Interreg Programme
Danube Region

Co-funded by the European Union

DANUBE REGION strategy
Energy

Geothermal heat utilization in Hungary: project preparation experiences with geological focus

Zagreb

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Ministry of Foreign Affairs and Trade of Hungary

This project was supported as part of Sustainable Energy, an Interreg Danube Region Programme project co-funded by the European Union (ERDF fund) with the financial contribution of partner states and institutions.

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Association of Hungarian District Heating Enterprises

Introduction and company profile

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ms energy solutions

planning / design / development / support

mining support

complex permitting and engineering for E&P companies

waste management

mine surveying

right of possession

reservoir engineering for O&G

MS Renewables

geothermal projects from A to Z

modelling and calculations: heat demand, consumption heat capacity

thermal water drilling existing well repurposing

WeHEAT Systems

MS Geo

geological expert tasks

reservoir modelling

geochemical analyses

Radon

MS Services

professional translations

event organization

audit and due diligence

PR & marketing

large format scanning and digitization

CEEC CONTINENTAL EUROPE ENERGY COUNCIL

What it takes to make a geothermal based heat utilization project?

Association of Hungarian District Heating Enterprises

2 key pillars to achieve geothermal heat supply

Geology

Market & Consumer Demands

aim: syncronization between the resource & demand side

way: adapted to local systems

requirement: extensive knowledge of geothermal (new) technologies

solution: conventional or alternative

Heat utilization

What it takes to make a geothermal based district heating project?

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The importance of geology, hydrogeology

Key factors to analyse in order to determine the location and heat potential of new well(s) for a geothermal based DH system

- water temperature, geothermal gradient

Temperature

- thermal water yield

Reservoir

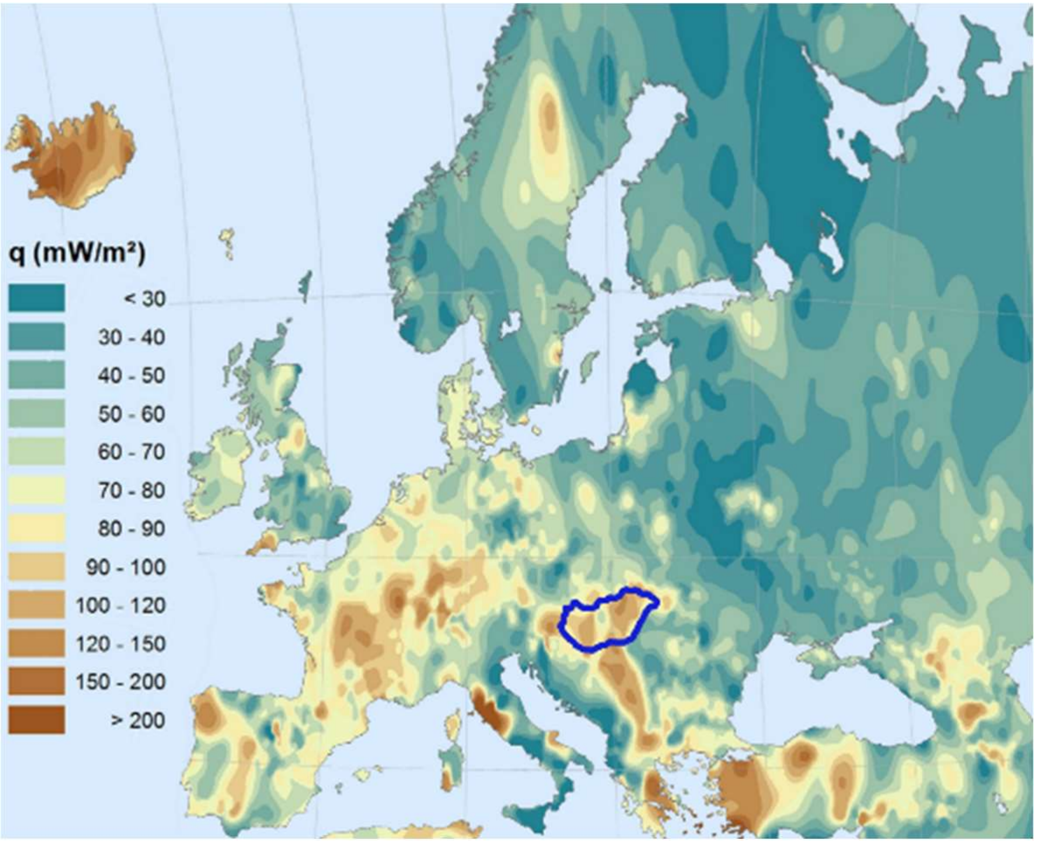
- dissolved solids and gas content

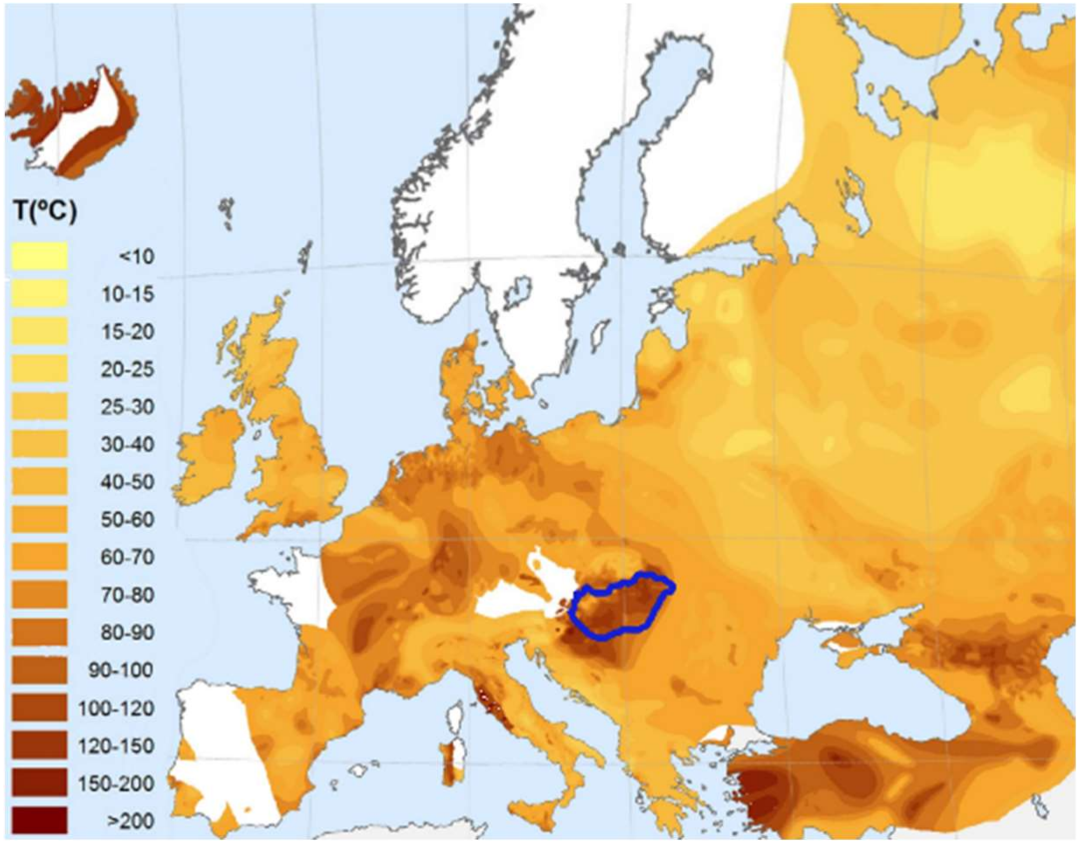
Water chemistry

Geothermal potential of the Pannonian Basin

Association of Hungarian District Heating Enterprises

Heat flow & Temperature



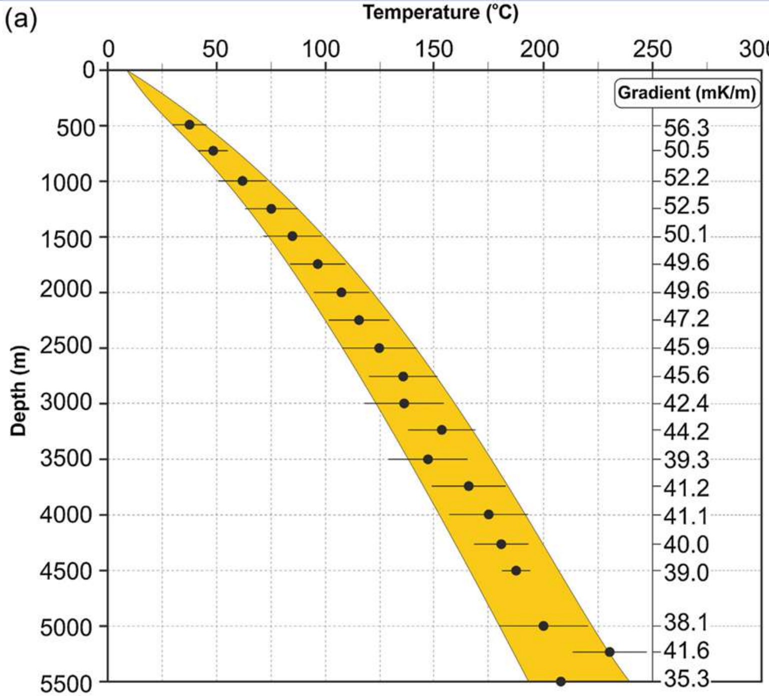


Heat-flow map and temperature distribution at the depth of 2000 m in Europe (Chamorro et al., 2013)

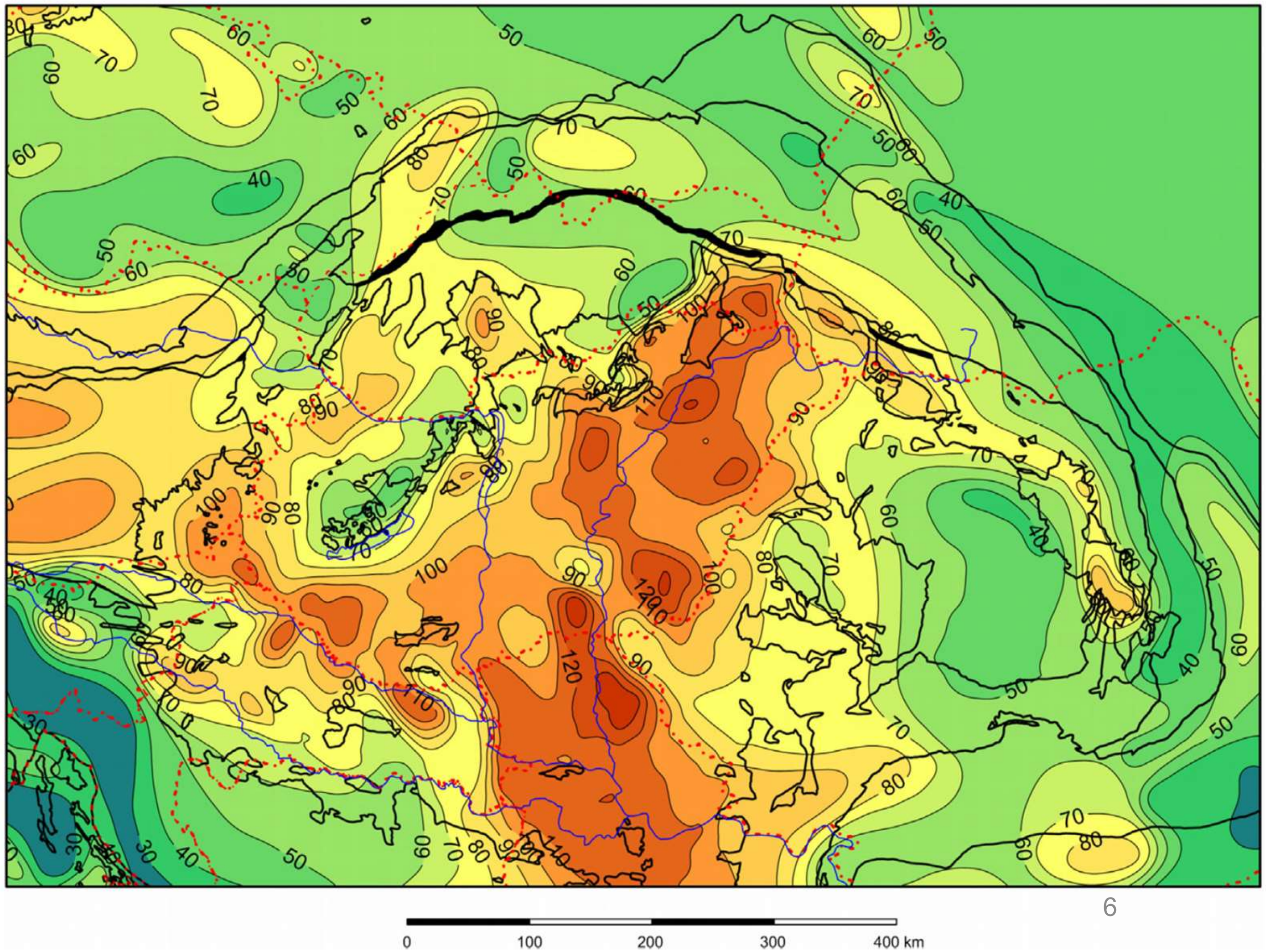
Geothermal potential of the Pannonian Basin

Heat flow map

Average temperature verusus depth profile within Hungary (a) and heat flow map of the Pannonian Basin and surrounding regions (heat flow in mW/m²), corrected for the cooling effect of the fast sedimentetion (b) (Horváth et al., 2015).



(b)



Geothermal potential of the Pannonian Basin

The 2 main thermal water reservoir types in Hungary

Reservoirs with **adequate permeablity** to produce **suitable flow rates** for geothermal purposes in Hungary

- **Upper Pannonian porous reservoirs** (Újfalu Sandstone Fm., occasionally Zagyva Fm.)

<u>Exploration risk</u>:

- ✓ low
- ✓ well known (a very large number of wells penetreted these layers)

- **Pre-Cenozoic fractured basement carbonates**

<u>Exploration risk</u>:

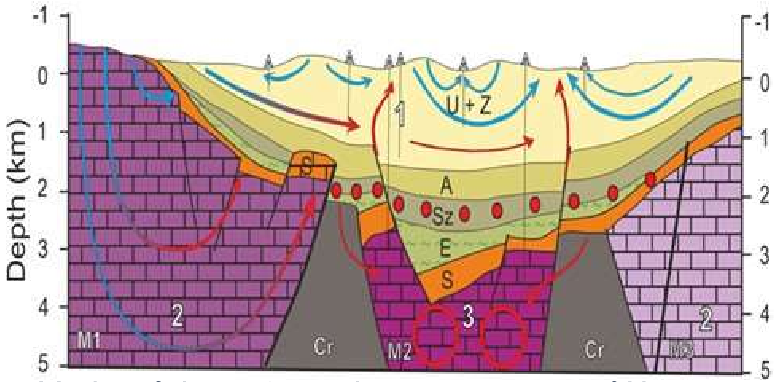
- ✓ higher
- ✓ existence and distribution of carbonate reservoir rock formation are uncertain, few wells penetrated these layers

Characteristic permeabilities of main hydrostratigraphic units in the Pannonian basin (after Tóth and Almási, 2001).

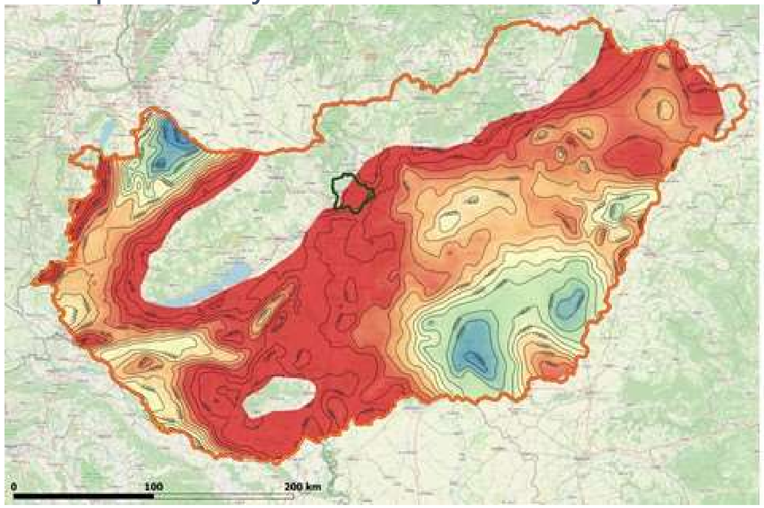
Hydrostratigraphic unit	Permeability range (mD)	Classification
Újfalu and Zagyva Fm.	100–500	Aquifer
Algyő Fm.	1–10	Aquitard
Szolnok Fm.	10–100	Aquifer
Endrőd Fm.	0.1–1	Aquitard
Early and Middle Miocene clastics	10–100	Aquifer
Early and Middle Miocene tuffs	10–50	Aquifer
Carbonates (fractured and karstified)	50–500	Aquifer
Crystalline (fracture)	10–100	Aquifer
Crystalline (intact)	0,001–0,1	Aquitard

1 mD = 10^{-15} m^2, which corresponds to 10^{-8} m/s conductivity.

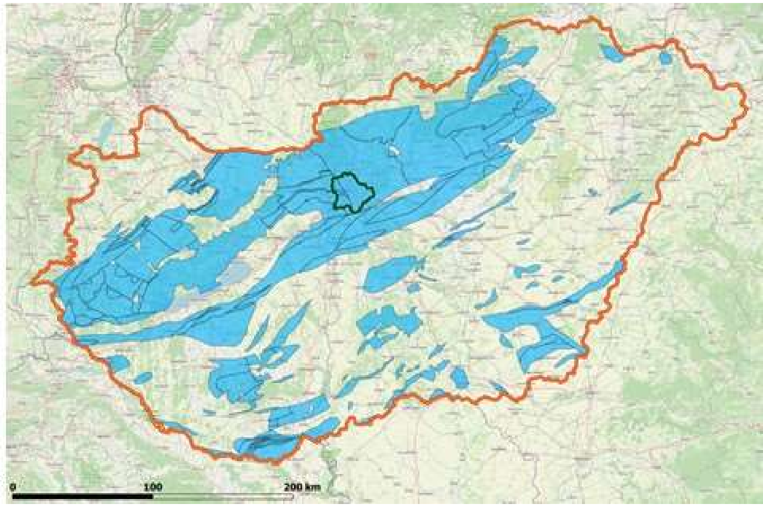
The main hydrostratigraphic units of Hungary and their permeability



Model of the main geohtermal systems of Hungary



Bottom map of Újfalu sandstones



Carbonate basement formations (based on Haas 2010)

Upper Pannonian porous reservoirs

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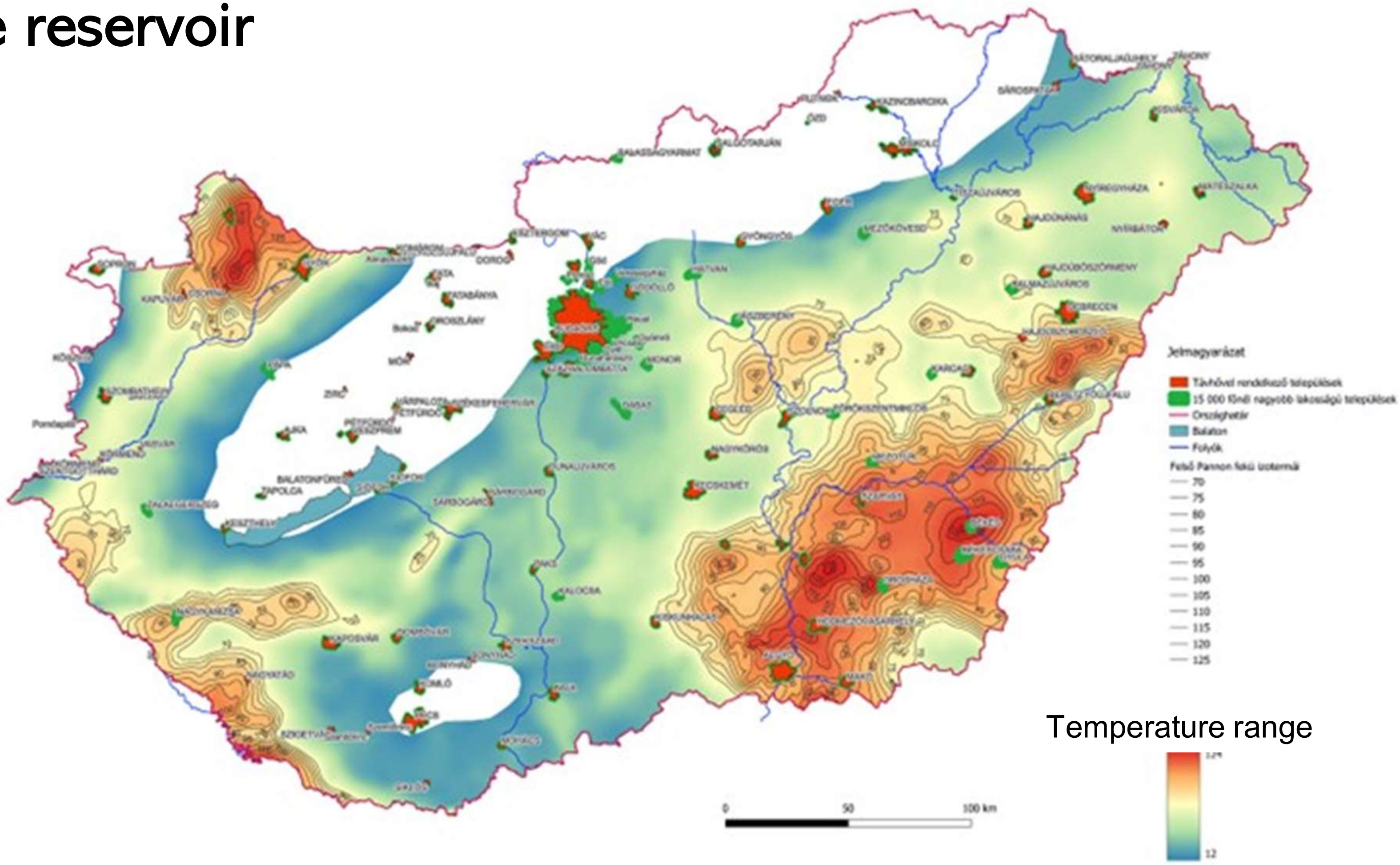
Features of the reservoir

- ✓ made up by sedimenatry rocks, sandstone aquifer
- ✓ regional reservoir
- ✓ Alföld, Kisalföld area
- ✓ absent in mountain areas
- ✓ purity, thickness and depth of the sandstone determines the geohtermal projects
- ✓ deeper sandstone generally means warmer waters
- ✓ 3-5 MWth/well (pair)
- ✓ ~70-125 °C
- ✓ low exploration risk, high injection risk



Temperature distribution at the bottom of the Upper Pannonian porous reservoirs

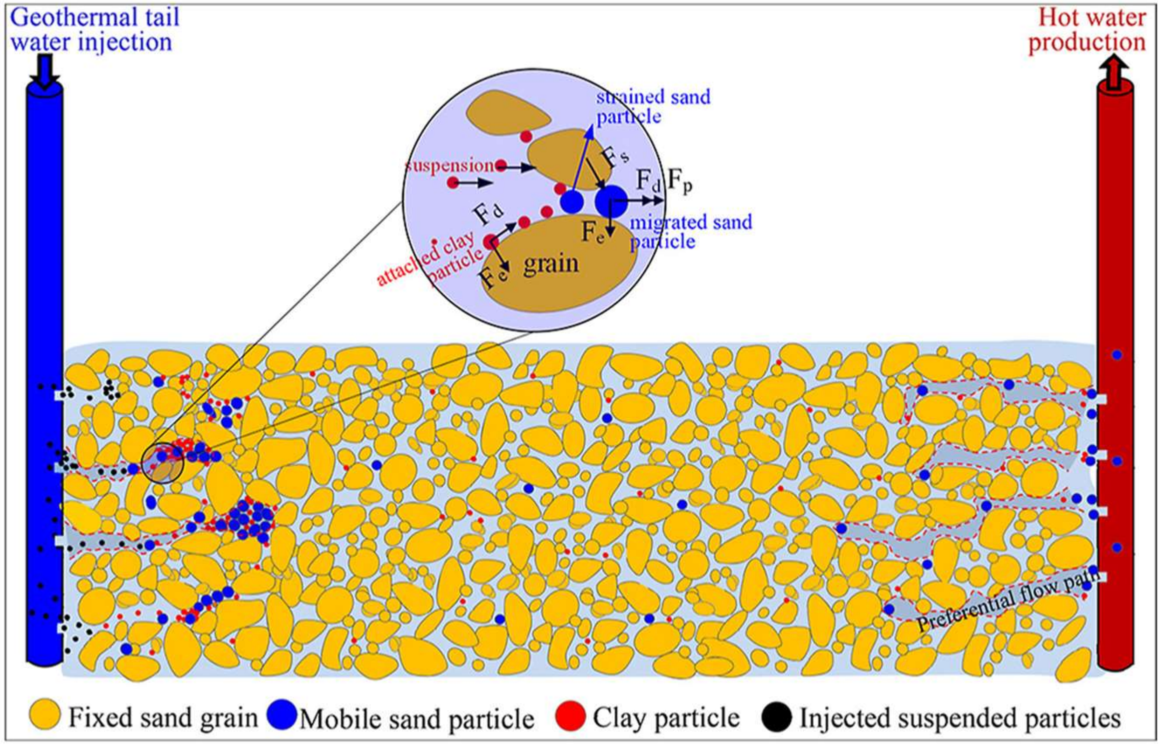
Injection into sandstone reservoirs

Aims:

- ✓ disposal of used geohtermal fluids, prevention of surface heat and chemical pollution
- ✓ maintenance of reservoir energy, prevention of pressure drawn-down
- ✓ ensuring the economical long-term utilization of the geohtermal reservoir

Occuring issues:
formation damage, clogging, scaling, biofilm formation, etc.

Solutions:
- To find favourable layers for reinjection
- Low pressure (2-5 bars) reinjection systems.
- 1:2 ratio of production and reinjection wells
- preventing biomass production

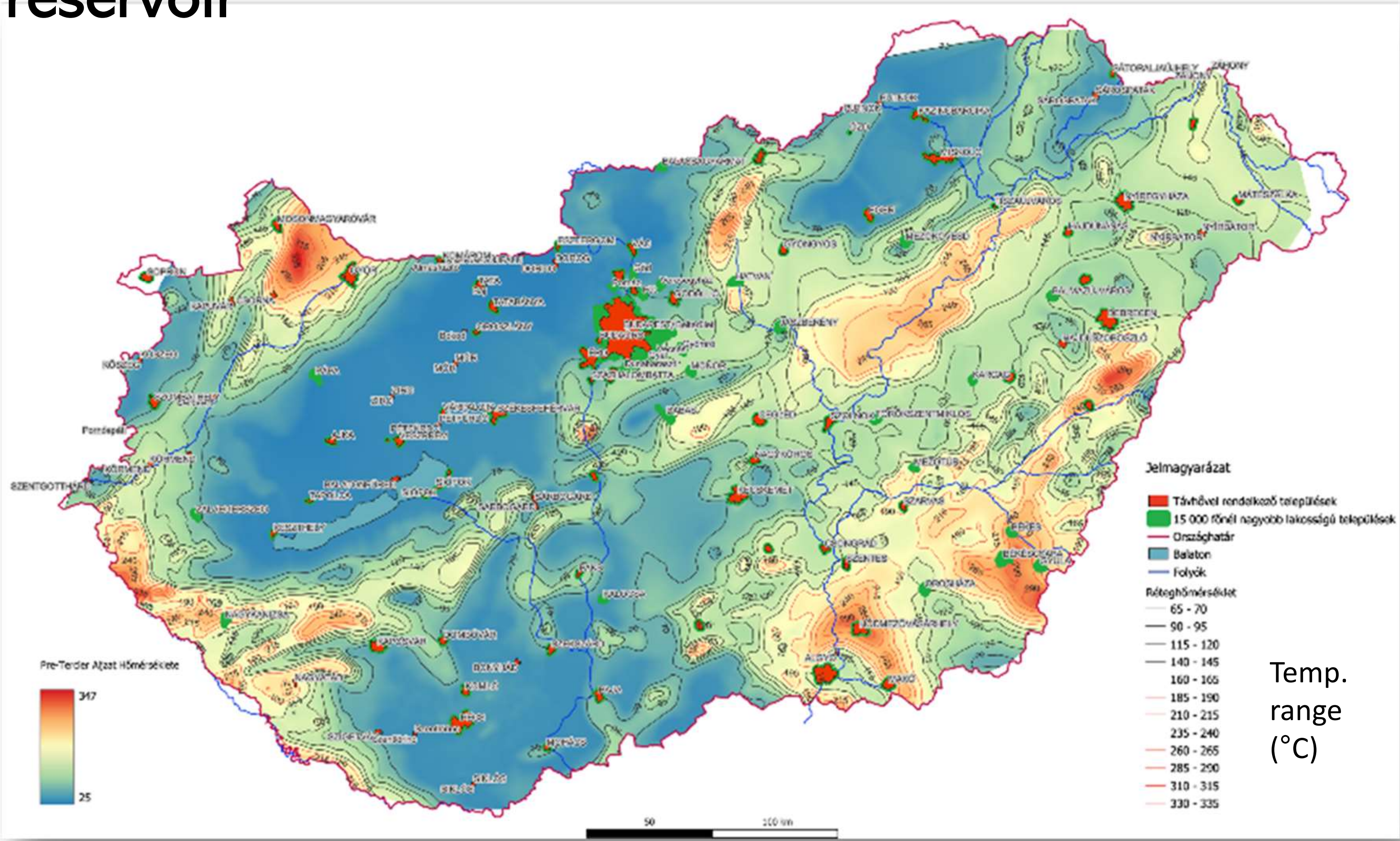


Particle migration and retention during geothermal energy exploitation via water recycling in a weakly consolidated sandstone geothermal reservoir (Cui et al. 2022)

Fractured carbonate reservoirs

Features of the reservoir

- ✓ carbonate rocks (limestone and/or dolomite
- ✓ fracture density (faults) and/or karstification determines the permeability
- ✓ local aquifers
- ✓ various temperature distribution with intense up and downflowing regimes
- ✓ it can be really deep
- ✓ higher exploration risk
- ✓ completly manageable reinjection
- ✓ 7-15 MWth/well (pair)
- ✓ ~70-150 °C



Temperature distribution at the top of the Pre-tertiary basement

Fractured carbonate reservoirs

Features of the reservoir

- ✓ carbonate rocks (limestone and/or dolomite
- ✓ fracture density (faults) and/or karstification determines the permeability
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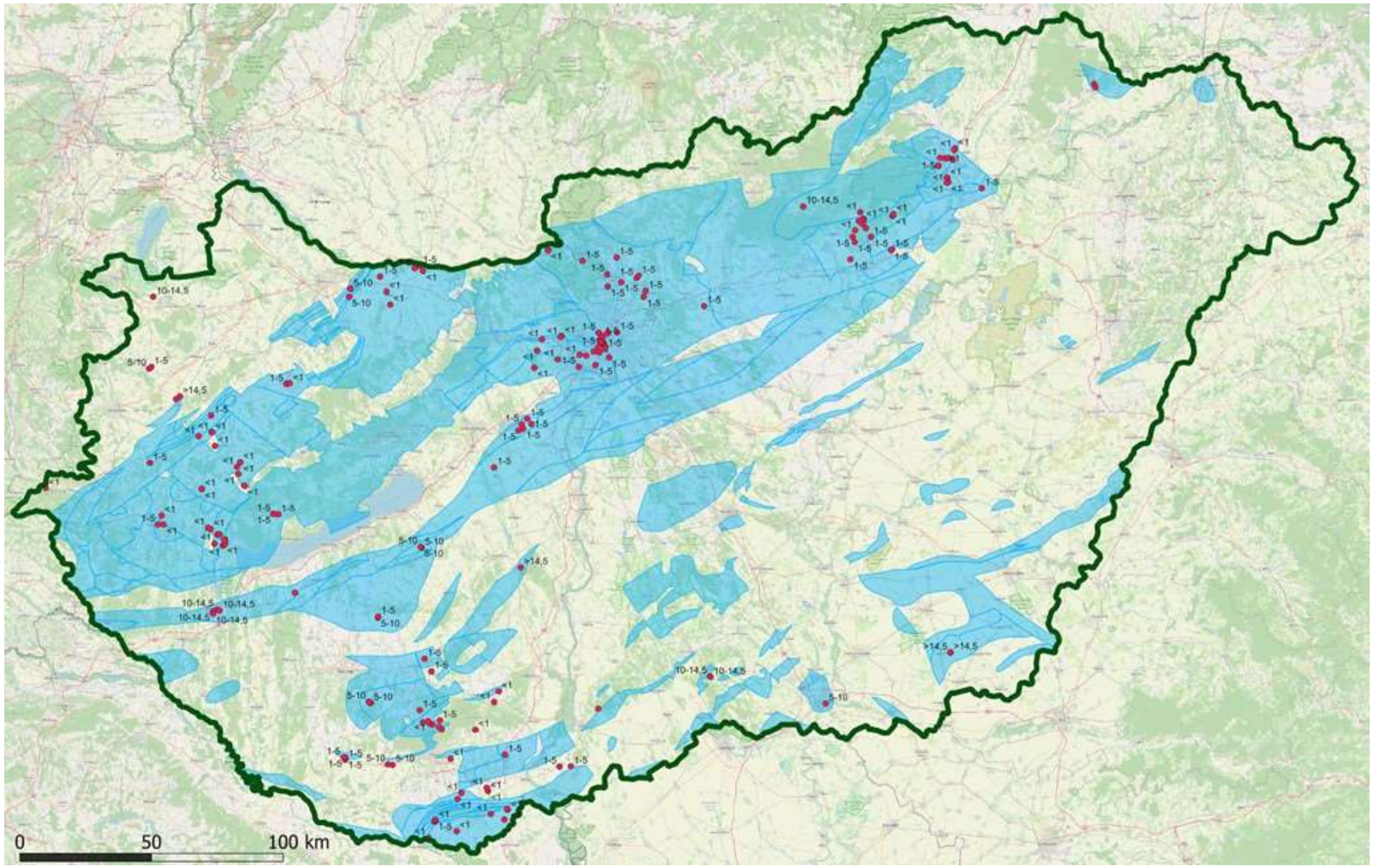

Location of the main carbonate aquifer formations (after Haas et al. 2010)

Fractured carbonate reservoirs

Features of the

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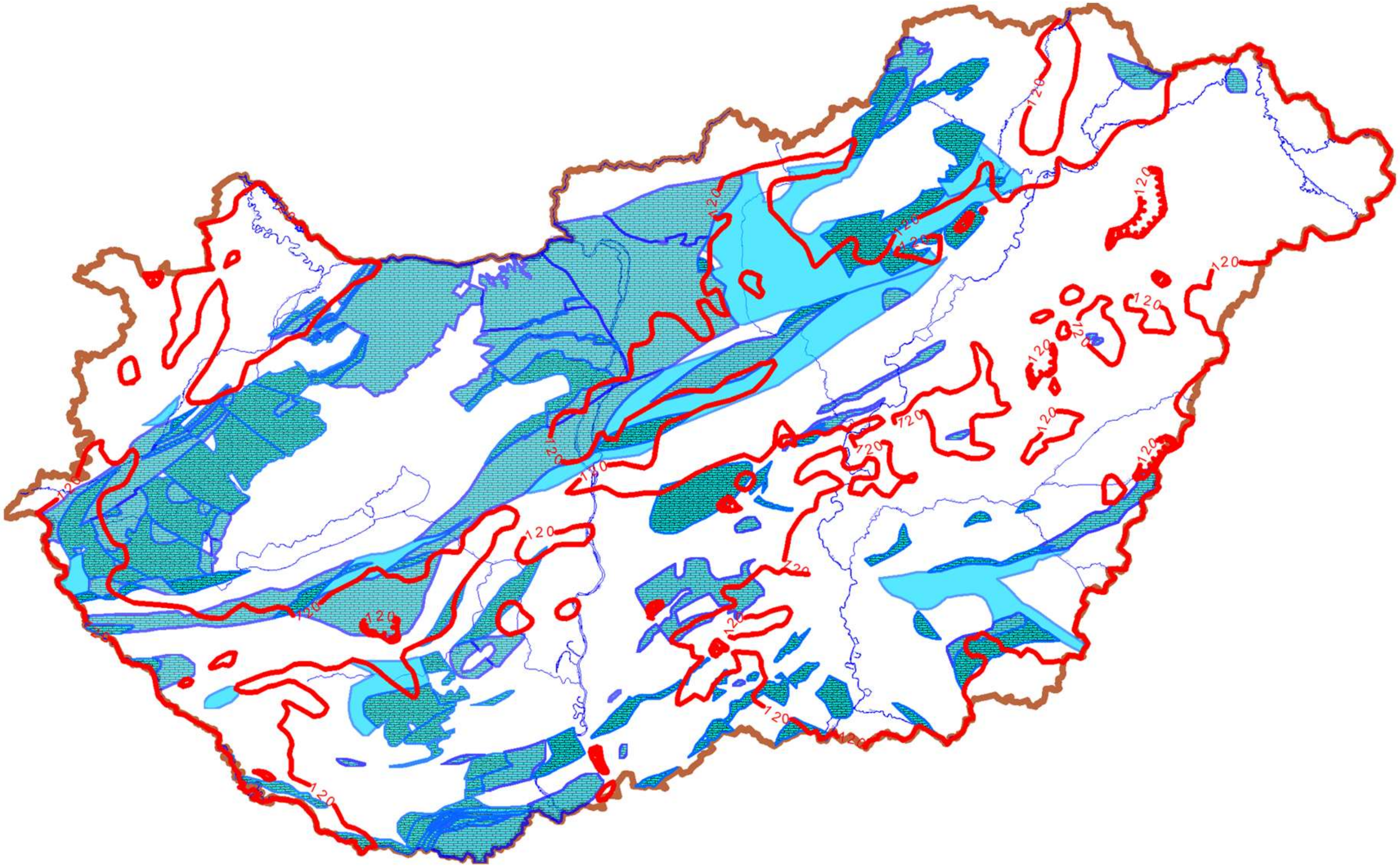
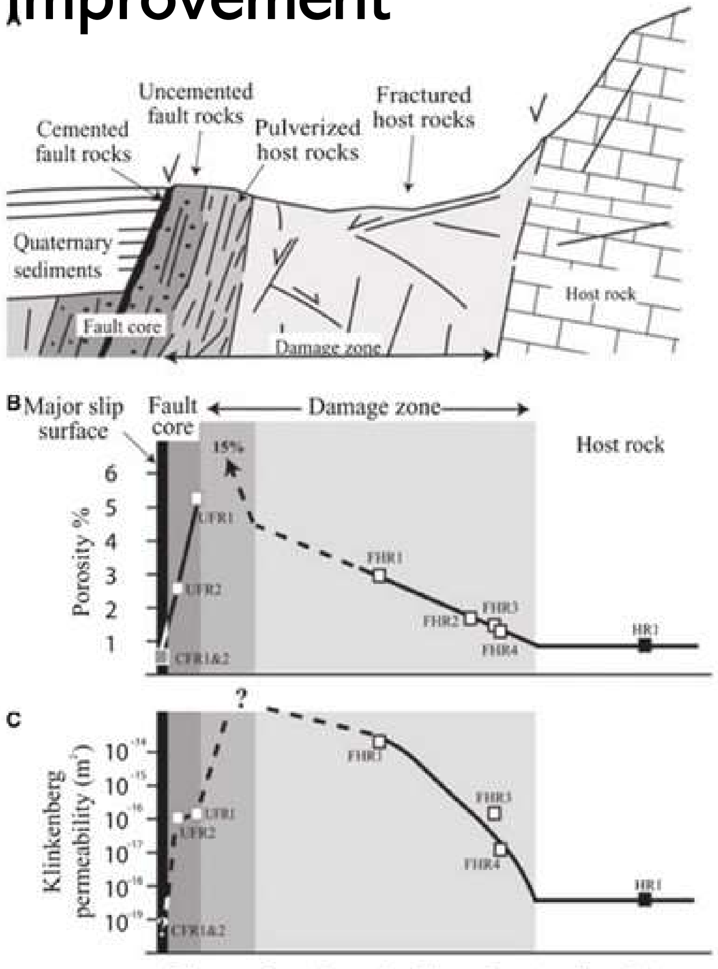


Distribution of carbonates & the 120 °C isotherm (based on the previous two maps)

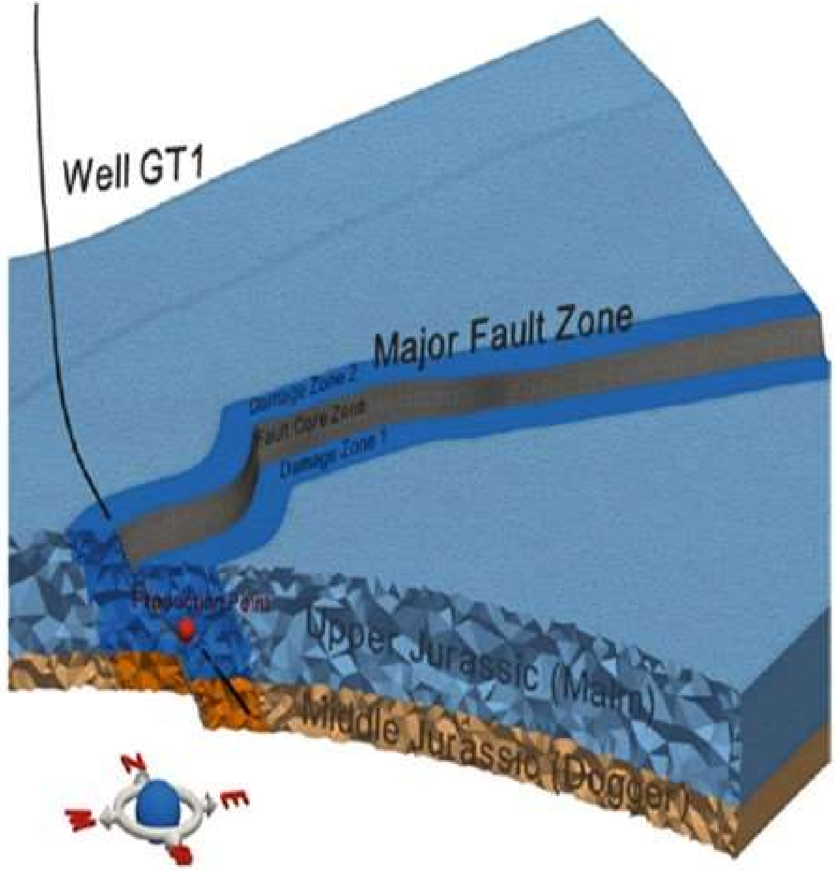
Fractured carbonate reservoirs

Water yield improvement

Identification of fractured zones
- faults & damege zones
- permeability of the damage zones could be orders of magnitude higher compared to rest of the formation



Permeability and porosity in demaged zone (Agosta et al., 2007)

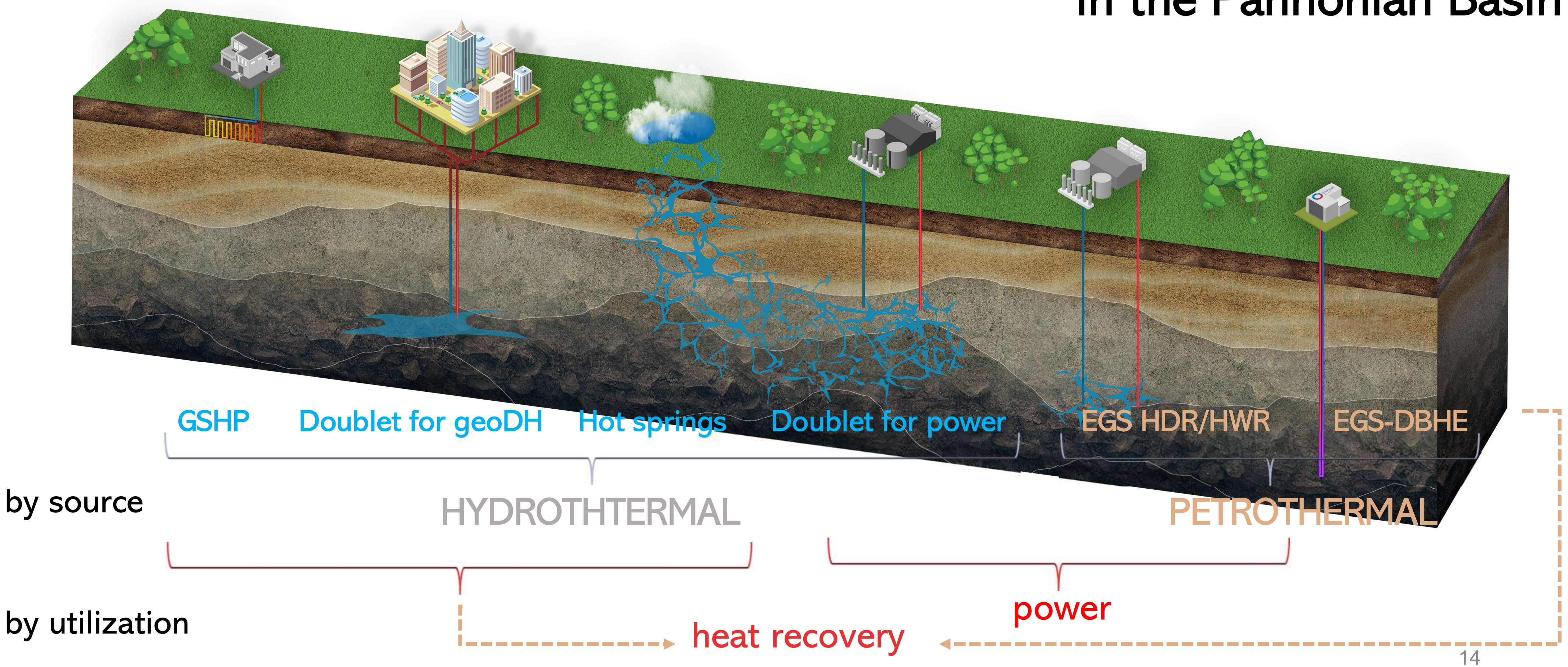


(a) Geometry of the model considering a production well within the damage zone

A geothermal well (Germany) planned in a fractured carbonate reservoir (Cacace et al., 2013)

Geothermal technologies

Types of implementable geothermal technologies in the Pannonian Basin

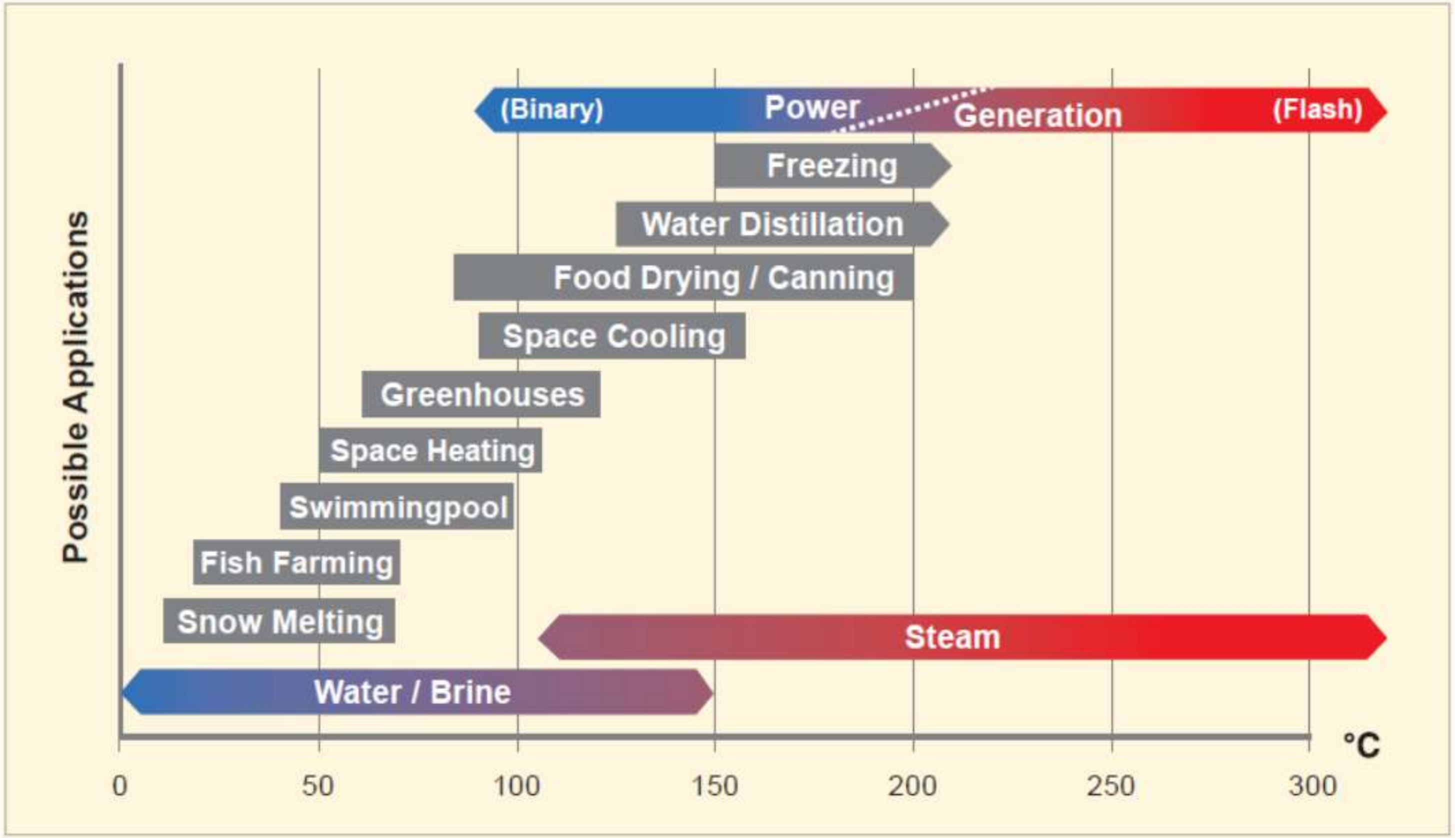


Geothermal utilization

- ✓ the possible utilization is limited by the resource temperature
- ✓ the feasibility could be enhanced by the cascade & CHP utilization

Examples

- ✓ <u>Cascade utilization</u>: first the geothermal water is used for industrial heating and than the same water is used for space heating
- ✓ <u>Combined Heat & Power (CHP):</u> a type of geothermal power plant that produces both electricity and hot water for district heating

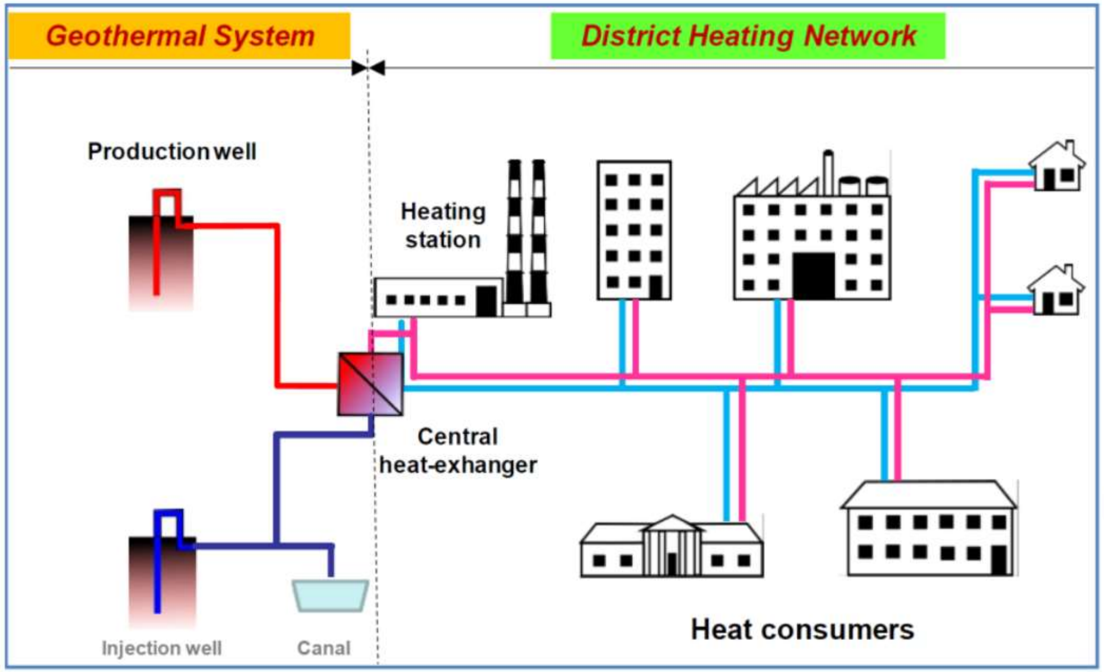


Modified Lindal diagram

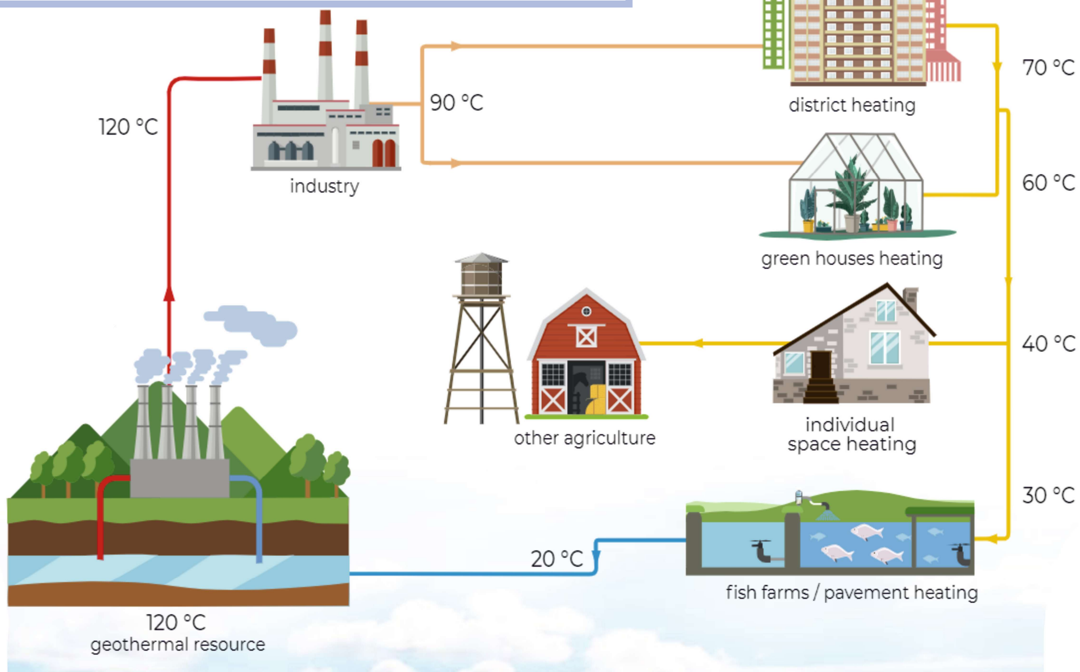
Source: Gehringer and Loksha, Geothermal Handbook: Planning and Financing Power Generation, ESMAP 2012

Geothermal utilization in district heating

Space and district heating is among the most successful geothermal direct applications in countries with cold or continental climate



Scheme of geothermal based district heating
Source: Barkaoui et al. 2018



Sketch of an ideal geothermal cascade system where users are sequentially linked according to their decreasing heat demand
Source: https://www.interreg-danube.eu/

DH Systems in Hungary

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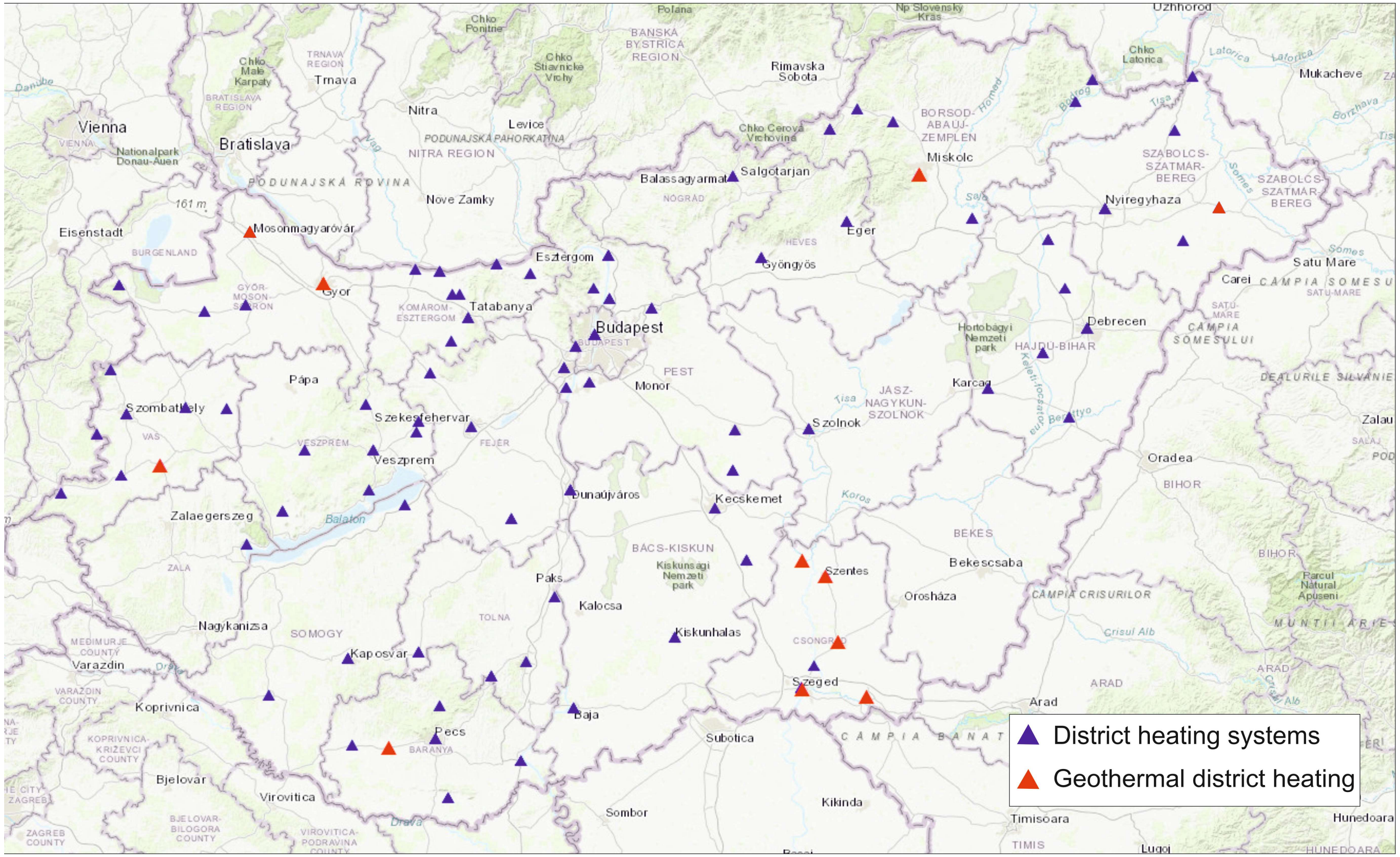


Source: OGRE – Geothermal Information Platform https://map.mbfsz.gov.hu/ogre/

- <u>Cities with district heating</u>: 92
  <u>Fuels</u>: eg. Natural gas, coal, biomass, fuel oil, communal waste, propane
- <u>Cities with geothermal</u> (totally or partly) <u>district heating</u>: 11 Csongrád, Győr, Hódmezővásárhely, Makó, Miskolc, Szeged, Szentes, Szentlőrinc, Vasvár, Mátészalka, Mosonmagyaróvár
  <u>Total installed thermal capacity</u>: 204,86 MW
  <u>Total Available thermal capacity:</u> 180,49 MW

How to fit geothermal resources into an existing DH system?

Example I.

Supply temperature: 65-110 °C

Return temperature: 44-57 °C

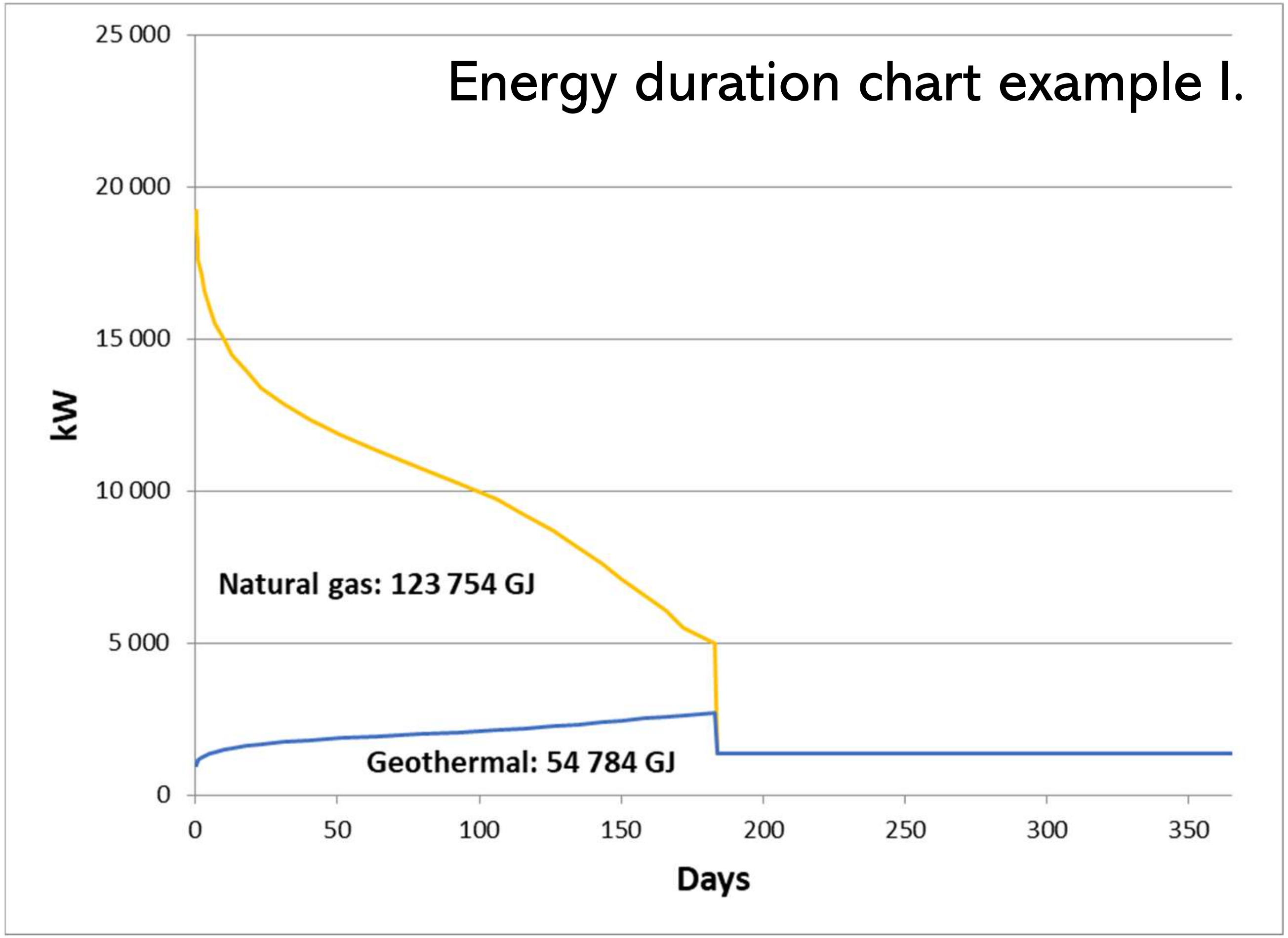
(Depending on the outside temperature)

Thermal well parameters

Outflow temperature: 64 °C

Yield: 2000 l/min (120 m^3/h)

✓ Enough for mainly the domestic hot water needs



How to fit geothermal resources into an existing DH system?

Example II.

<u>Supply temperature</u>: 77-105 °C

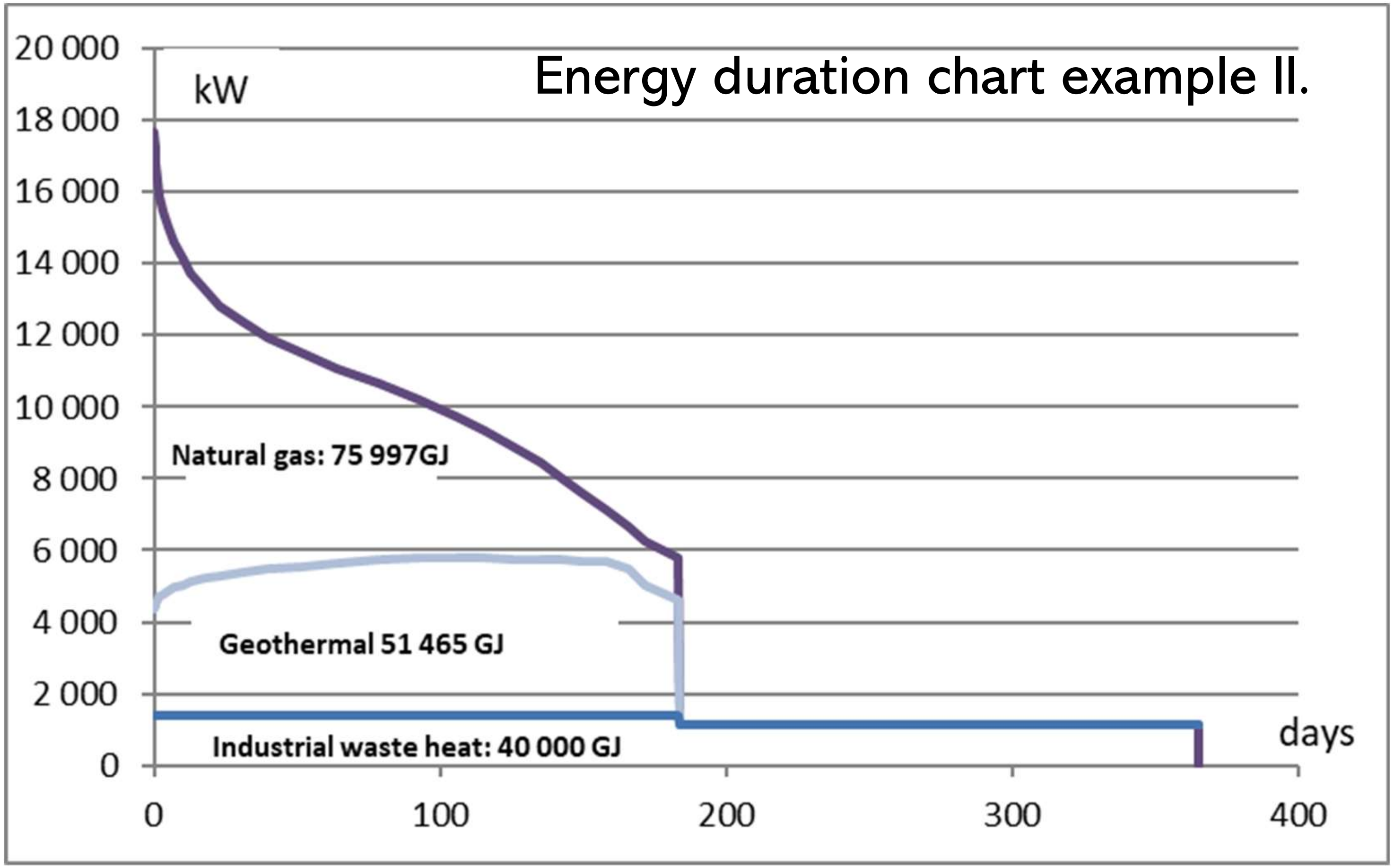
<u>Return temperature</u>: 43-60 °C

(Depending on the outside temperature)

Thermal well parameters:

<u>Outflow temperature</u>: 81 °C

<u>Yield</u>: 2000 l/min (120 m^3/h)



Alternative solutions

High temperature heat pumps

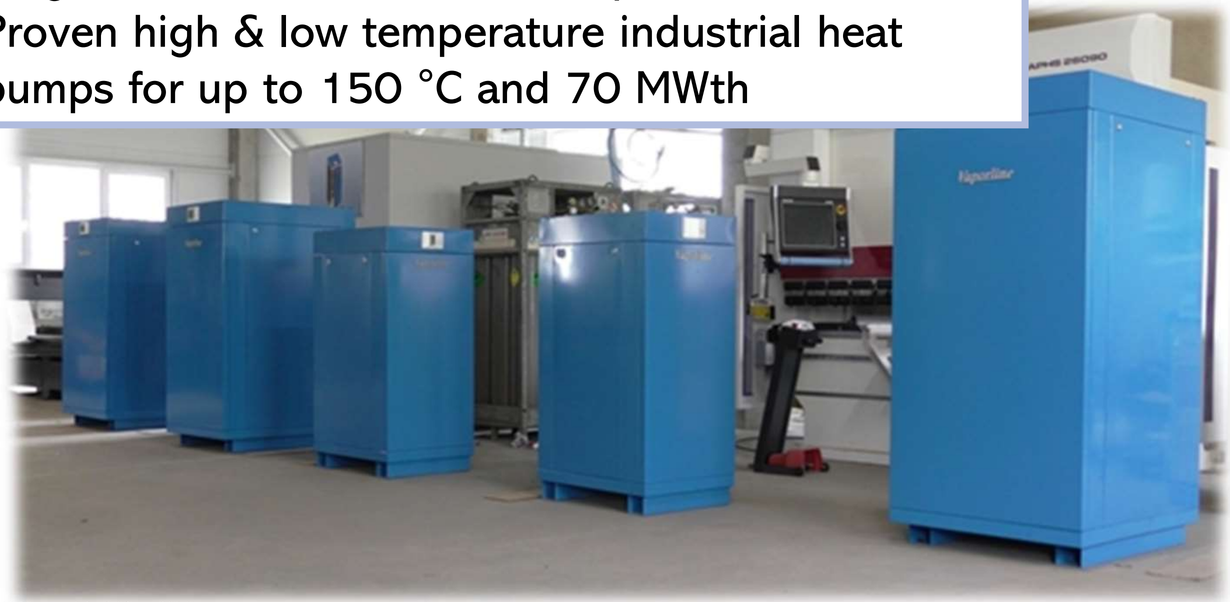
<u>Hungary</u>: Geowatt Ltd. & Vaporline technology ™

- ✓ <u>Production</u>: 70-80 °C form 30-50 °C thermal water
- ✓ <u>Capacity</u>: 50-300 kW/unit
- ✓ <u>COP</u>: ~3-8

<u>Internationally</u>:

- ✓ Large-scale Industrial Heat Pumps
- ✓ Proven high & low temperature industrial heat pumps for up to 150 °C and 70 MWth

Industrial heat pump configuration for up to 100°C forwarding temp and 45 MWth



Industrial heat pump configuration for up to 150°C forwarding temp and 70 MWth

Alternative solutions

WHEAT technology – What is it & values

WeHEAT DEFINITION

deep geothermal probe

closed loop

no water production

fluid circulation extracts the heat

repurpusing old wells

weather independent

green heating system

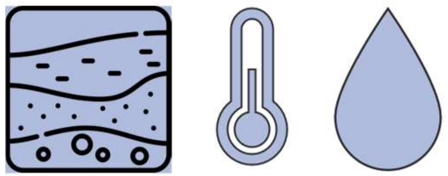
- one-time investment
  low operational cost
  minimal maintenance requirements
- P&A and clean-up costs
- predictable, permament heating system
  fully automatized control
- quick, flexible installation
  complete system in a few days
- no CO_2 emission → EU targets
  zero waste technology

Summary & Conluding remarks

What it takes to make a geothermal DH project?

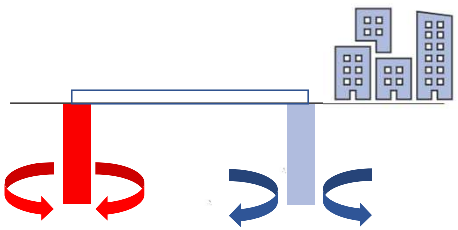
GEOLOGICAL PILLAR

- complex analysis of the key factors
  - reservoir
  - temperature
  - water chemistry



GEOTERMAL ENGINEERING PILLAR

- understanding consumer needs & demands
- complex technological experience



SYNCRONIZATION

- complex response to consumer needs
- taking into account local geological features
- system optimization
- local adaptation
- conventional/ alternative solutions

LONG TERM INVESTMENT

- successful projects for any cities
- money saving
- increased energy security
- mitigation of CO_2 release

THANK YOU FOR YOUR ATTENTION!

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www.weheat.systems

www.ms-energy.org.

https://www.msrenewables.com/

https://www.youtube.com/watch?v=VcS4_IgxDGE

https://www.youtube.com/watch?v=HW2MFK-jR-M

Ministry of Foreign Affairs and Trade of Hungary

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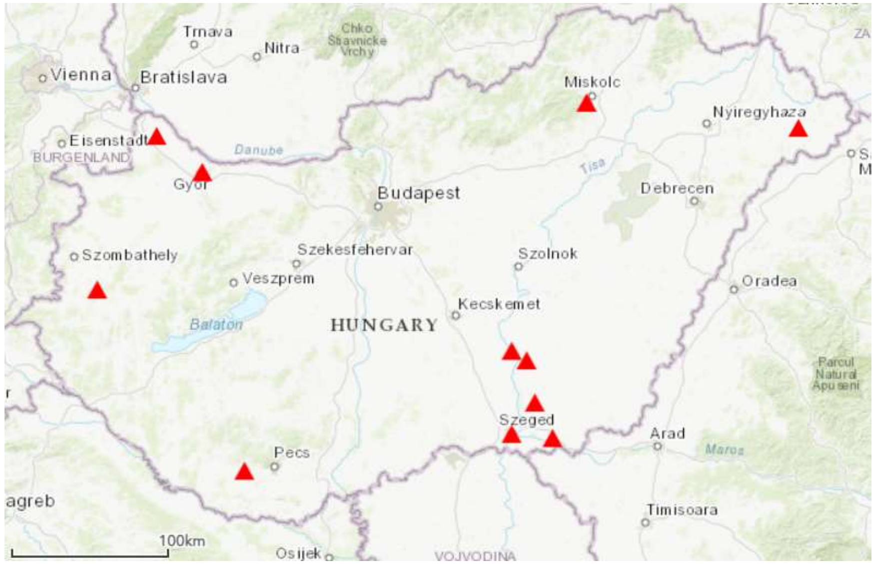
Interreg Programme Danube Region

Co-funded by the European Union

Combining geology & market potential

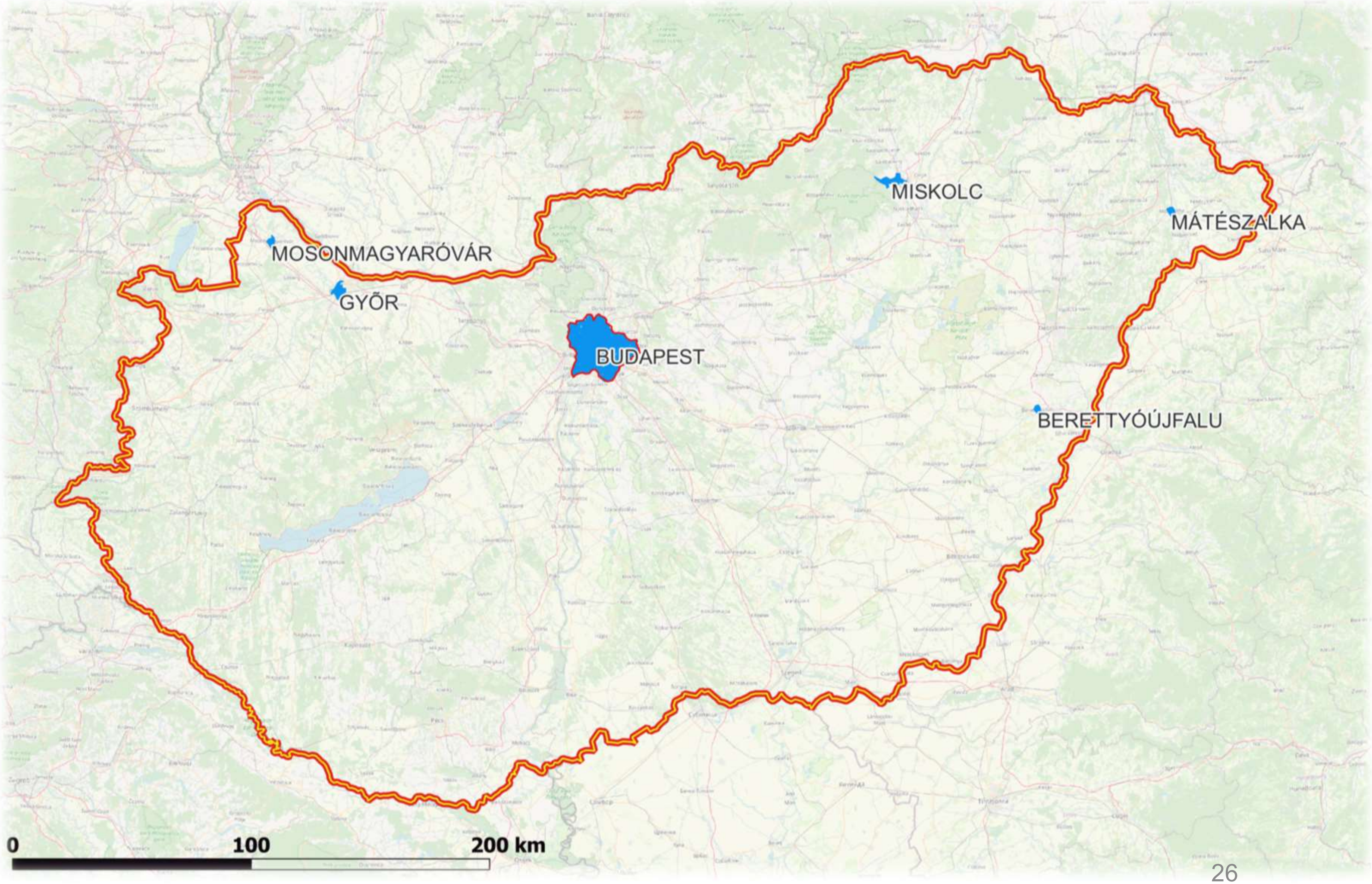
Evaluation and interpretation of geology & DH systems:
Features of systems that already have geothermal energy

No.	City	Installed th. capacity (MW)	Available th. capacity (MW)	Reservoir type
1.	Győr	60	50	Carbonate basement
2.	Miskolc	60,3	60,3	Carbonate basement
3.	Vasvár	1,6	1,6	Carbonate basement
4.	Csongrád	4,19	3,72	UP
5.	Szentes	30,67	26,64	UP
6.	Hódmezővásárhely	37,67	27,8	UP
7.	Szentlőrinc	4,6	4,6	Fractured metamorphite basement
8.	Szeged	Under construction		UP
9.	Makó	5,83	5,83	UP
10.	Mosonmagyaróvár	~5	~5	UP
11.	Mátészalka	~2,2	~2,2	UP



Geothermal energy production in DH systems with thermal water in Hungary

MS Energy Solutions' references in DH systems of Hungary



- ✓ Mosonmagyaróvár
- ✓ Győr
- ✓ Budapest
- ✓ Miskolc
- ✓ Mátészalka
- ✓ Berettyóújfalu

MS Energy Solutions' references in DH systems of Hungary

MOSONMAGYARÓVÁR
- 2017-2020
- EU-FIRE Ltd.
- Project management support
- Supervison, and technical inspector for 2 wells
- Support of surface technology
- Water well permit
- Usage permit

GYŐR
- 2015-2018
- Pannergy Plc.
- Validation and interpretation of a geological model
- Support for documentation
- Supervison during drilling
- Drilling plan of 3 wells

BUDAPEST
- 2021-today
- Budapest Public Utilities Company
- Geothermal Exploration, CCRS-risk management, professional consultancy for Budapest Geothermal System project plans.

MÁTÉSZALKA
- 2020
- EU-FIRE Ltd.
- Project management support
- Supervison, and technical inspector for a production well

MISKOLC
- Pannergy Plc.
- Drilling plan of production wells
- Supervison, and technical inspector for a production and reinjection wells