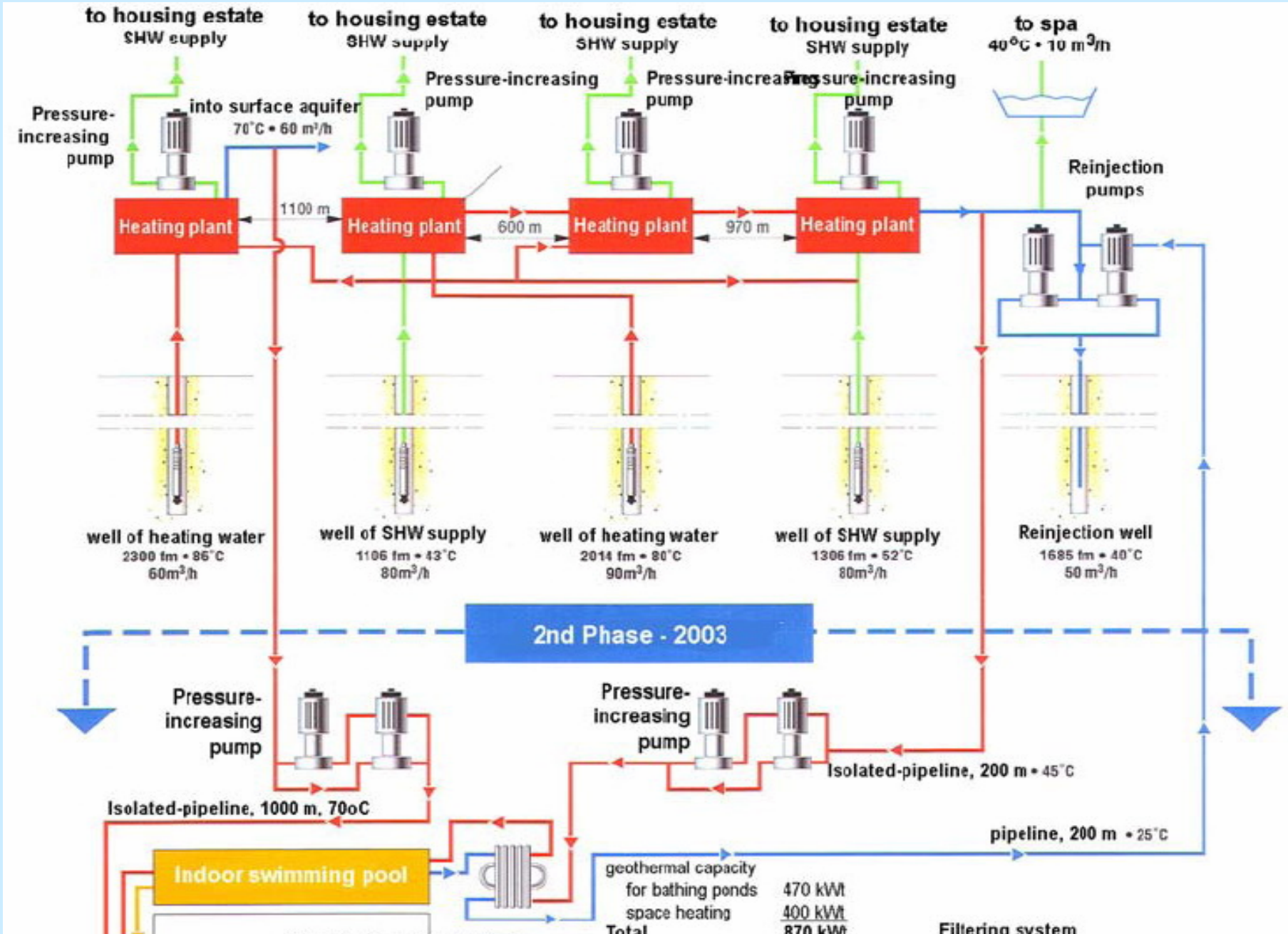
2. Installation of reinjection well I. (1998), first phase of the complex geothermal public utility system (4 SHW and DH system). Historical cost: HUF 305M (EUR 1,22M)

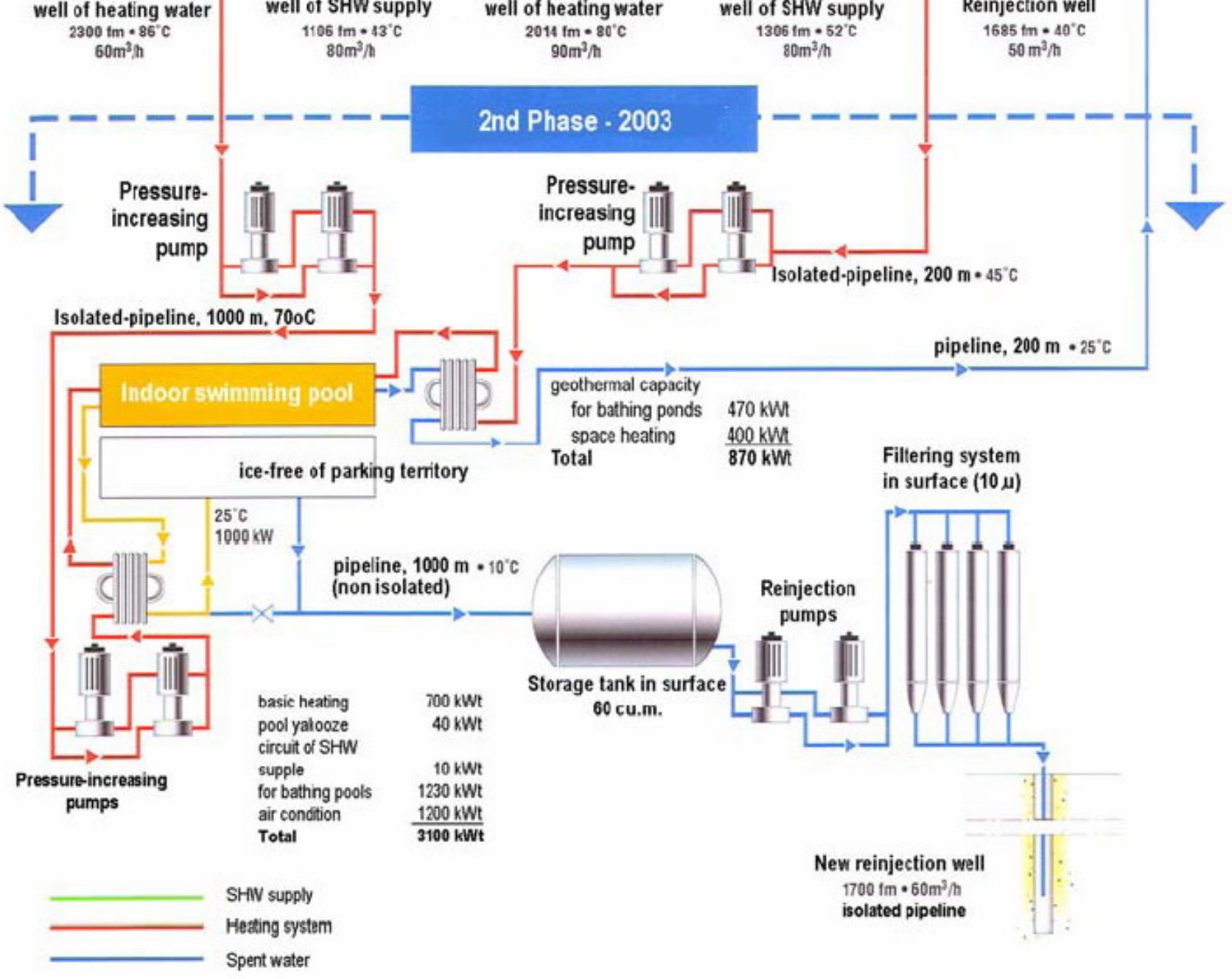
3. 2003: The utilisation of rest (refuse) water at the (GreenFieldInv) indoor swimming pool as SHW and DH at HC HUF 130M (EUR 0,52M) – phase II

4. Additional reinjection well at an estimated cost of HUF 126M (EUR 0,5M) – end of phase II

Outcome - environmental

- Implementation cost of the 10 MW geothermal energy project on 2005 price is HUF 800 M (EUR 3,2M), with only 10% financial support
- Reduction of 2,5M m^3 (imported) gas utilisation / year (CO:6t, SO_2:75t, NO_2:19t, dust:15t) in the city centre
- The cheapest way of CO_2 reduction
- 1,5M m^3 reinjected water during 7 years
- Reduction of use of drinking water reserves


to housing estate
SHW supply
to housing estate
SHW supply
to housing estate
SHW supply
to housing estate
SHW supply
to spa
40°C • 10 m³/h
Pressure-increasing pump
into surface aquifer
70°C • 60 m³/h
Pressure-increasing pump
Pressure-increasing pump
Pressure-increasing pump
Reinjection pumps
Heating plant
1100 m
Heating plant
600 m
Heating plant
970 m
Heating plant
well of heating water
2300 fm • 86°C
60m³/h
well of SHW supply
1106 fm • 43°C
80m³/h
well of heating water
2014 fm • 80°C
90m³/h
well of SHW supply
1306 fm • 52°C
80m³/h
Reinjection well
1685 fm • 40°C
50 m³/h
2nd Phase - 2003
Pressure-increasing pump
Pressure-increasing pump
Isolated-pipeline, 200 m • 45°C
Isolated-pipeline, 1000 m, 70oC
pipeline, 200 m • 25°C
Indoor swimming pool
geothermal capacity
for bathing ponds 470 kWt
space heating 400 kWt
Total 870 kWt
Filtering system


well of heating water
2300 fm • 86°C
60m³/h
well of SHW supply
1106 fm • 43°C
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Isolated-pipeline, 1000 m, 70oC
pipeline, 200 m • 25°C
Indoor swimming pool
geothermal capacity
for bathing ponds 470 kWt
space heating 400 kWt
Total 870 kWt
ice-free of parking territory
25°C
1000 kW
pipeline, 1000 m • 10°C
(non isolated)
Filtering system in surface (10 μ)
Reinjection pumps
Storage tank in surface
60 cu.m.
Pressure-increasing pumps
basic heating 700 kWt
pool yalooze 40 kWt
circuit of SHW supple 10 kWt
for bathing pools 1230 kWt
air condition 1200 kWt
Total 3100 kWt
New reinjection well
1700 fm • 60m³/h
isolated pipeline
SHW supply
Heating system
Spent water

Hódmezővásárhely PPP project

Outcome – economic, phase I

- **3000 flats** equivalent residential and institutional SHW (~1MW)
- **50% of district heating** of those residential areas and **100% of hospital and connecting institution** is provided by geothermal energy
- Heating of outdoor sport swimming pool and partly supply of thermal baths
- **Partly reinjection** of potential cooled water

Outcome – economic, phase II

- The greenfield investment of the indoor swimming pool was planned to **use the rest water energy (40-45°C)** – 2000m heat isolated pipeline and 4MW additional heat energy
- **De-iced parking lot**
- **Reinjection of all energetically utilised water** (reinjection well II. is starting its operation in 2007)

- Comprehensive IT control and automatic guidance in the dispatcher centre
- 1,5M m^3 reinjected water in the last 7 years with 3-4 bar pressure (2005: further decreasing)
- All spent water which formally was environmentally unfriendly disposed is reinjected
- **All types of endusers receive heat and hot water cheaper in comparison with gas equivalence**
- The average gas based price of hot water in 2004 is HUF 390 / m^3 (EUR 1,56)
- The actual total cost price of hot water in 2004 is HUF 70 / m^3 (EUR 0,28) – 18%
- The average gas based price of 1GJ heating energy is HUF 1500 (EUR 6)
- The actual total cost price of 1GJ heating energy is HUF 550 (EUR 2,2) – 36%
- **The return period of investment is 6-7 years**

AQUAPLUS

Reinjection of waste water is the only safe and environment friendly solution!

- Traditional methods of used water disposal:
  - Into public sewage systems;
  - Into systems for inland water and precipitation;
  - Other surface disposition (through cooling ponds);
  - Directly into the rivers.
- Problems
  - Damages by salt;
  - Damages by geothermal heat;
  - Sinking of water level in the production wells.
- There is enough information to pre-calculate reinjection costs and the know-how to operate it safely, environmentally friendly and profitably

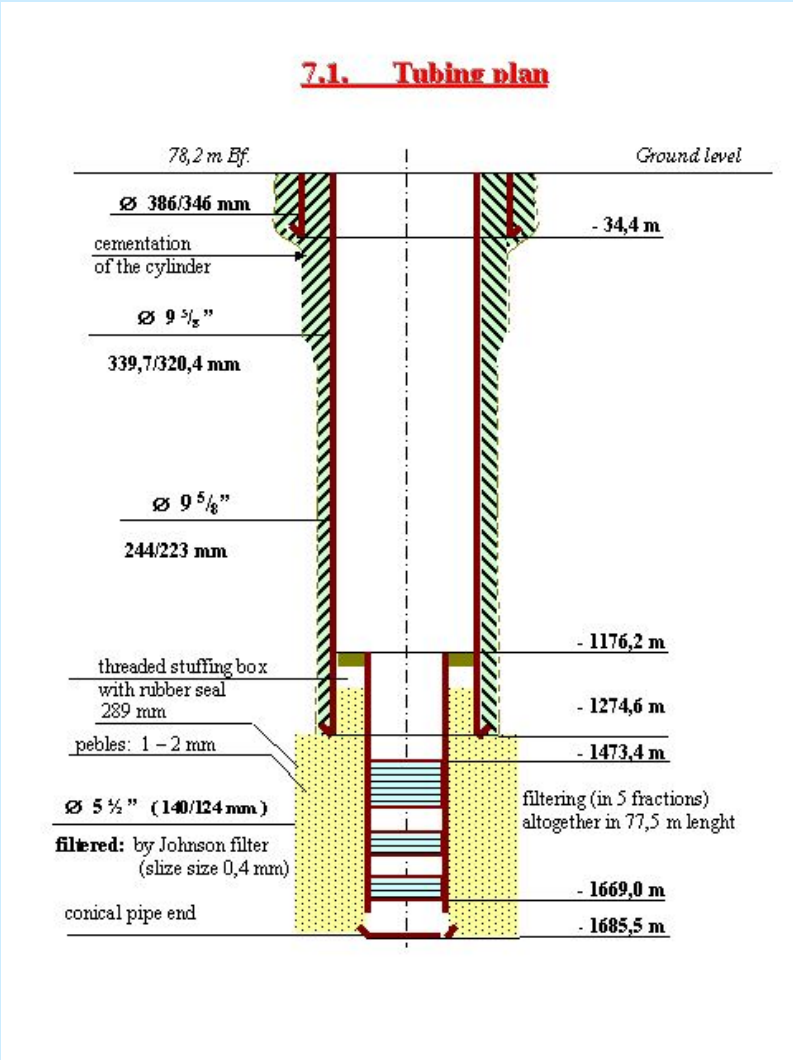
Running costs of reinjection

- **Electricity (0,2 kWh/m^3)** **0.014 Euro/m^3,**
- **Textile filter** **0.025 Euro /m^3,**
- **Labour cost of screen changing** **0.0007 Euro /m^3,**
- **Surface equipments service** **0.0007 Euro /m^3,**
- **Service of reinjection well** **0.053 Euro m^3**
- **Total cost of reinjection 0.1 Euro /m^3, i.e. 0.64 Euro /GJ, 1GJ cost produced by gas recently 3.57-4.64 Euro.**
- **Reinjection pressure has been 3-4 bar for 7 years and it decreased in January of 2005!**
- **Reinjection technology in karst rocks was already solved, today the economical reinjection technology in pannonian sandstone also seems to be solved.**

Environmentally friendly disposal of waste water

Main aspects of the establishment and operation of wells:

- Suitable site and proper depth ;
- Process of casing has to meet the optimal hydrodynamic and energetic requirements;
- Importance of filtering technology, both on surface (prefiltering) and in the well;
- During well drilling close attention must be paid to the protection of the filtered layer and to the mud technology (mud loss in certain formations);
- Application of production technology avoiding hydraulical vibration around filter frame and its maintenance;
- Permanent monitoring and recording of operational parameters.



Heat pump systems in Hungary

- The implementing of the heat pump systems depends on the gas and electricity prices.
  - gas price: less than in the EU (price support)
  - electricity: at same level in the EU (no supported electricity price for heat pump systems)

- hindering ‘activity’ of very strong natural gas lobby
- preferential electricity price for heat pumps
- The equalisation of the Hungarian and the EU gas-prices will increase the spreading of the heat pump systems in large scale

The process of the geothermal heat pump systems in Hungary

- 2003 – first small and medium sized heat pump systems (20-50 units).
  - First regulations for closed-loop ground source heat pump systems.
  - Harkány Thermal Spa: installed capacity – 2,2 MW.
- 2004 – larger heat pump systems with 100-300 kW capacity (50-100 units)
- 2005 – family houses, industrial buildings up to 300-600 kW capacity (150 units)
- 2006 – Office/business buildings up to 800 kW capacity (200 units)

Total installed capacity: ~ 7,5 – 10 MW (the calculation based on selling data because most of the heat pump systems have no license).

The distribution of the heat pump systems in Hungary

- Closed loop type: 50 – 60 %
- Open systems (groundwater): 30 – 40 %
- Thermal water: 10 %

There is big possibility for the multistage utilization of the thermal water in Hungary.

The multistage utilization is supported by the Ground Heat Program (starting phase).

Conception: to enhance the proportional rate of thermal energy from 3,6 PJ to 10 PJ by 2013.

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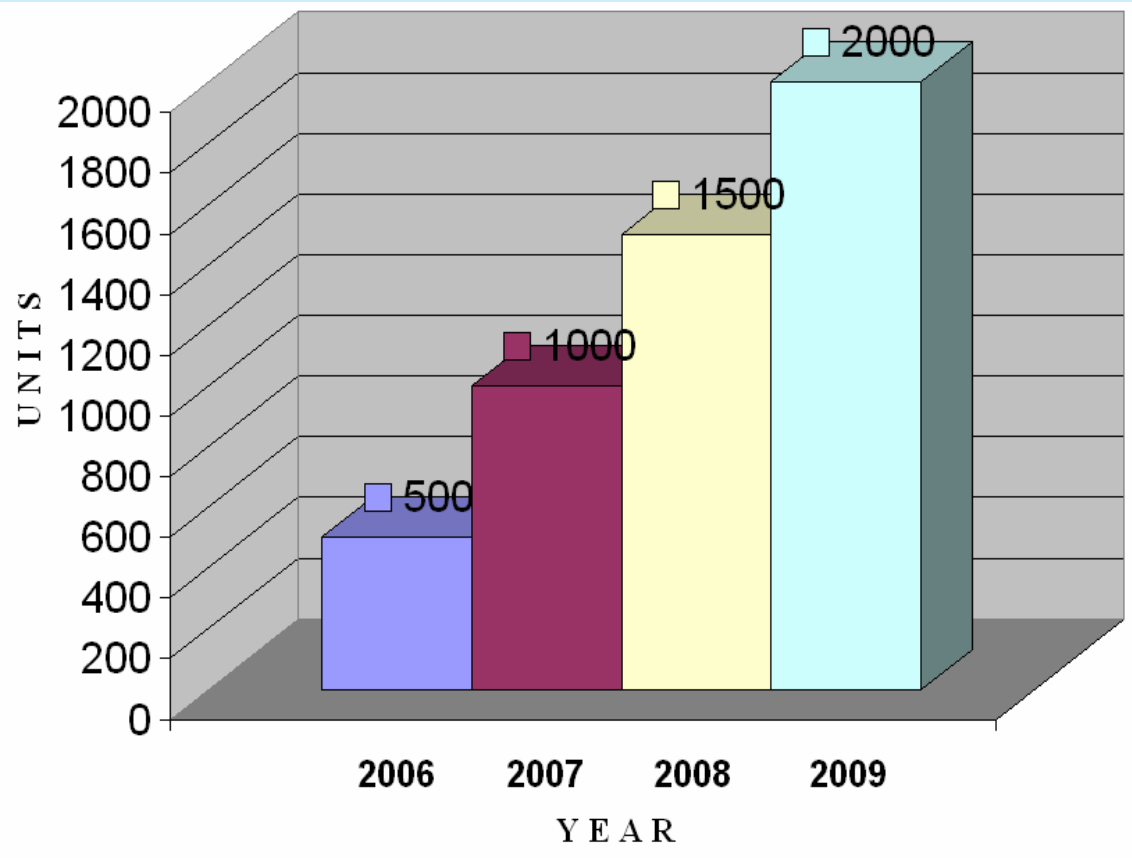
Payback time of the additional investment

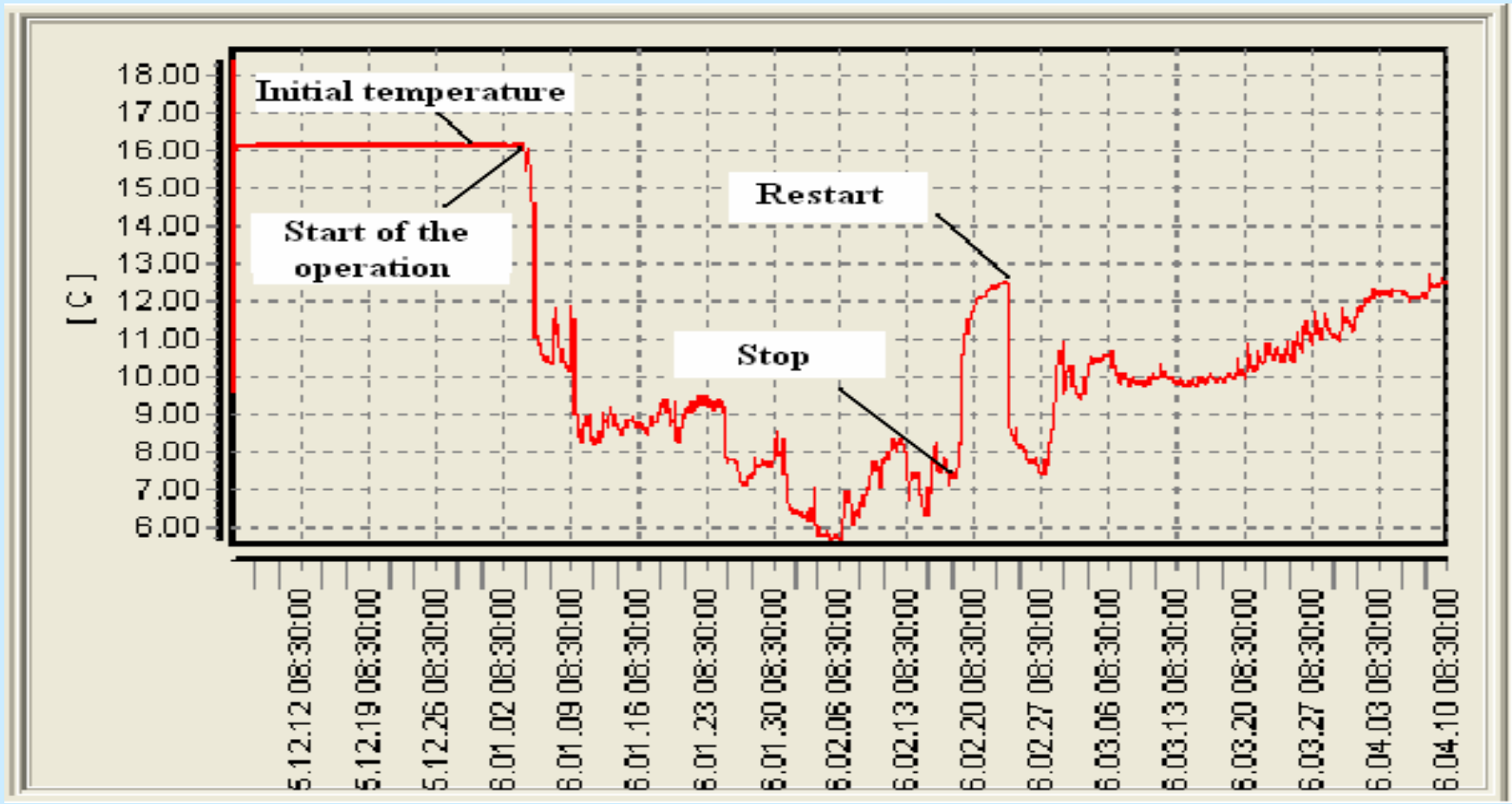
- Family house
  - 11 kW (not supported): 10 years
  - 11 kW (supported): 7 years
- Industrial building
  - 70 – 100 kW (not supported): 7,7 years
  - 70 – 100 kW (supported): 3,2 years

Future activity plan

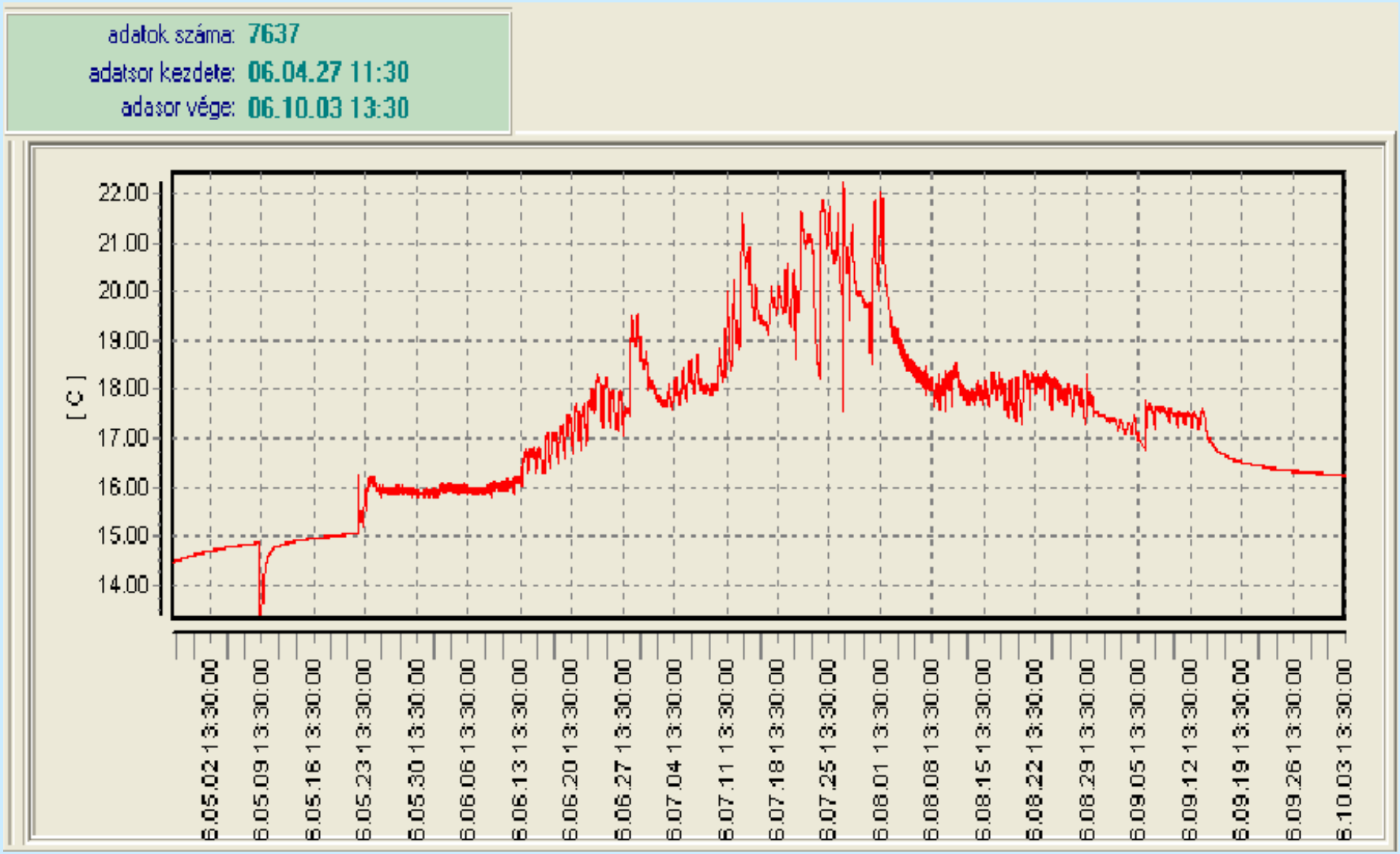


Thermal Response Test and Monitoring systems of the large projects are introduced by the market leading desinger and installing companies

Budapest X. district, Oriental Herbs Company **heating period**



Budapest X. district, Oriental Herbs Company
cooling period



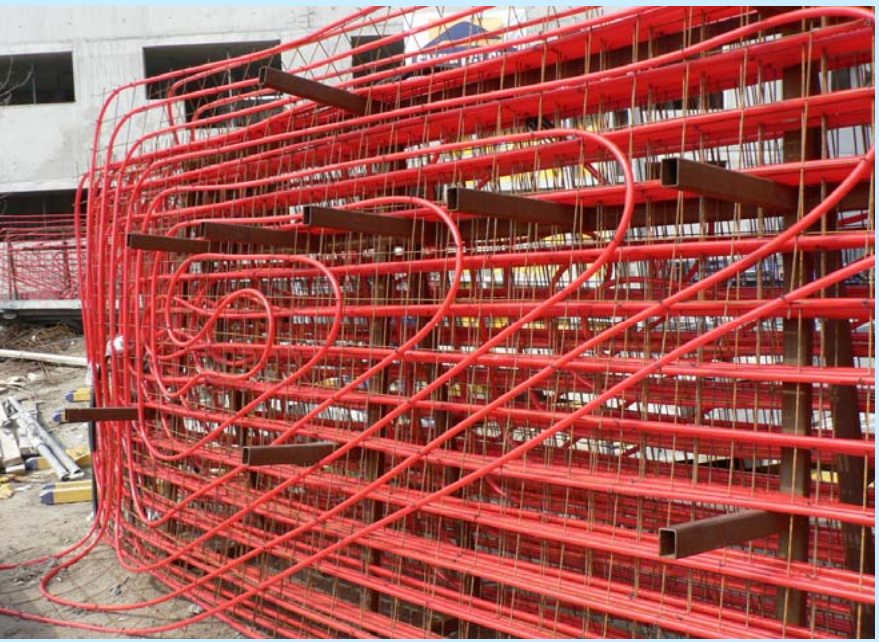
Recently the largest Hungarian geothermal heat pump project: Raiffeisen Bank Office

Heating capacity: 500 kW

Cooling capacity: 818 kW

Number of BHE: 81 vertical loops

Type of BHE: double ‘U’ tube, each 100 m deep



Thank you