Iceland Liechtenstein Norway grants

Norway grants

Project User4GeoEnergy

Improving the energy efficiency of geothermal energy utilisation by adjusting the user characteristic

Leszek Pająk

the project manager

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The overview of the project

MEERI PAS

GeoModel conference,
Kraków, 5 September 2023

General information about the Project

- *Financing:* 90% Fund EEA and Norway Grants Fund for Regional Cooperation + 10% own contribution,
- ***Fund priority sectors:*** **Environment, Energy, Climate Change and Low Carbon Economy**,

- *Project title:*

Improving the energy efficiency of geothermal energy utilisation by adjusting the user characteristics
Project index number 2018-1-0502

- The lead partner organisation Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Country of the lead partner organisation Poland

- **Start date of implementation 01/10/2020**, end date of implementation 30/09/2023, **duration 36 months**
- ***Total eligible Project costs*** **1.319.681 €**; *maximum requested grant amount* 1.215.217 €

General information about the Project

THE CONSORTIUM consists of 2 donor members and 3 beneficiary partners.

Donor members

With Iceland in the forefront of high and medium enthalpy geothermal use and **National Energy Authority (NEA, Iceland)**

Norway leading the way in low enthalpy applications.
NORCE Norwegian Research Centre AS are included in the consortium as expertise partners and sources of capacity building.

ORKUSTOFNUN
National Energy Authority

NORCE

General information about the Project

The consortium consists of 2 donor members and 3 beneficiary partners.

Beneficiary partners

Mineral and Energy Economy Research Institute, Polish Academy of Sciences **(MEERI PAS, Poland)** is the lead partner and the primary expert of the innovation.

A market leading geothermal operator **SLOVGEOTERM** is responsible for all activities carried out in **Slovakia** and will lead data gathering activities.

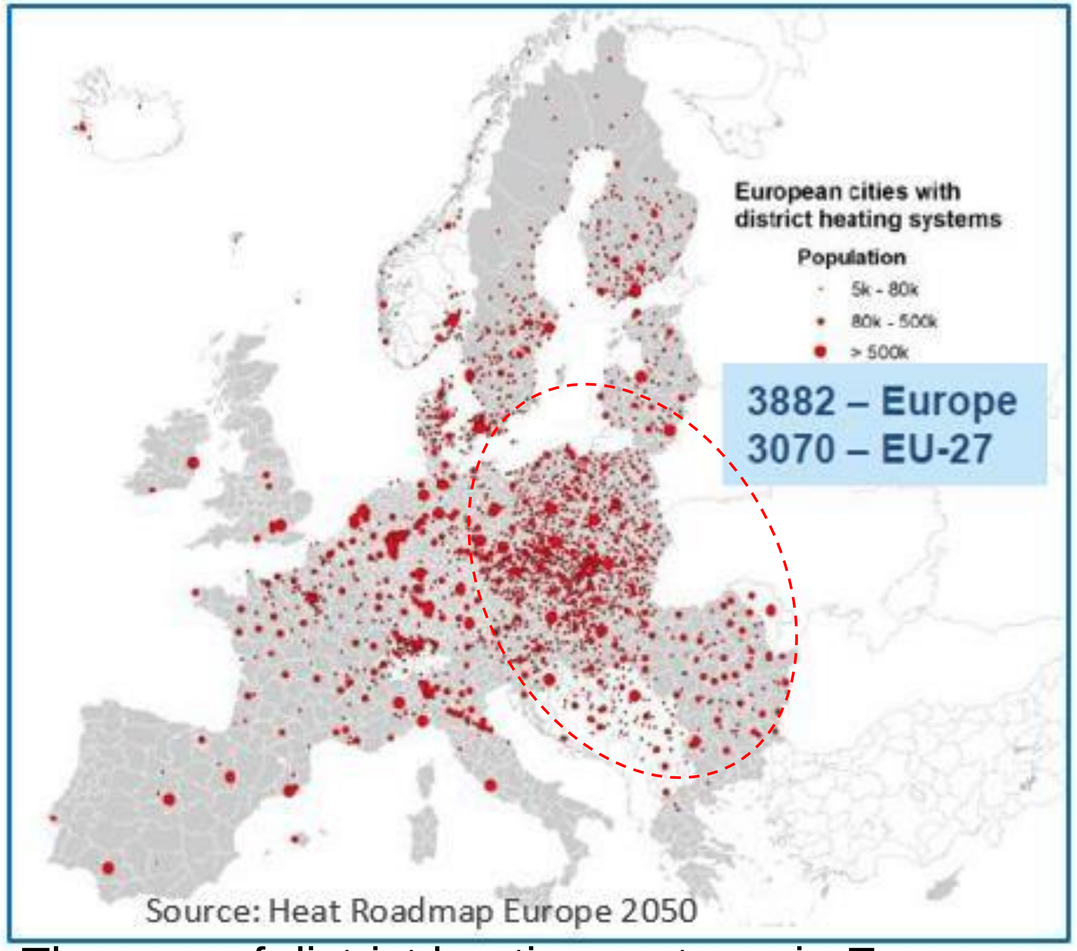
INNOGEO is a research non-profit responsible for engaging **Hungarian** stakeholders and designing the operation of the Geothermal District Heating Service Hubs.

Mineral and Energy Economy Research Institute
Polish Academy of Sciences

SLOVGEOTERM a.s.

InnoGeo

Design parameters standards for energy users and district heating grids



The map of district heating systems in Europe

USERS

Typical design users' heating systems:
- older 90/70°C,
- new based on radiators 70/55°C,
- new high surface (eg. floor heating) 38/30°C,
- entirely possible from the technical point of view 35/28°C.

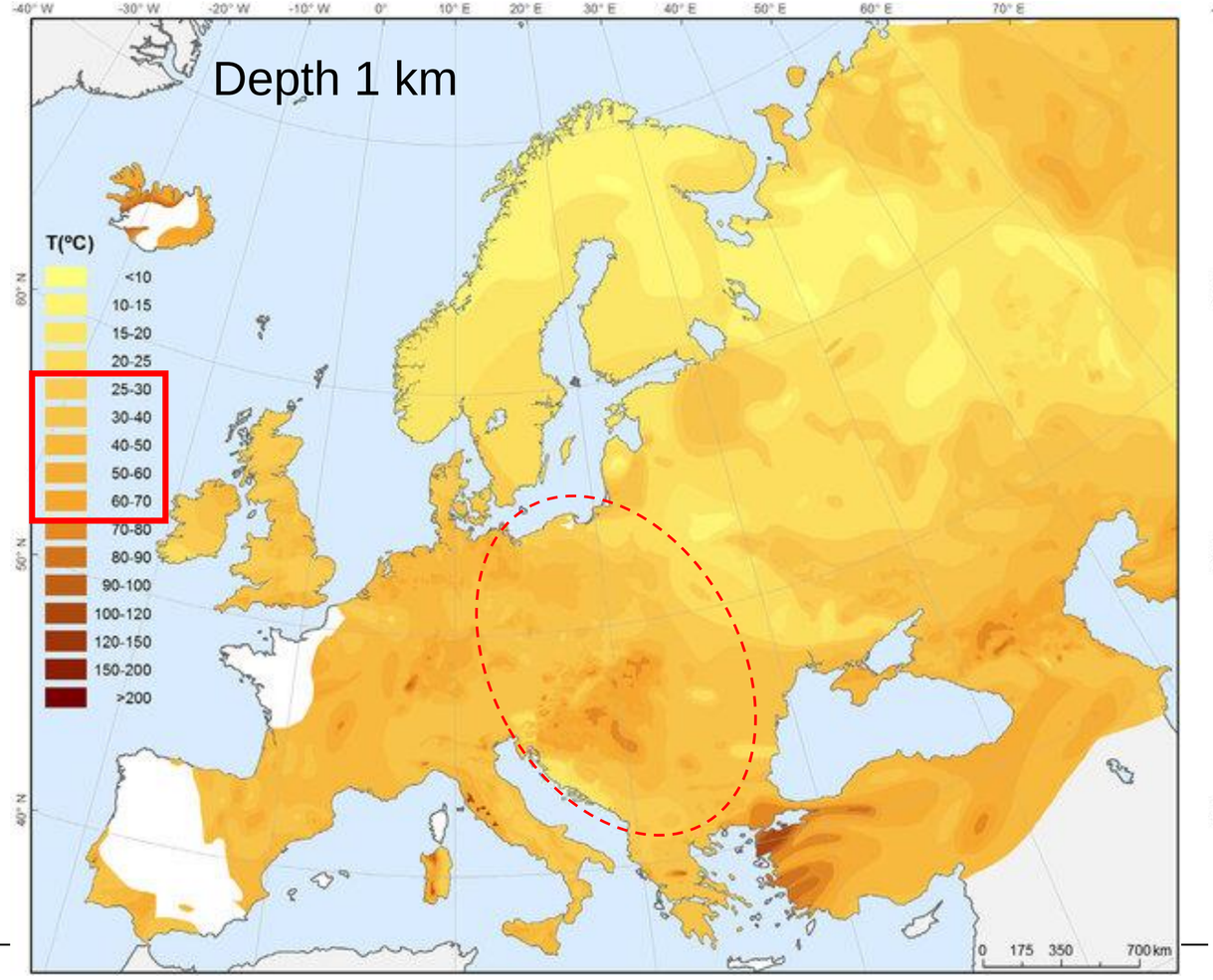
DH systems

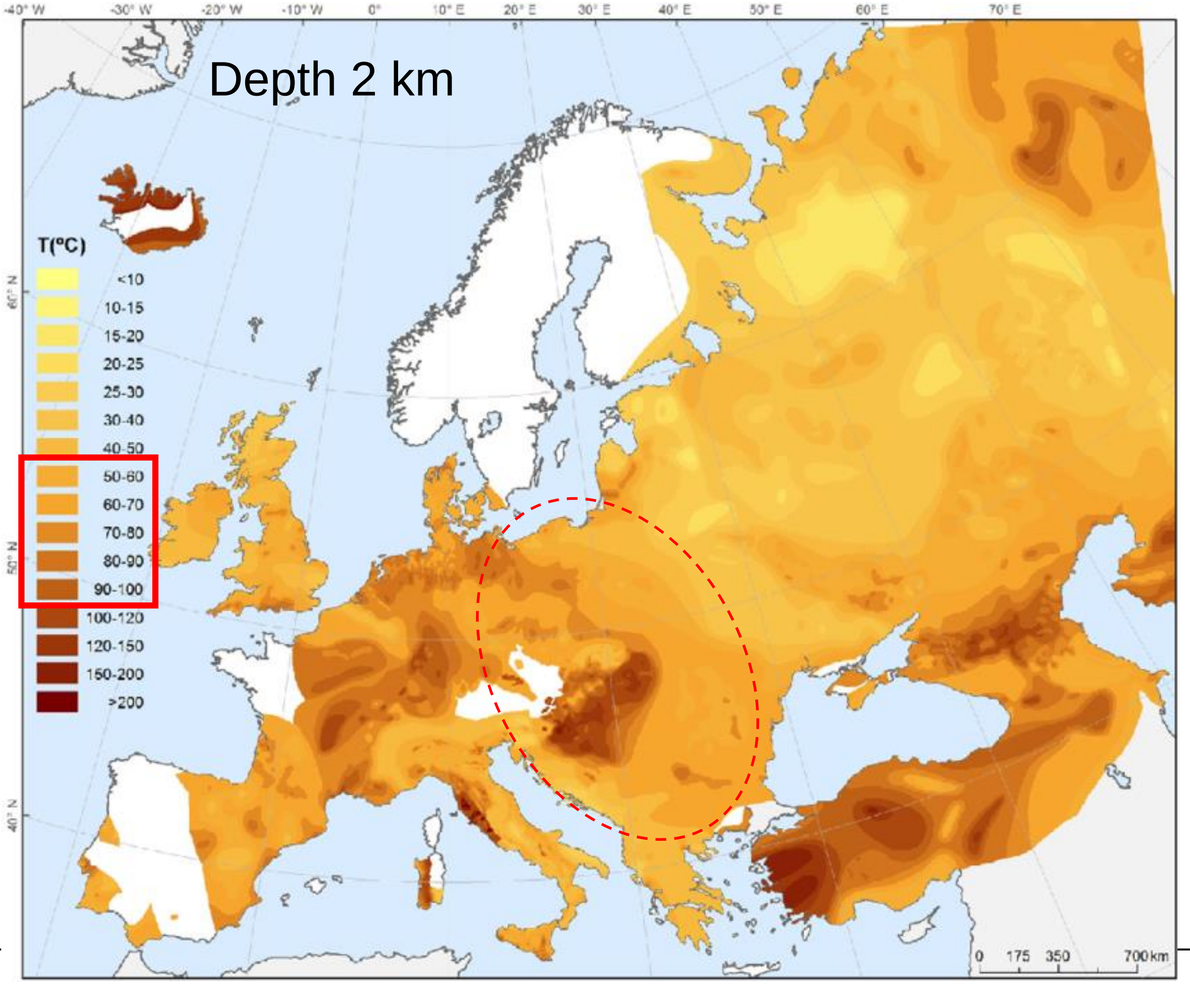
Typical design parameters of a district heating system:
- large (length dozen to more than a hundred km) 150/90°C, 150/70°C, 130/70°C;
- medium (dozen km) (130/70°C, 110/70°C),
- small (several to dozen) 95/70°C, 90/70°C,
- in some cases, where attention has been drawn to the fact that design parameters are often excessive to real needs 85/60°C, 80/60°C.

Geothermal condition in Europe

Typical temperature of geothermal resources in Central and Eastern Europe:
- at the depth of 1 km up to 30-50°C, rarely 70-80°C,
- at the depth of 2 km up to 60-80°C, rarely ~90-100°C.

(based on European Commission, Directorate-General for Research and Innovation, Hurter, S., Haenel, R., *Atlas of geothermal resources in Europe*, Hurter, S.(editor), Haenel, R.(editor), Publications Office, 2002)



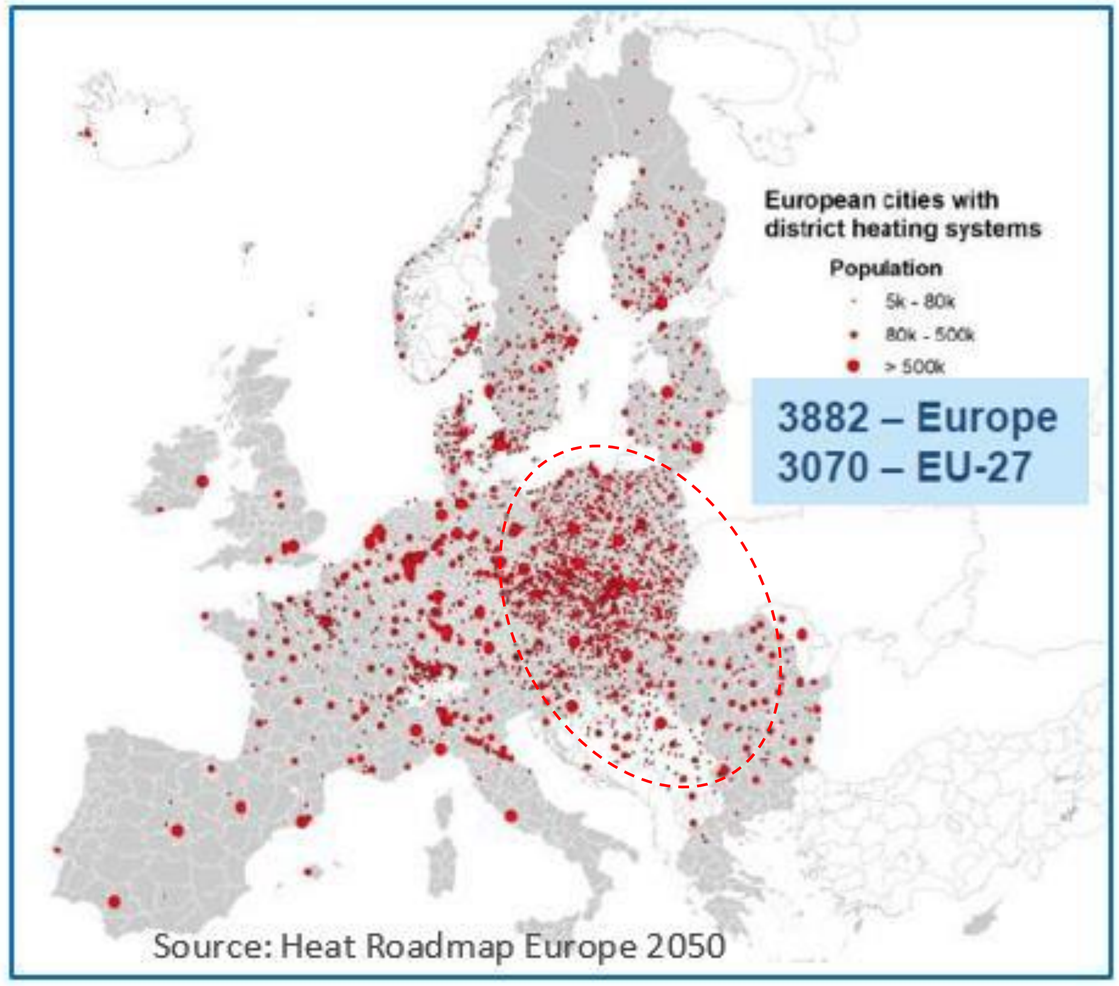


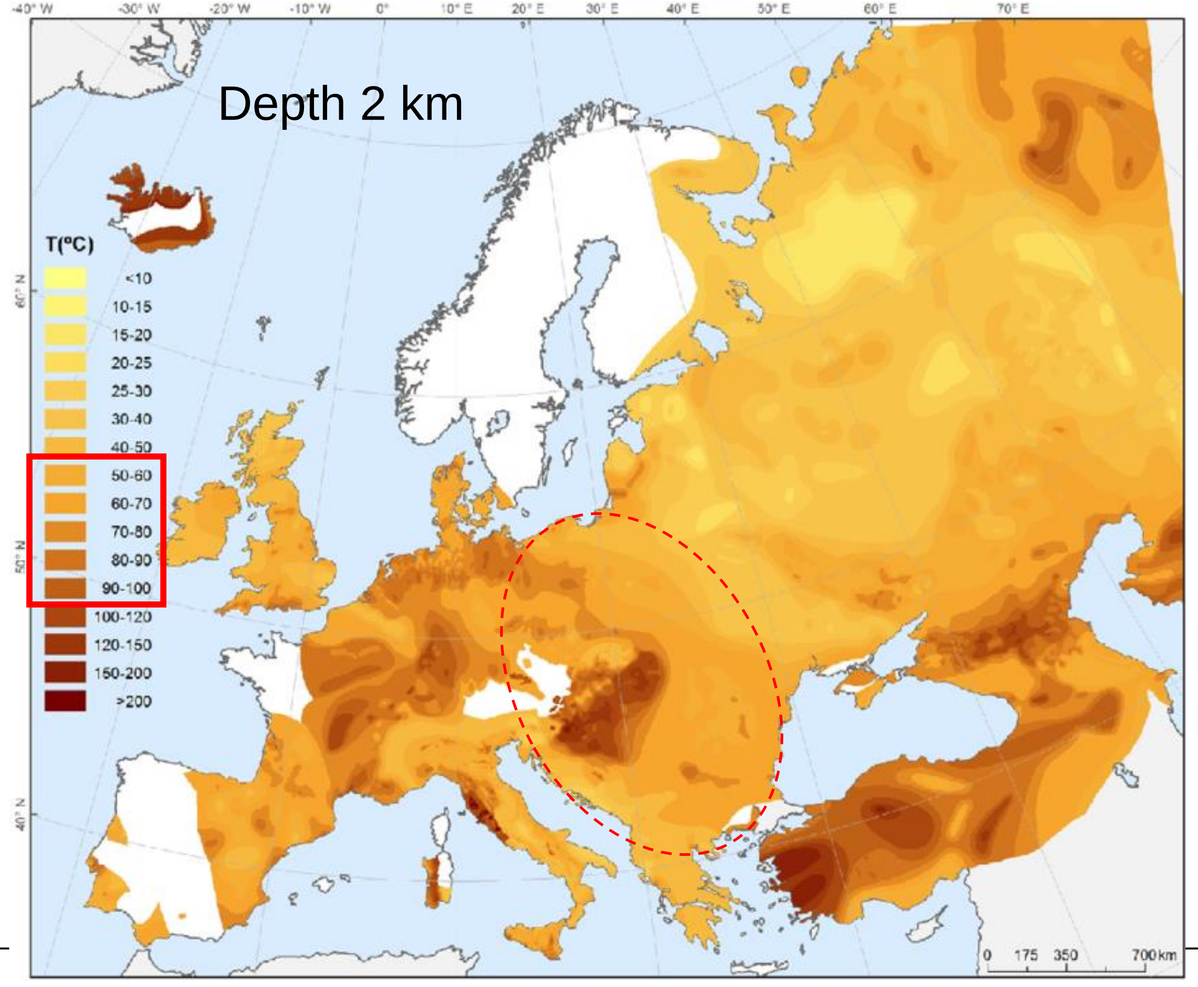
Typical temperature of geothermal resources in Central and Eastern Europe at a depth up to 2 km up to 60-80°C, rarely ~90-100°C **--► OFTEN at 2 km depth 60-80°C**

Temperature demands of a district heating system: from 60 to 150°C **--► OFTEN 80-110°C**

The problem definition:

Lack of coherence between the design parameters of heating installations and geothermal resources





The Project summary

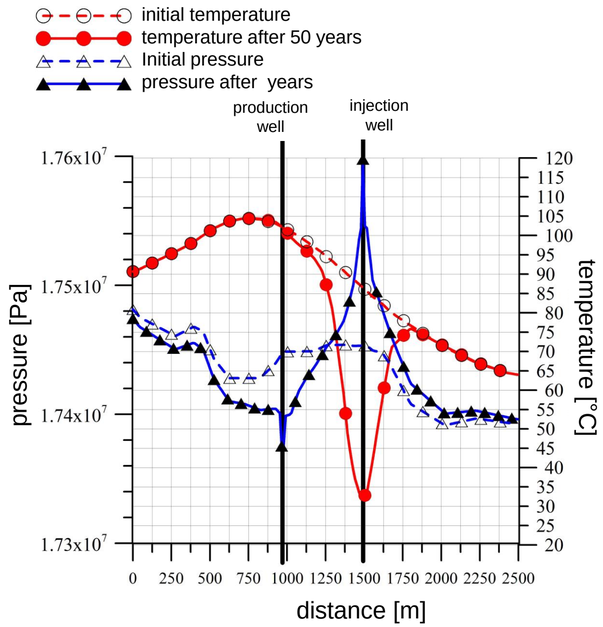
The Project background

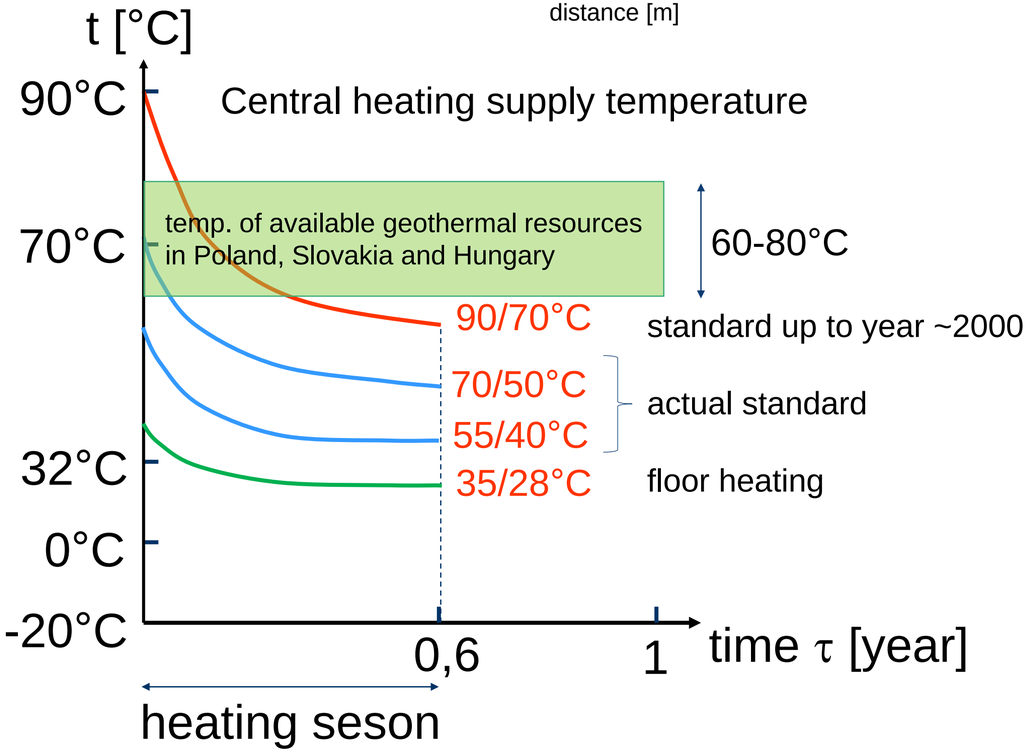
- **Geothermal energy is renewable – but it is not infinite nor free.** Overexploitation can deplete a reservoir while inefficient use of the water. The operation might be uneconomical.
- Still, **40-60°C thermal fluids being discarded without further use in many geothermal systems**, even new ones.

We have the technology allows use even 35°C for space heating.

Why? Because:

- **it is easier to control a DHS while it is overheated** (each user have high enough temperature),
- if an operator needs to **reduce the supply temperature users have to be ready**. An DHS is „as good as the worst user”.
- to get users ready **money have to be spent for extending the heating surface**.
- increase of heating surface might be done by **DH Operator** or by **USER**. Both sides **should know how much does it cost** and **what kind of results are expected** (economical, ecological, energy-saving effect).





The Project summary

The Project background

A heating system is characterised by technical requirements:

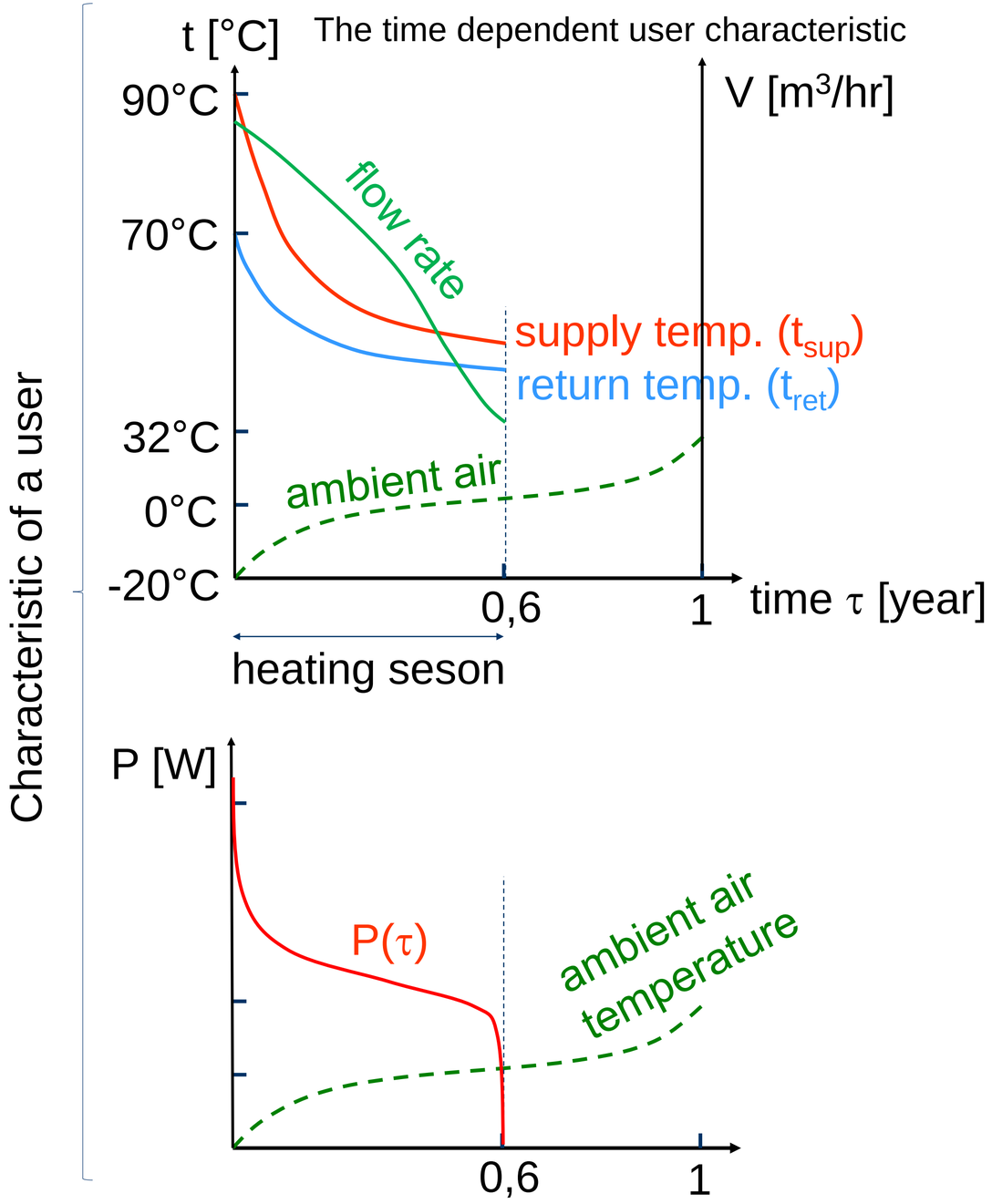
- supply temperature,
- the required flow of water.

Heat demand and the temperature of the return water depend mainly on the efficiency of the heating systems and weather conditions, but also the characteristics of the user(s) and the technology used.

The selection of appropriate parameters and management of the system is referred to as the control of power delivery. Suitable equipment and software control the work of an energy source.

$$P(\tau) = V(\tau)\, c\, \rho\, [t_{sup}(\tau) - t_{ret}(\tau)]$$

$$Q[J] = \int_0^{1\,yr} P(\tau)\, d\tau$$

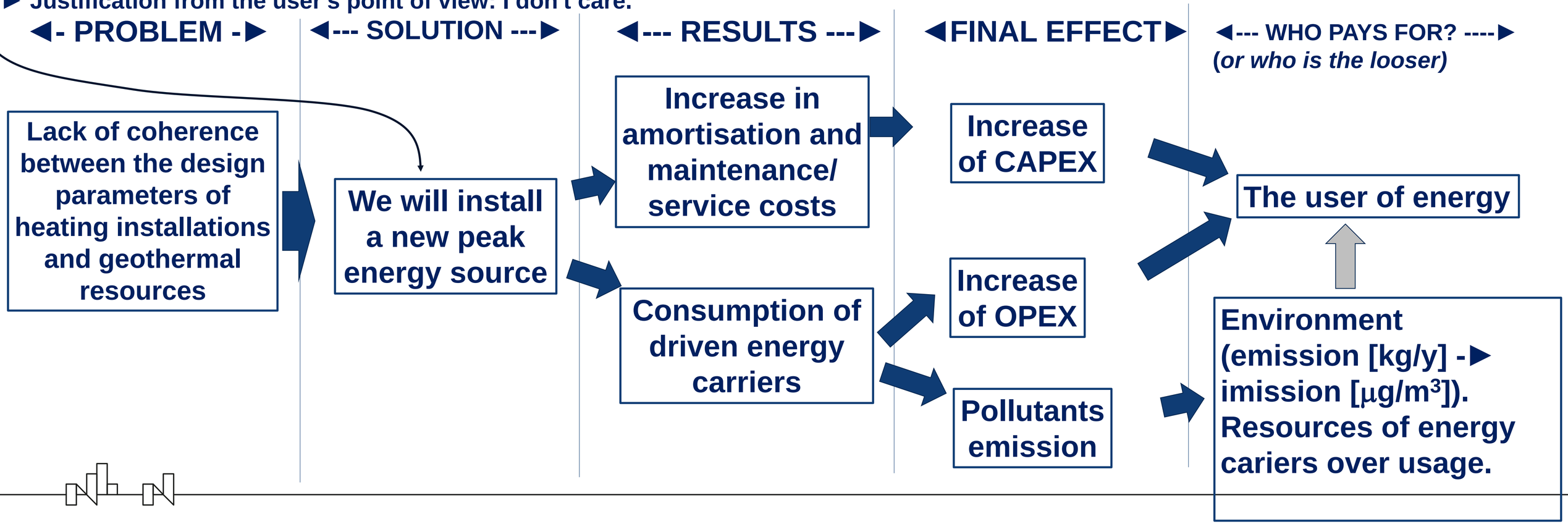


Problem definitione and possible solutions

1. Improvements in an energy user belonging heating installation and adjustment of the characteristics of the energy transmission and distribution system bring real effects in the form of savings in the consumption of drive energy carriers, savings in geothermal resources and reduction of pollutant emissions **BUT it is costly**
2. There are few of possibilities/options to cover the power and energy deficit

OPTION 1 – The easiest to practical implementation – the most common choice

- ► Justification from the point of view of the Energy Source Operator: I only interfere with what belongs to me.
- ► Justification from the user's point of view: I don't care.

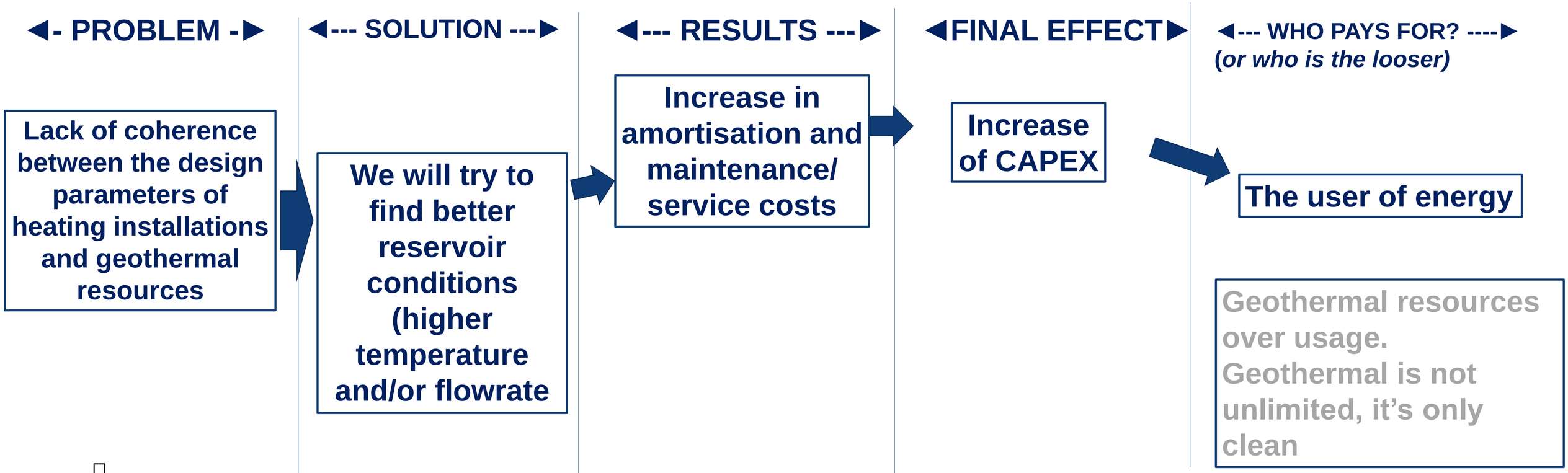


Problem definition

OPTION 2 – RISKY, option chosen when there is a chance for better geothermal conditions

► Justification from the point of view of the Energy Source Operator: I only interfere with what belongs to me, and I undertake a geological risk.

► Justification from the user's point of view: I don't care.

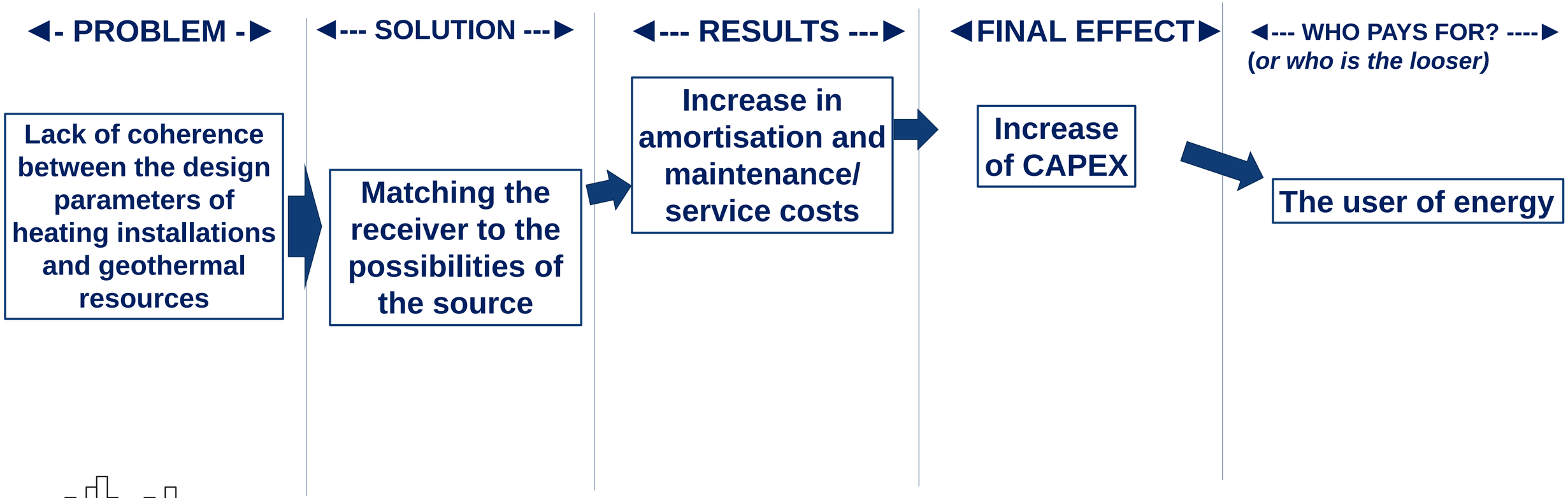


Problem definition

OPTION 3 – DIFFICULT BUT BRINGING THE GREATEST ENVIRONMENTAL BENEFITS,
practically an option not chosen in reality

► An advantage from the point of view of the Energy Source Operator: no interference with the source, apart from adjusting the delivered power control.

► From the user's point of view: I am a creator. The more I do, the cheaper and cleaner the heating can be.

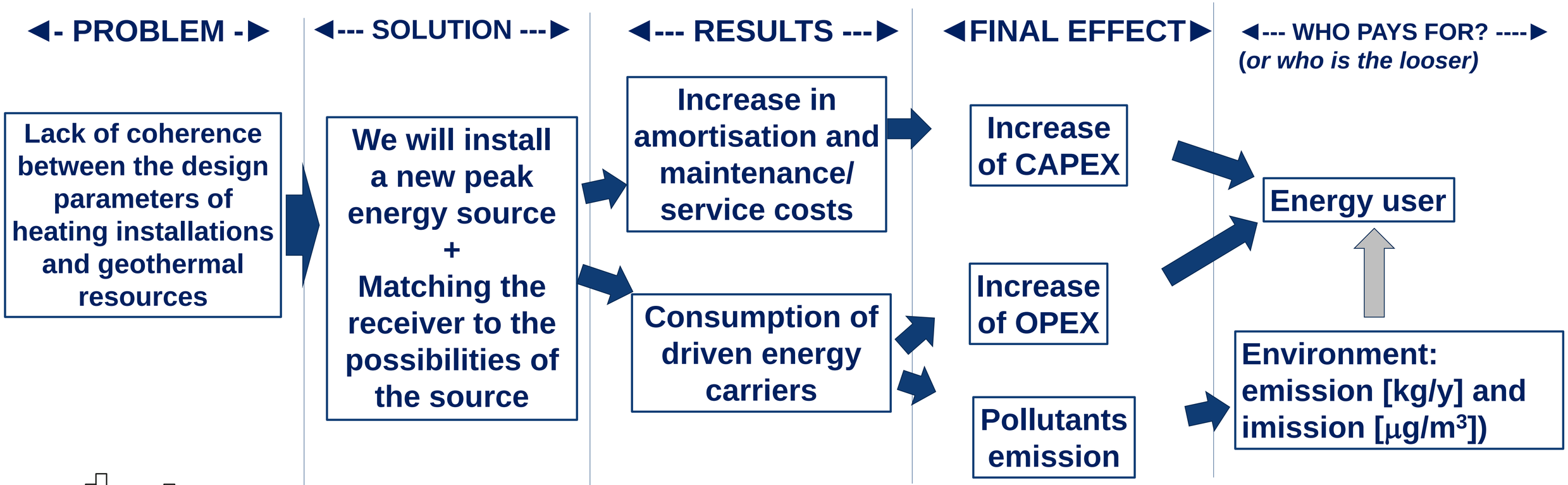


Problem definition

OPTION 4 – Searching for the best solution – minimizing energy generation costs and environmental impact

► An advantage from the point of view of the Energy Source Operator, but the user and operatro must cooperate. The question is „how to encourage the user to change”?. --► I produce cheaper than I can sell cheaper.

► An advantage from the user's point of view: if it fits properly, I have a chance for cheap heating.



The Project summary

The Project objectives

Main activities within the project:

- **Mathematical modelling of geothermal systems** (energy source – heat distribution – end users), **in order to identify optimal solutions for the supply of geothermal heat in the beneficiary countries**, considering geothermal conditions and heat prices on domestic markets.
- The **focus will be on individual customers in their homes by providing knowledge, experience, and technical solutions to improve the efficiency of geothermal heating**. This will be based on data utilisation and the roles of public and individual sustainable solutions. The project will also focus on encouraging customers to modify heating installations in their homes in order to increase their heating efficiency.
- **Exchange of good practice in the management of geothermal district heating between the donor countries** (Iceland, Norway) **and the beneficiary countries** (Poland, Slovakia, Hungary), that will increase economic as well as environmental and climate benefits for all.

The Project background: goals & target groups

The Project target groups

The target groups of our activities **are:**

- the **researchers and scientists** of the beneficiary partners,
- the general scientific community, **DH system operators, energy users** throughout Europe.

The end-beneficiary of our project **is the environment**.

The Project summary

The Project objectives

- Our **objectives are a long-term improvement in the efficiency of geothermal operations and a decrease in their environmental footprint:** direct contributions to a **less carbon-intensive and more energy secure economy in Europe.**

- Our **goal is to increase the economics of geothermal DH systems and to support their environmental sustainability simultaneously.** We wish to achieve this goal by expanding the knowledge of our staff and by providing innovative solutions to operators.

- Moving towards **low-carbon and energy secure economies requires the use of renewables** on the one hand, **and, maintaining a good status of the environment** on the other**.**
  These objectives can be achieved simultaneously.

The Project summary

The Project background

What we are going to do?

We are going to answer the question: WHETHER IS IT PROFITABLE?

Model database (WP 4)
Description of:
1. **current state of a system** (numerical model calibration), unitary price of primary energy carriers

2**. possible undertakings on a side of: energy users, district heating system, energy source**.
Information about available technology, which allows:
- changing characteristic of energy users,
- improve a district heating grid,
- modernise an energy source.

Local weather conditions
- ambient air temperature,
- wind speed,
- relevant humidity,
- solar radiation

Mathematical Modelling (WP5 & WP6)
- users demand (characteristic vs weather conditions).
- district heating (heat and pressure losses, characteristic, power controlling),
- the energy source (technology, efficiency, power controlling),
- primary energy carriers.

Results
- Primary energy carriers consumption,
- Power vs time for all sources used,
- Energy production by each source,
- Pollutants emission,
- Cost of energy production,
- Estimated financial expenditures for assumed retrofitting and modernisation,
- CAPEX, OPEX estimation,
- Results interpretation.

Example of results obtained based on U4GEcalc

U4GEcalc - User4GeoEnergy calculator ver 2023.08.17

Select the location:

Choszczno PL

SECTION 3 ---------- geothermal conditions

► GEOTHERMAL RESOURCES ◄

■ imported, 56 °C

Geothermal fluid wellhead temperature [°C]

28,0 — 84,0

56,0

■ imported, 240 m³/h

Geothermal fluid flow rate [m³/h]

120,0 — 360,0

240,0

SECTION 4 ---------- peak energy source

■ imported: Hard coal

Select suitable peak energy source type

Hard coal

▶ parameter you need to set

Select the peak heating source status

- (●) Peak heat source exists
- ( ) Peak heat source doesn't exist

▶ parameter you need to set

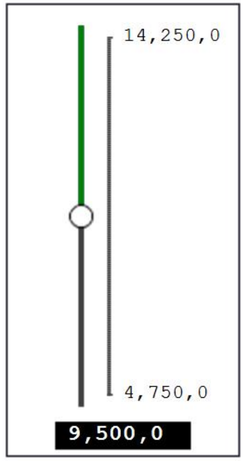
Are you paying for CO2 emission (select)?

- ( ) Payment for CO2 emission included
- (●) Payment for CO2 emission excluded

SECTION 5 ---------- user definition, current state

■ imported, 9500 kW

Power demand for central heating [kW]

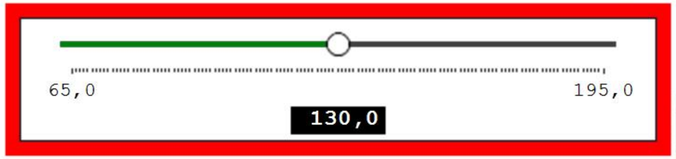


► installed heating power

PcoSlider · multiple kW = 9500 kW

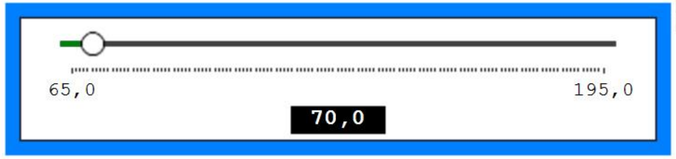
■ imported, 130°C

Design supply temperature, space heating [°C]



■ imported, 70°C

Design return temperature, space heating [°C]



► parameter you need to set

Select the heating system status

- (●) Central heating system exists, might be retroffited
- ( ) Central heating system does not exist, must be build

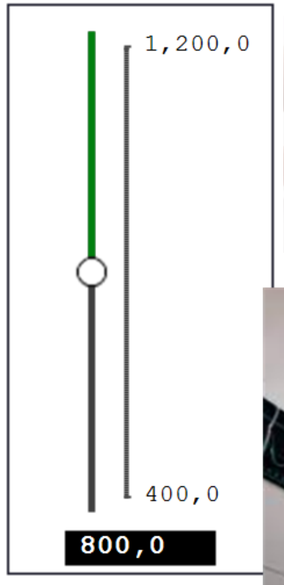
► parameter you need to set

Dominated type of a heating system

- ( ) floor heating
- ( ) panel radiators
- ( ) pipes and finned pipes
- (●) radiators
- ( ) convection heaters

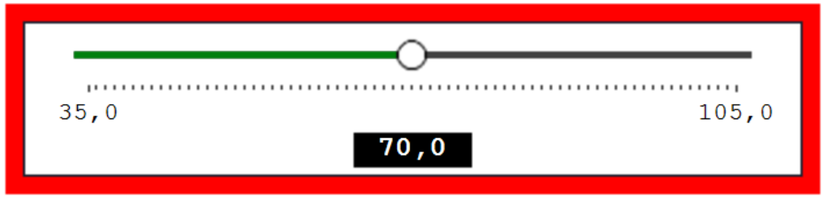
■ imported, 800 kW

Power demand for hot water [kW]



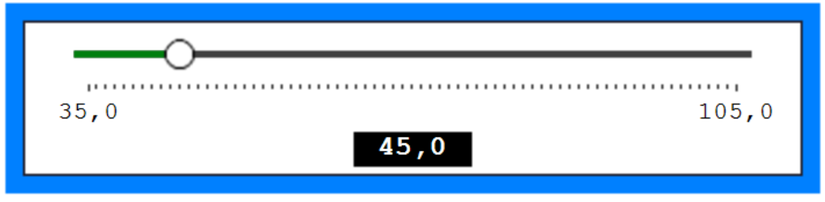
■ imported, 70°C

Design supply temperature, hot water [°C]



■ imported, 45°C

Design return temperature, hot water [°C]



► installed power of hot tap water

PcwuSlider · multiple kW = 800 kW

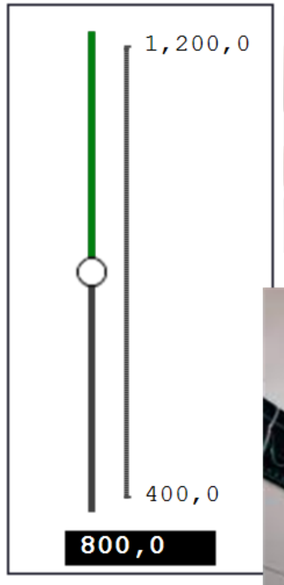
► parameter you need to set

Select the hot tap water system status

- (●) The hot tap water system exists, might be retroffited
- ( ) The hot tap water system does not exist, must be build

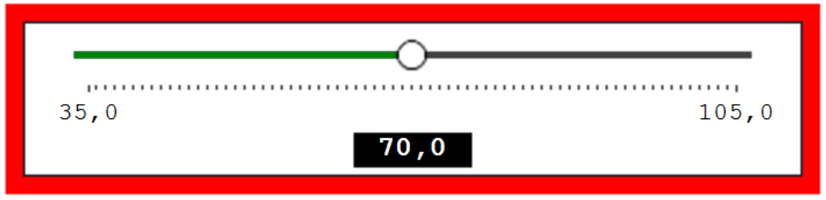
■ imported, 800 kW

Power demand for hot water [kW]



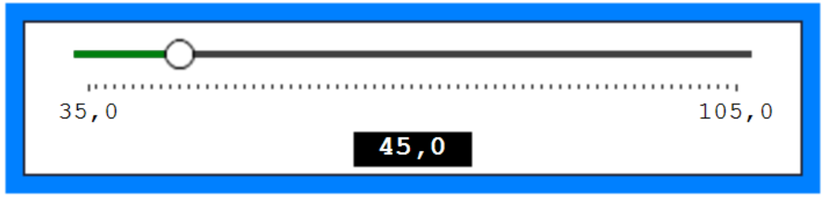
■ imported, 70°C

Design supply temperature, hot water [°C]



■ imported, 45°C

Design return temperature, hot water [°C]



► installed power of hot tap water

PcwuSlider · multiple kW = 800 kW

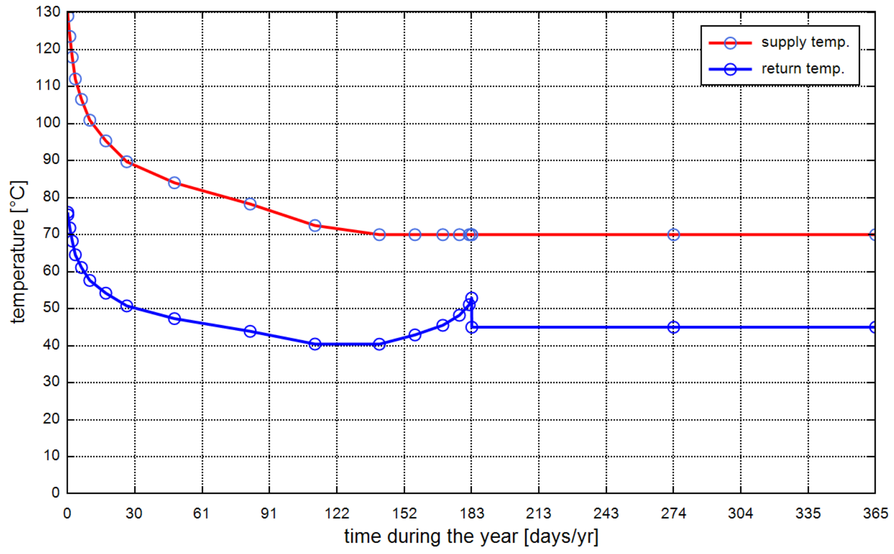
► parameter you need to set

Select the hot tap water system status

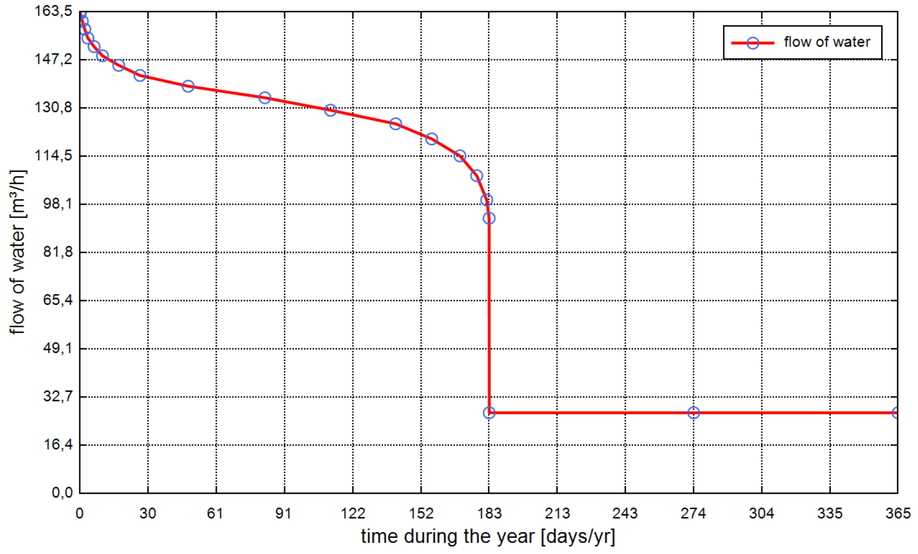
- (●) The hot tap water system exists, might be retroffited
- ( ) The hot tap water system does not exist, must be build

SECTION 7 --------- graphs describing the current situation (the user characteristic)

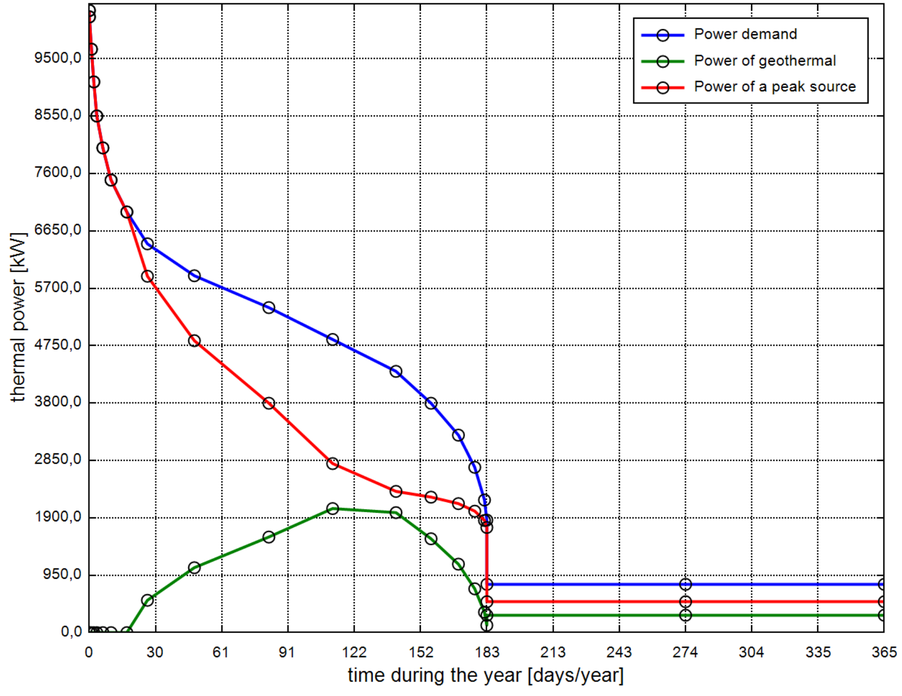
Supply and return temperature vs time



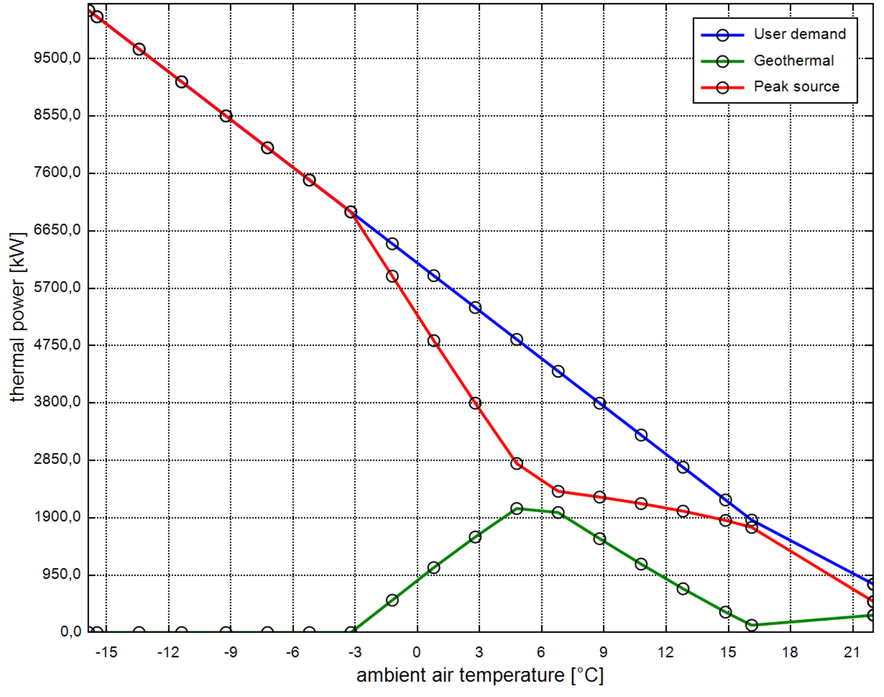
Flow of district heating water vs time



Power demand and its cover by energy sources vs time



Power demand and its cover by energy sources vs ambient air temperature



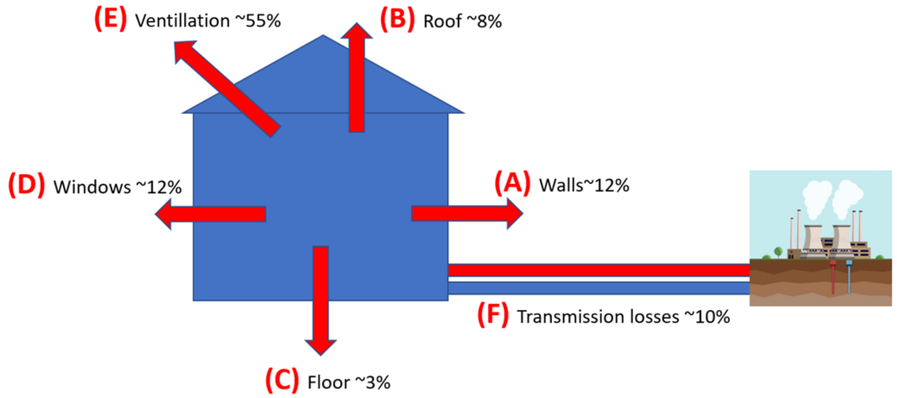
SECTION 8 ---------- retrofitting activity

Definition of heat losses structure, friction (heat losses/total heat losses; must=1.00)

$$HeatLosses := \begin{bmatrix} \text{"(A) External wall"} & 0{,}12 & 0 \\ \text{"(B) Roof"} & 0{,}08 & 0 \\ \text{"(C) Floor on ground"} & 0{,}03 & 0 \\ \text{"(D) Window and external door"} & 0{,}12 & 0 \\ \text{"(E) Ventilation"} & 0{,}55 & 0 \\ \text{"(F) Heat transmission by pipes (DH)"} & 0{,}10 & 0 \\ \text{"Estimated heating surface [m2]"} & Fgrz\ nGrz & nTypGrz\ 2 \end{bmatrix}$$

Heat losses structure properly estimated ◄- Checking the heat losses structure

Assumed, average heat losses by buildings and a district heating line:



(A) 20

◄- (A) Reduction of heat losses by **EXTERNAL WALLS** on [%] in accordance to current state

(B) 20

◄- (B) Reduction of heat losses by **ROOFS** on [%] in accordance to current state

(C) 20

◄- (C) Reduction of heat losses by **FLOOR** on the ground on [%] in accordance to current state

(D) 20

◄- (D) Reduction of heat losses by **WINDOWS** and external doors on [%] in accordance to current state

(E) 20

◄- (E) Reduction of heat losses by **VENTILATION** (including recuperation, regeneration etc.) on [%] in accordance to current state

(F) 20

◄- (F) Reduction of heat losses by **TRANSMISSION LINES** (DH) on [%] in accordance to current state

(G) 60

◄- (G) Extendents of **HEAT EXCHANGE SURFACE** on [%] accordance to current state

(H) 60

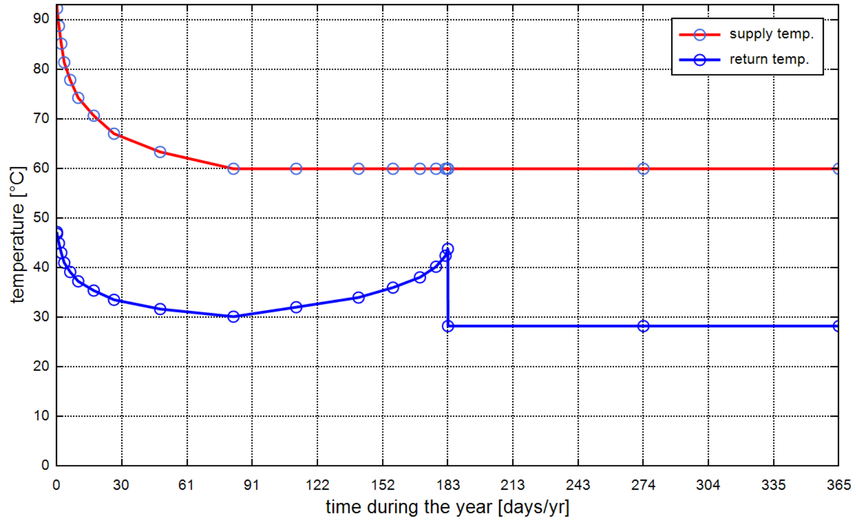
◄- (H) **Hot tap water - extendents of heat exchange surface** on [%] accordance to current state

(I) 60

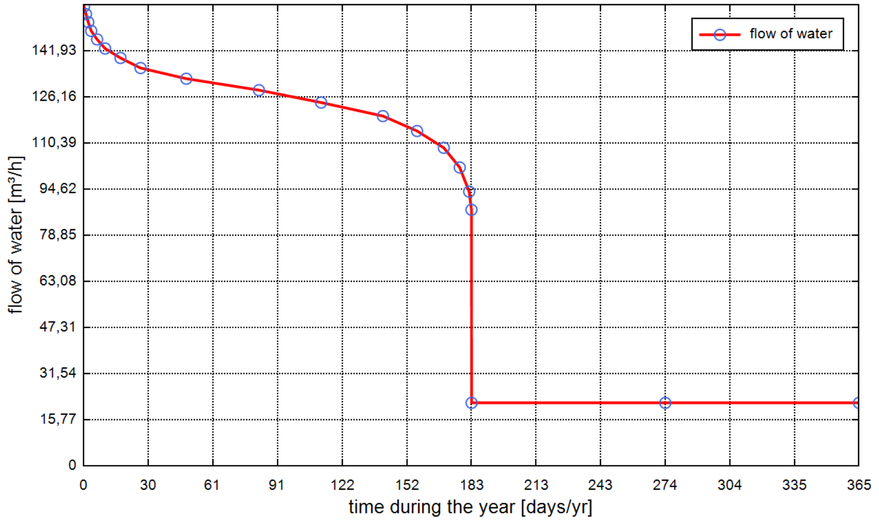
◄- (I) **Reduction of hot tap water supply temperature** to the statted here value [°C] (current value is the max)

SECTION 10 --------- resuts of the retrofitting activity, the user charcteristic after retrofitting

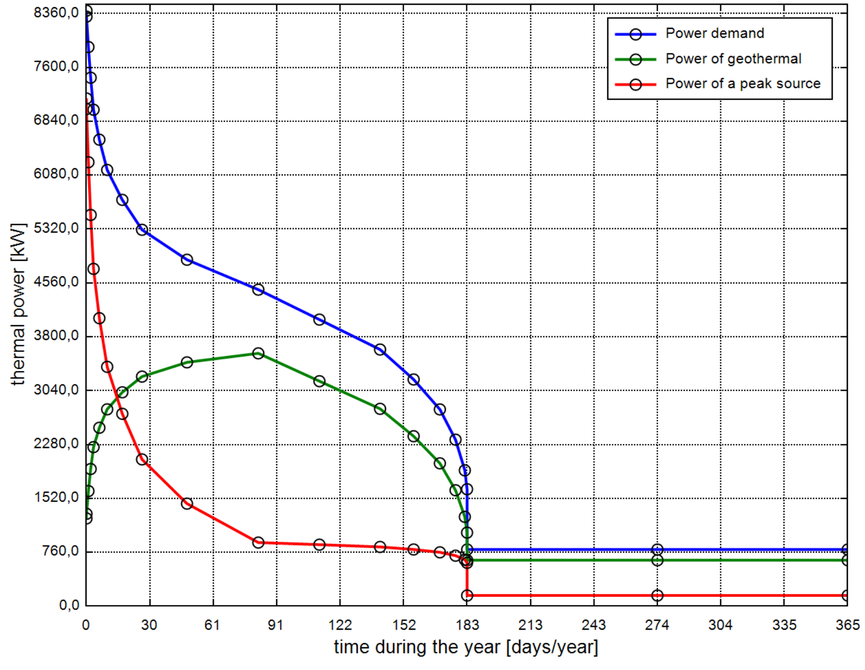
Supply and return temperature vs time



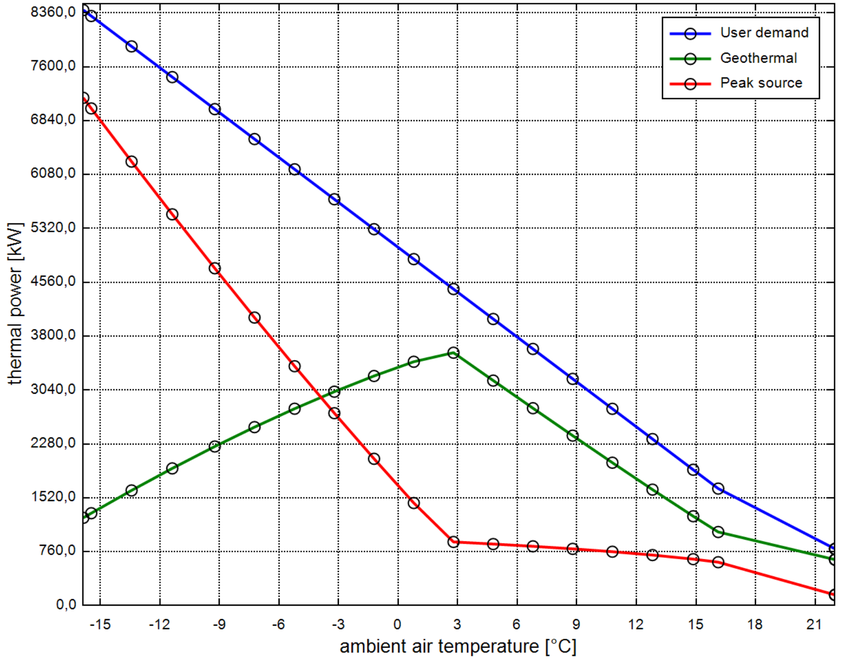
Flow of district heating water vs time



Power demand and its cover by energy sources vs time

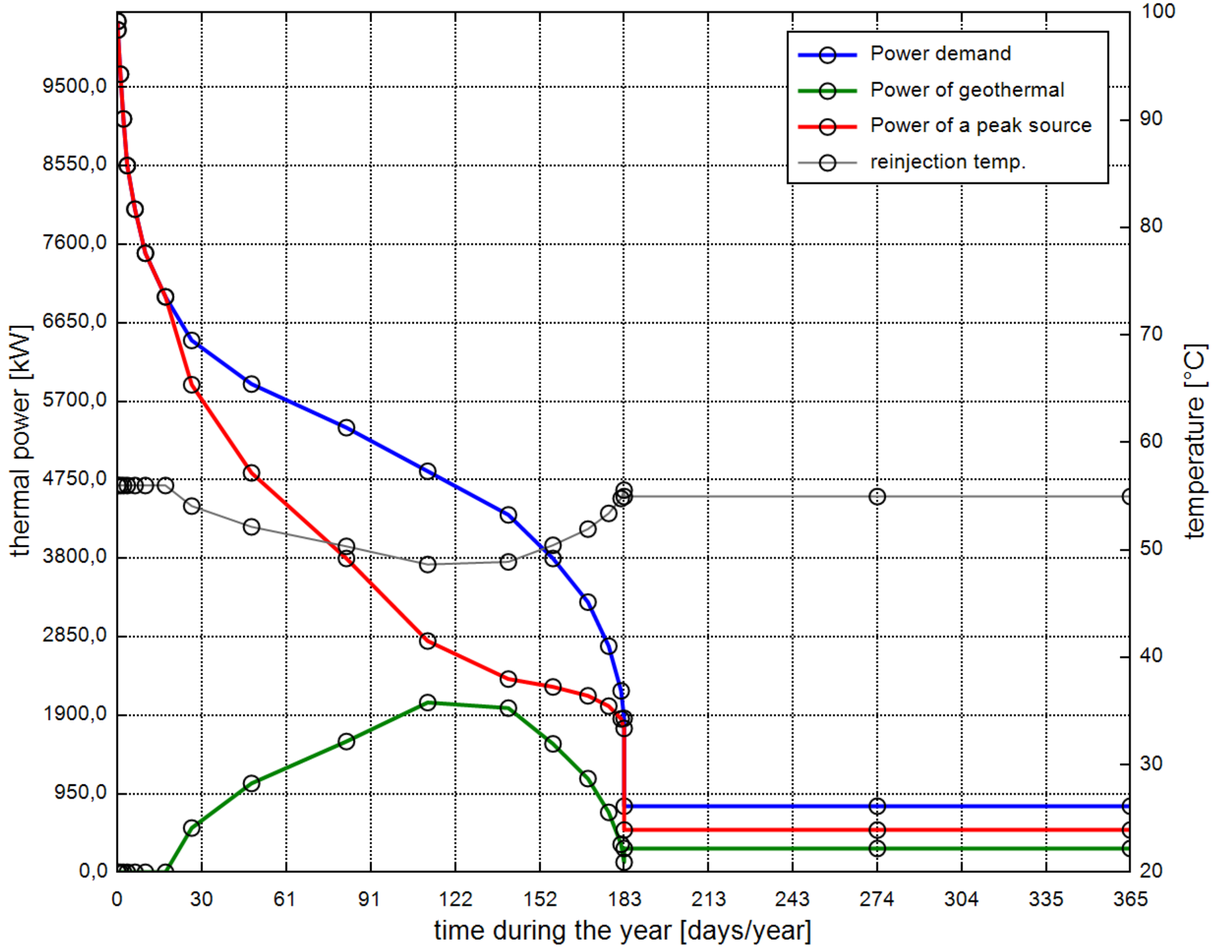


Power demand and its cover by energy sources vs ambient air temperature

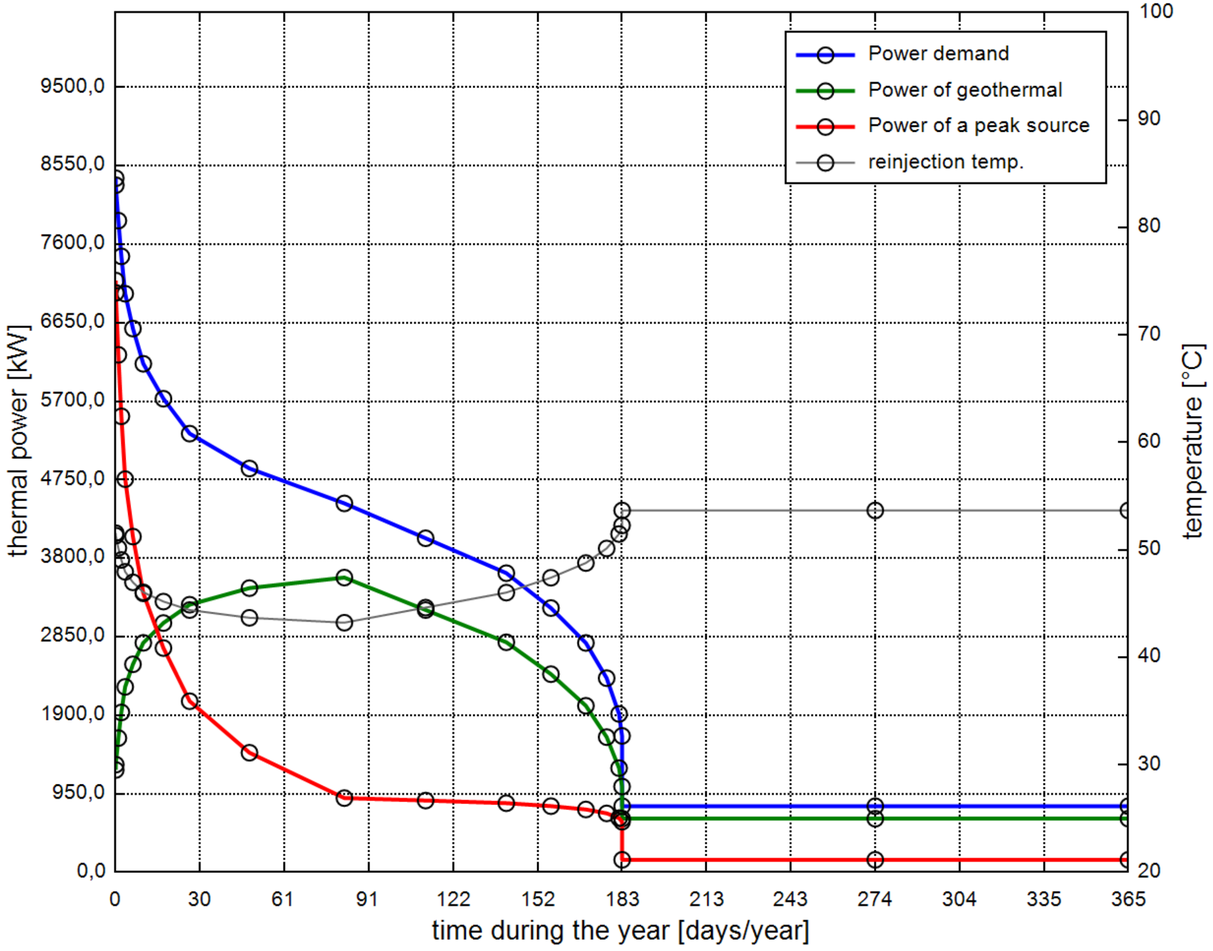


SECTION 11 --------- comparison of power demand coverage in the current state and after retrofitting

Power demand and its cover by energy sources vs time, BEFORE retrofitting



Power demand and its cover by energy sources vs time, AFTER retrofitting



SECTION 12 --------- SUMMARY

Table 1. List of the most important parameters and their values

	Current state	After retrofitting
Location: city and country	Choszczno PL - current state - imported	Choszczno PL
Geothermal resources: flow [m³/h] | temp.[°C]	240 | 56	240 | 56
Type of heat peak source	Hard coal	Hard coal
Status of heating system at users (radiators)	Central heating system exists, might be retroffited	
Status of hot water system at users	The hot tap water system exists, might be retroffited	
Status of heat peak source	Peak heat source exists	Peak heat source exists
Payment for emission of CO2 (status)	Payment for CO2 emission excluded	Payment for CO2 emission excluded
Power and energy lossed by connected objects' elements:		
(A) external walls [kW | GJ/yr ► % of energy]	1140 | 8384,1 ► 12,00	912 | 6707,3 ► 12,00
(B) roofs [kW | GJ/yr ► % of energy]	760 | 5589,4 ► 8,00	608 | 4471,5 ► 8,00
(C) floors on ground [kW | GJ/yr ► % of energy]	285 | 2096 ► 3,00	228 | 1676,8 ► 3,00
(D) windows and external doors [kW | GJ/yr ► % of energy]	1140 | 8384,1 ► 12,00	912 | 6707,3 ► 12,00
(E) ventilation inc. recuperation (if applied) [kW | GJ/yr ► % of energy]	5225 | 38427 ► 55,00	4180 | 30741,6 ► 55,00
(F) transmission losses [kW | GJ/yr ► % of energy]	950 | 6986,7 ► 10,00	760 | 5589,4 ► 10,00
(G) increase of heat exchange surface for heating (eg. radiatiors) [%]		60,00
(H) increase of heat exchange surface for hot water [%]		60,00
(I) reduction of supply temperature for hot water from ► to [°C]		70,00 ► 60,00
Status of a peak heat source after retrofitting		We are using the same peak heating source
Design parameters for heating | hot water [°C]	130/70 | 70/45	92,9/44,9 | 60/28,3
Power demand: total | heating / hot water [kW] # Energy demand: total | heating / hot water [GJ/yr]	10300 | 9500 / 800 # 95094,6 | 69867,3 / 25227,4	8400 | 7600 | 800 # 81121,2 | 55893,8 / 25227,4
Maximal power utilised: total; geothermal; peak source [kW]	10300 ; 2054 ; 10300	8400 ; 3567 ; 7162
Energy production: total; geothermal; peak source [GJ/yr]	95094,6 ; 24619,1 ; 70475,6	81121,2 ; 57000 ; 24121,2
Share of sources in total energy production: geothermal; peak source [%]	25,89 ; 74,11	70,27 ; 29,73
Energy carrier used by a peak source [kg/yr]	3437832,59	1176642,9
Emission of selected pollutants		
* CO2 [ton/yr]	8282,6	2834,83
* SO2 [kg/yr]	48129,66	16473
* NOx [kg/yr]	14610,79	5000,73
* total dust [kg/yr]	412539,91	141197,15
Completeness of input data in terms of price indicators		Input data for the location full and correct
Investment expenditures [k€]	0	8526,6
Total cost | CAPEX | OPEX [k€/yr]	1504,4 | 129,3 | 1375,1	1026,3 | 555,6 | 470,7
Simple payback time for additional expenditures SPBT [yr]		9.4
Energy price reduction for final user [€/GJ]		11,15

Thank you