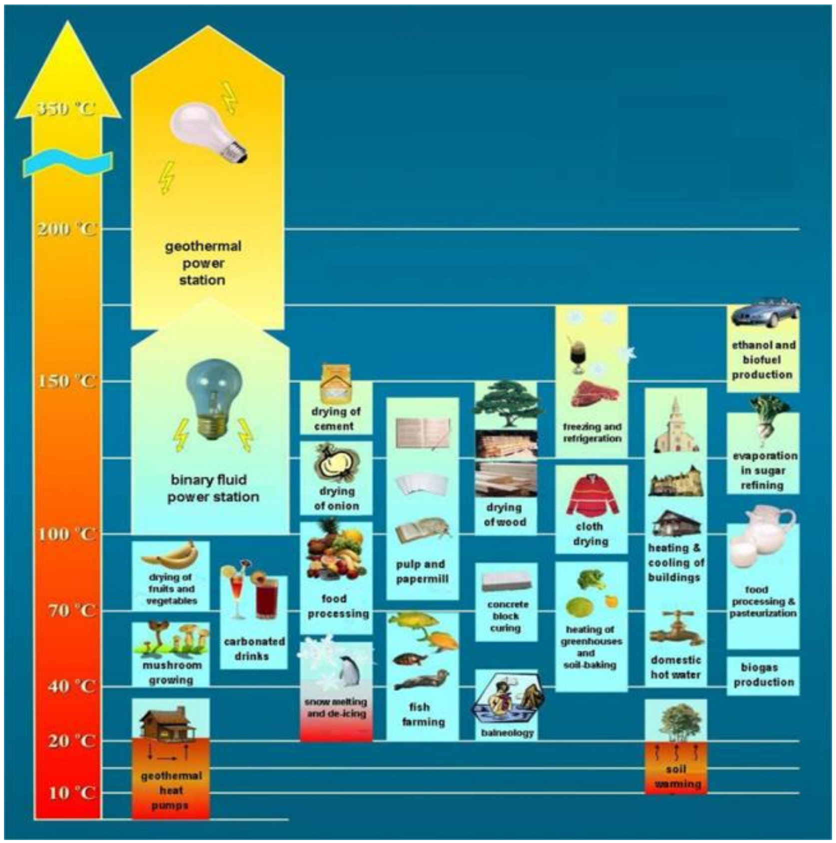
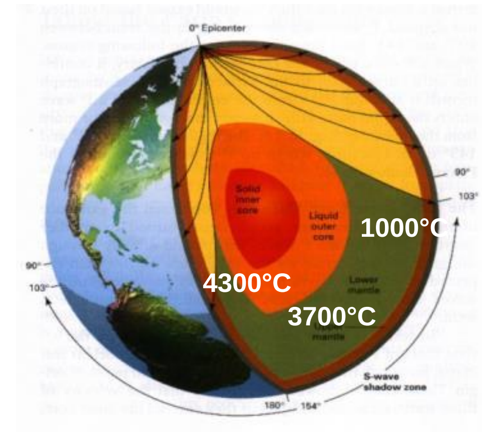
How can geothermal resource assessment and mapping influence decision-making for district heating: Experience from Hungary and the Danube Region

Annamária Nádor
Mining and Geological Survey of Hungary

IRENA - Energy Solutions for Cities of the Future: Facilitating the Integration of Low-Temperature Renewable Energy Sources into District Energy Systems.
Capacity building workshop, December 5-6, 2019, Belgrade, Serbia

Why geothermal?





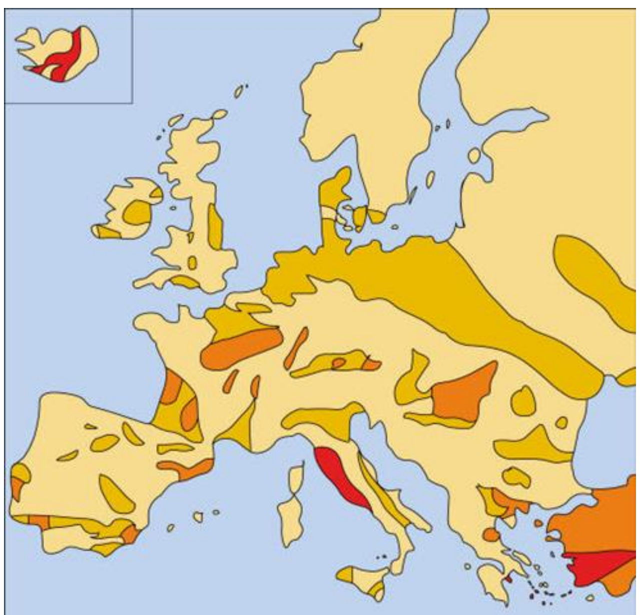
- ✓ Widely avaliable
- ✓ 24/7 delivery
- ✓ Large untapped potential
- ✓ Predictable output
- ✓ Numerous applications
- ✓ Domestic and green resource
- ✓ Can be combined with other energy sources to increase efficiency
- ✓ Suitable for cooling
- ✓ Low environmental footprint, invisible

Geothermal energy – how to classify?

- Very low: <30°C – requires heat pumps
- Low: 30-125 °C – direct heat
- Medium : 125-150 °C – electricity generation with binary cycles, CHP

Heat source: mainly Earth's heat flux

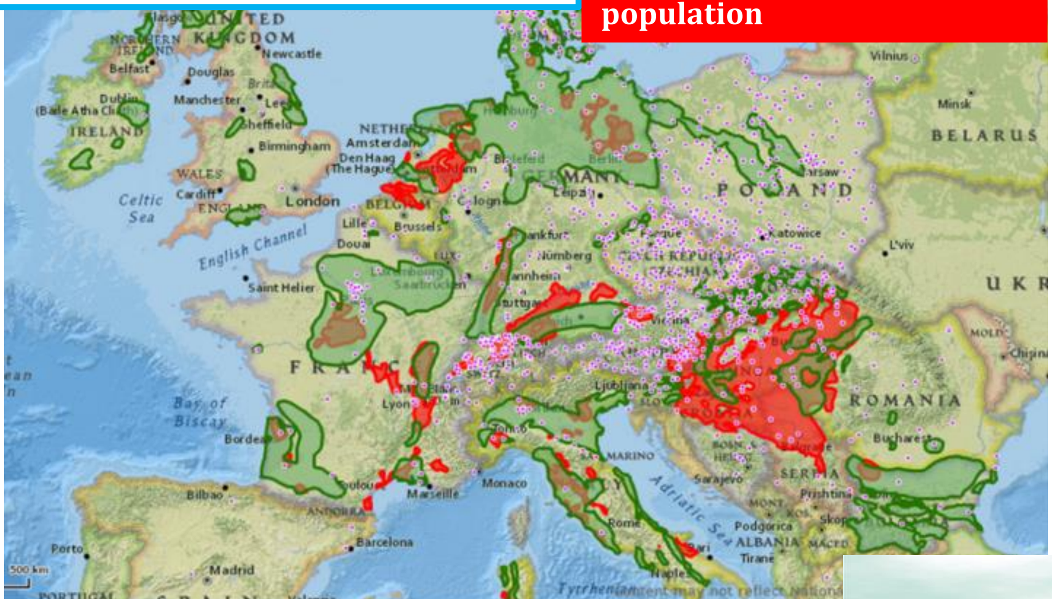
- High: >150°C – „efficient" electricity production. Heat source: mainly magma in magma chambers located at shallow depths (restricted in Europe)

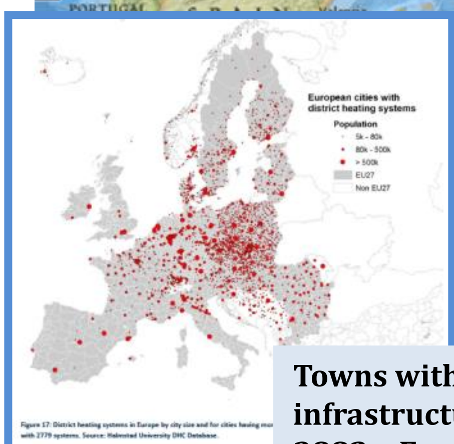


Geothermal energy for the decarbonisation of the heating sector

Matching resources and heat demand in Europe – GeoDH project (2011)

Geo-DH would be available for 26% of the EU-27 population



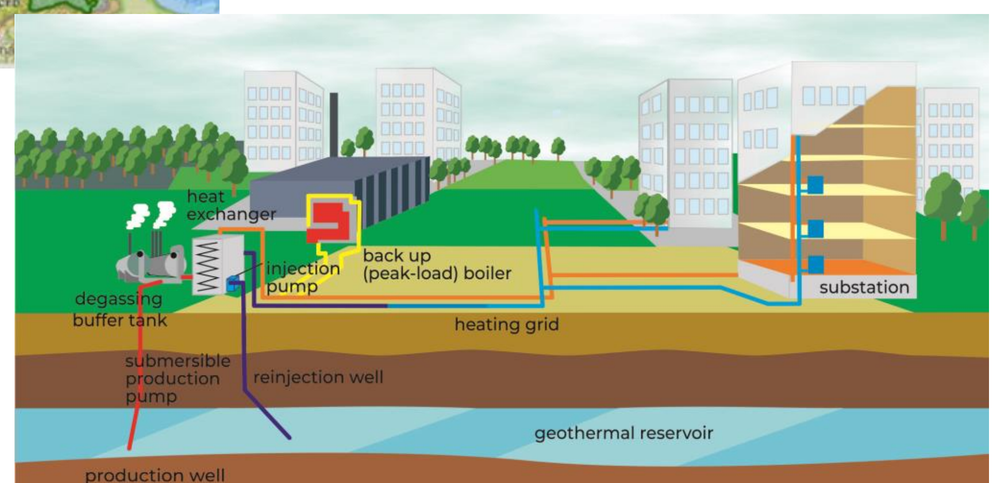


Towns with DH infrastructure
3882 – Europe
3070 – EU-27

47% of EU energy consumption is heating & cooling (HC)

12% of the total communal heat demand is district heating

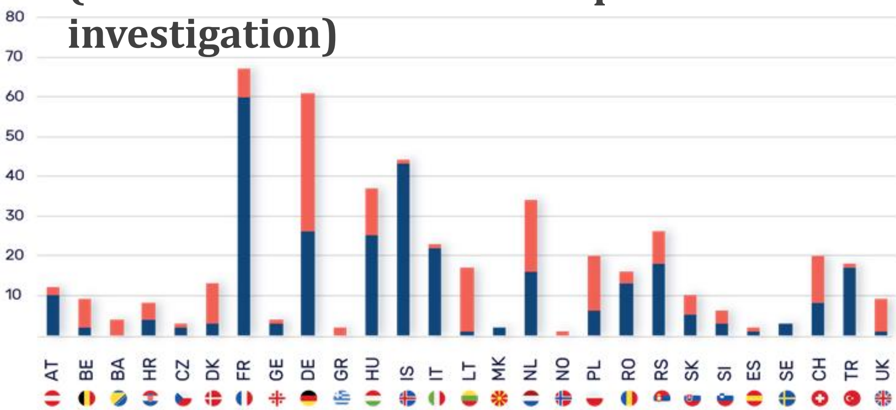
RES / geothermal must be a pillar in the clean energy transition

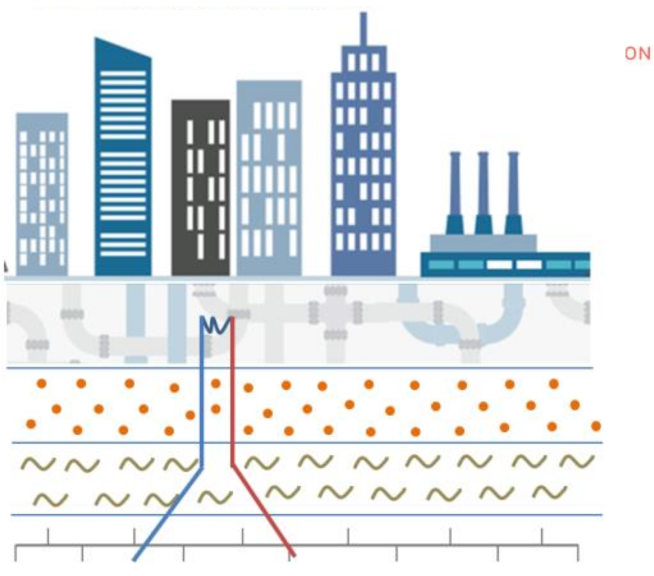


Geothermal district heating: an increasing momentum

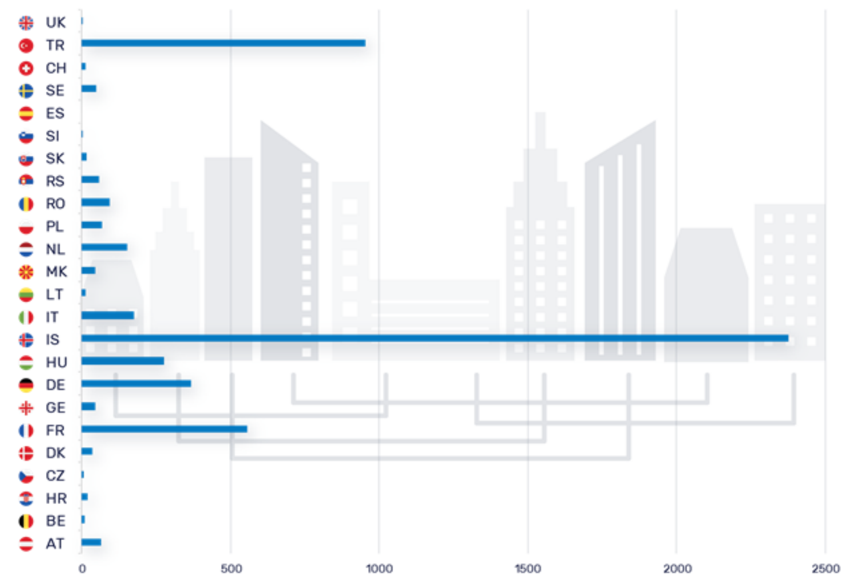
EGEC Market Report 2017

280 GeoDH systems in operation in Europe (another 164 under development or investigation)



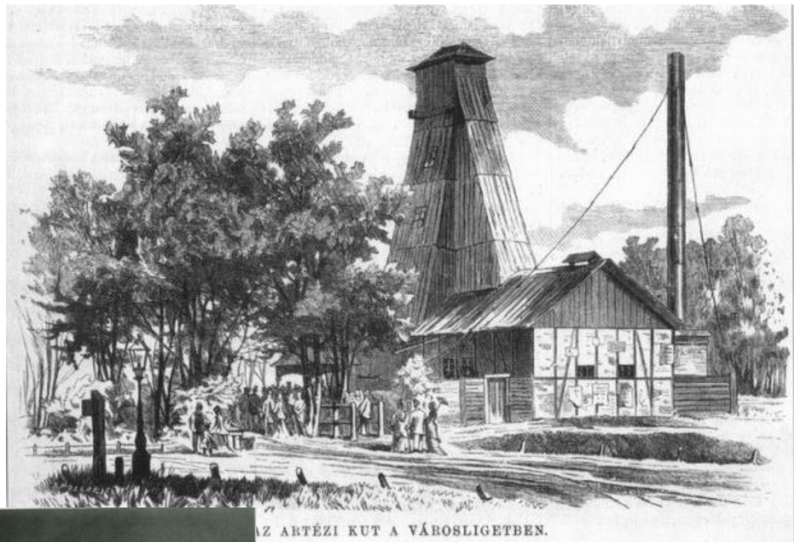


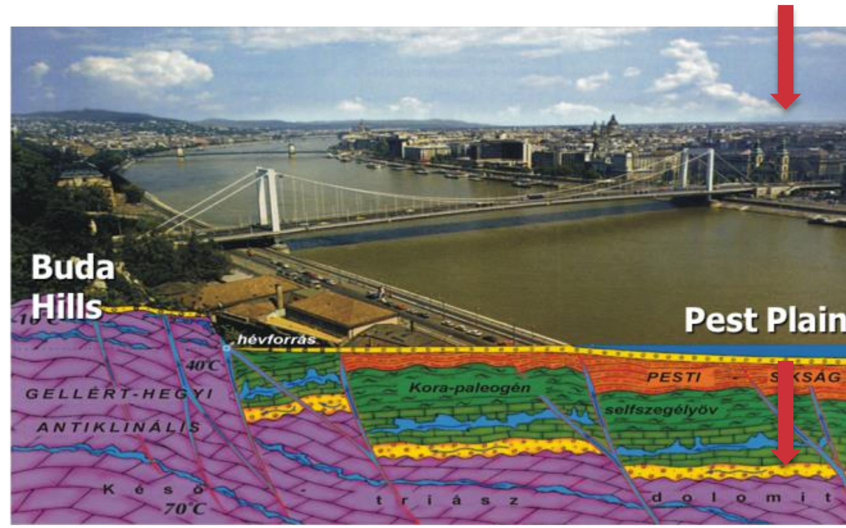
Total installed capacity 4,8 GWth (2017)



Traditions of geothermal energy use in Hungary

1878: Városliget well: 970 m (deepest well in Europe): 78 °C

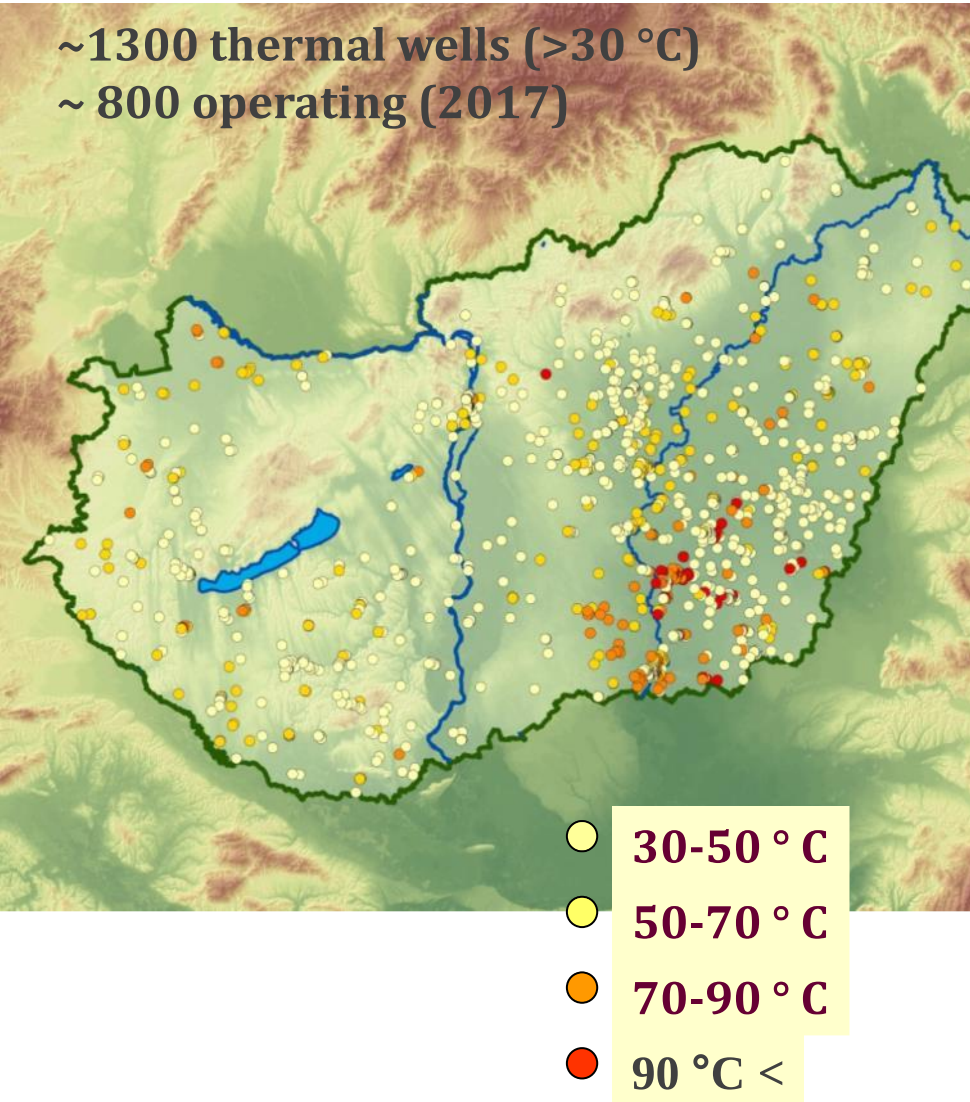




Vilmos Zsigmondy (1821-1888)

Széchenyi Spa, Budapest

Current utilization schemes in Hungary



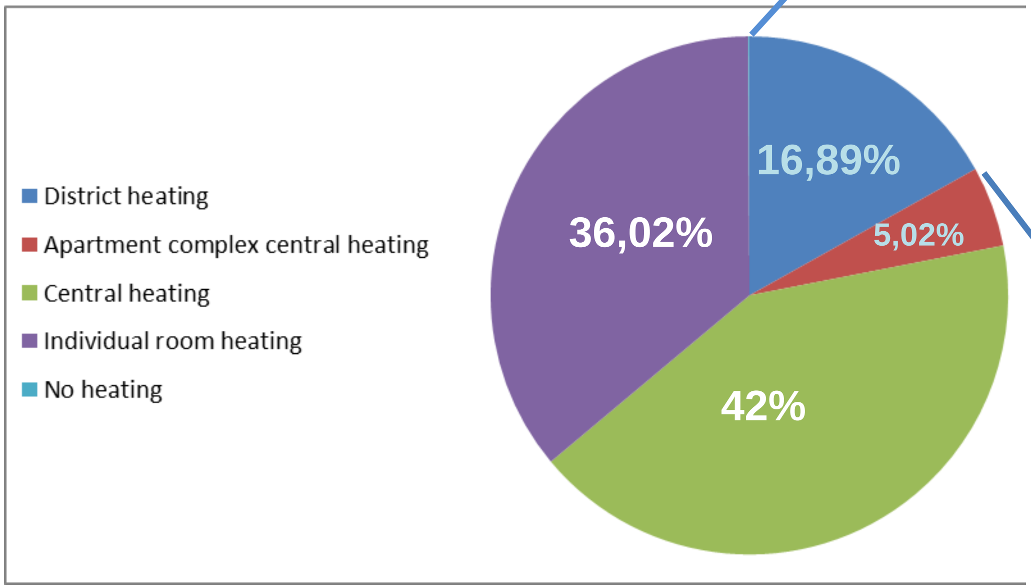
	installed capacity (MWt)	annual production (GWh/y)
Geothermal district heating (23 towns)*	223,36	635,66
Individual space heating (cca 40 loactions)	77,2	83,1
Greenhouse heating	358	803
Balneology (cca 250 wells)	249,5	745,5
	908,06	2267,26

* DH: 8, thermal water town heating: 15

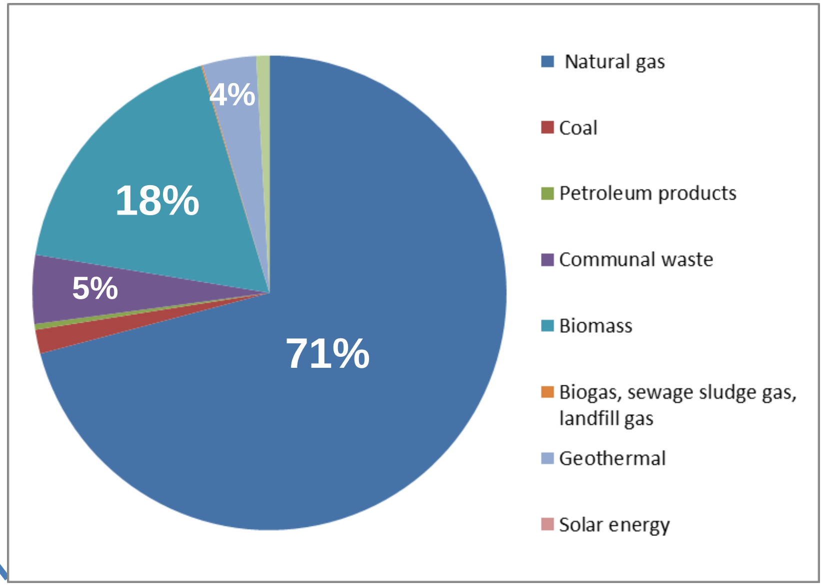
District heating in Hungary

Settlements with district heating infrastructure	**95**
District heating suppliers	**110**
District heating networks	**220**
Number of flats with district heating	**648 500**

District heating in Hungary



Distribution of Hungary's housing stock according to the type of heating



Source of district heating

Source: Association of Hungarian District Heating Supliers / www.tavho.org

Good examples for geoDH: Miskolc (Pannergy Ltd)

- Miskolc, Hungary's 2nd largest town (industrial), population: 170 000 (heat market)
- Offtake partner: city-owned company, offtake contract: 15 y
- CAPEX: 25 million euro (appr. 9 million euro non-refundable grant (2010-2013)
- Capacity: 55 MW
- Annual production: 800-950 TJ

- Triassic carbonate reservoir
- 2 production and 3 reinjection wells
- Production depth: 1500-2300 m
- Q= 6600-9000 l/min
- T outflow= 95, 105 °C
- Installed capacity: 55 MWt

Good examples for geoDH: Szeged (Szetáv Ltd)HU)

- Szeged: Hungary's 3rd largest town, population: 162 500 (heat market)
- Fossil fuel (gas) based distric DH system: 50% of the city's population (27 000 apartments and 500 public buildings
- 23 DH circuits, 235,8 MW / 843 TJ/y
- Ongoing development: replacement of 9 circuits with geothermal: 1 production – 2 reinjection wells each
- 140 M euro investment (50% EU funding)
- Porous reservoir: 1700-2000 m, T outflow= 90 °C, Q= 1200 l/min

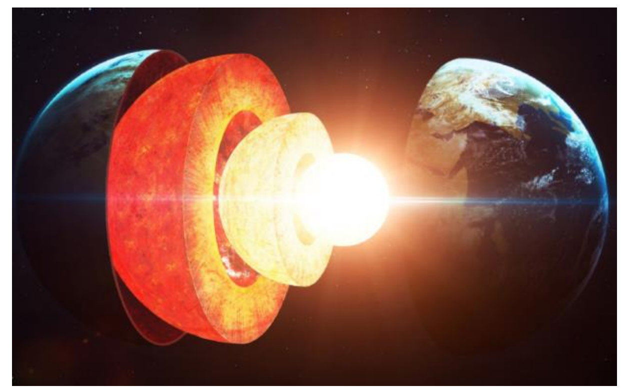
Development plans in Hungary

	2020		2030	
				
Share of **RES**	20%	14.65%	32%	20%

Modernization of the DH system is in focus!
(Efficiency and RES)

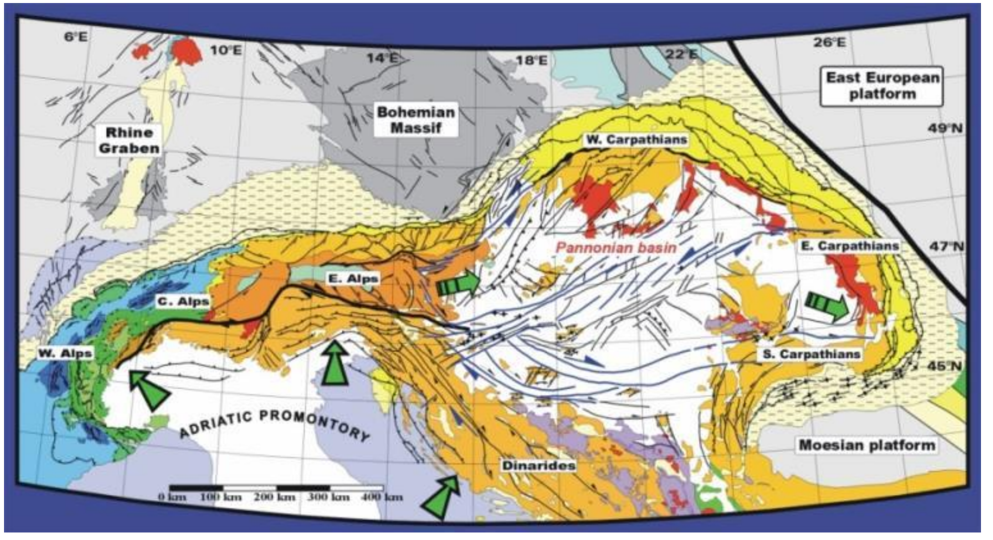
Source: NECAP of Hungary

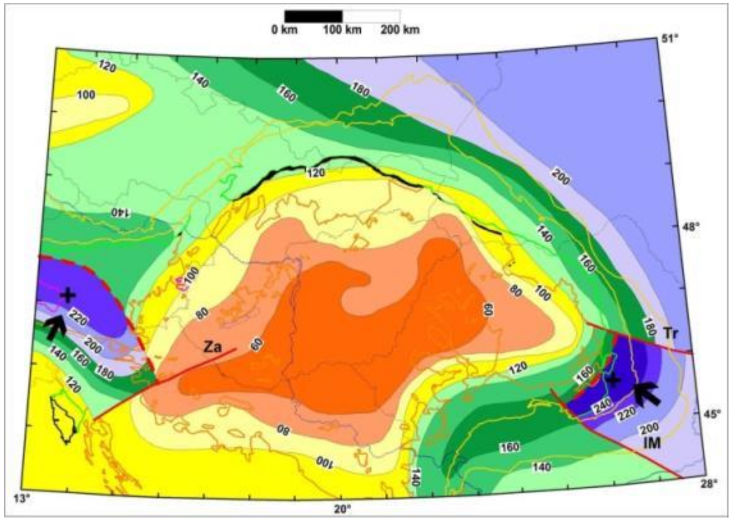
	2018	2020
Geothermal		17% of total RES
Heat	*~8,2 PJ*	*14,95 PJ*
Power	*3 MW*	*57 MW*



Preparation: feasibility studies: selected DH systems, assessment of geothermal potential in the given regio - 3 categories
Cots assessments (CAPEX from 1-2 M euro/MW, OPEX 0,5 M euro/year)

Geothermal energy in Central Europe





Outstanding potential due to favourable geological conditions (formation of the Pannonian basin):

Thinned lihosphere → high heat flux 100 mW/m^2 (continental average: 60 mW/m^2)

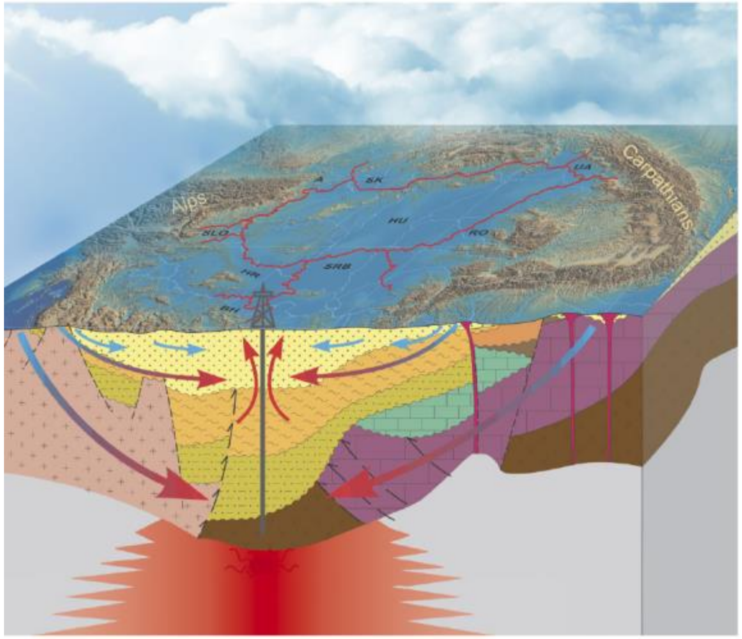
High geothermal gradient: 45 °C/km (continental average: 33 °C/km)

Thick porous basin fill sediments – thermal insulation + geothermal aquifers

Rich low-enthalpy resources (up to 125 °C) – largely untapped

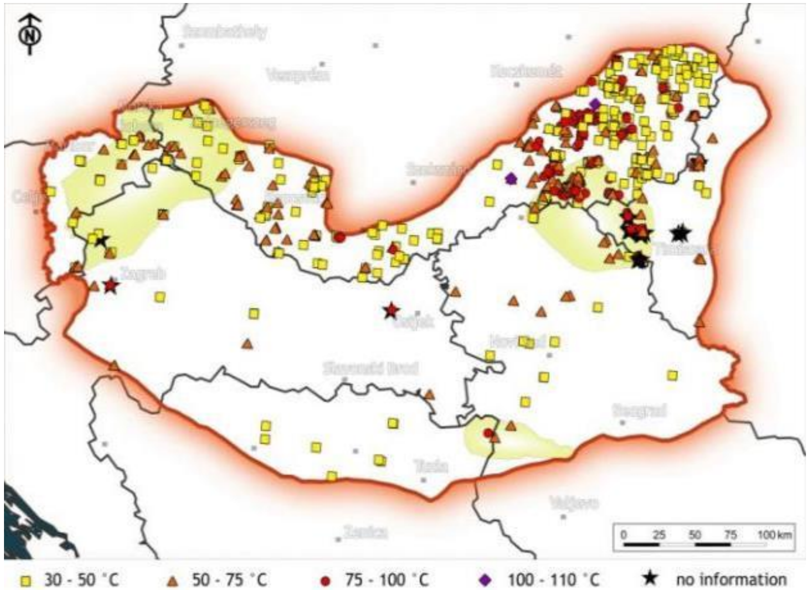
DARLINGe project

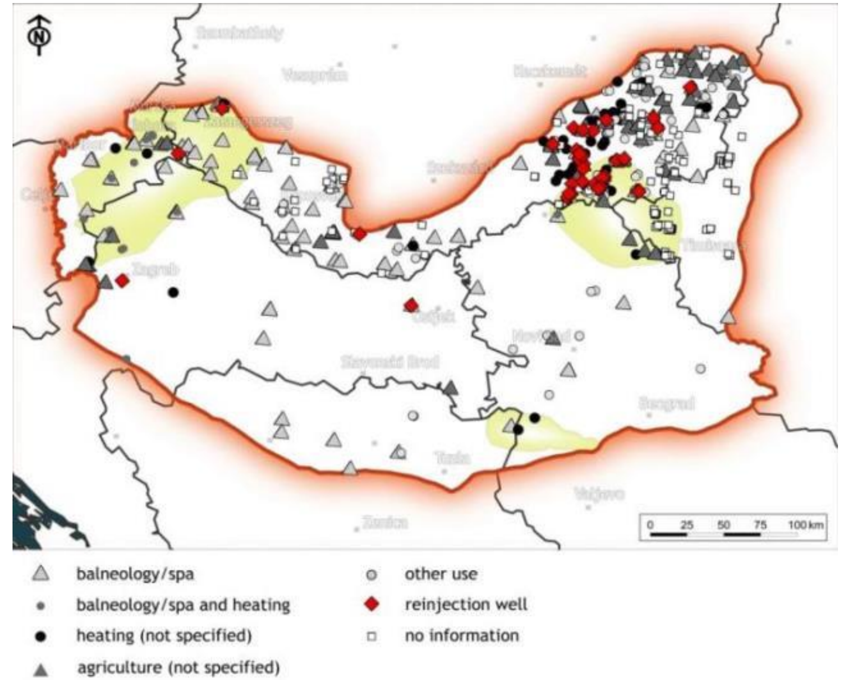
Geothermal reservoirs are controlled by reginal geological structures – cut-cross by country borders – **needs for joint evaluation and harmonized management**



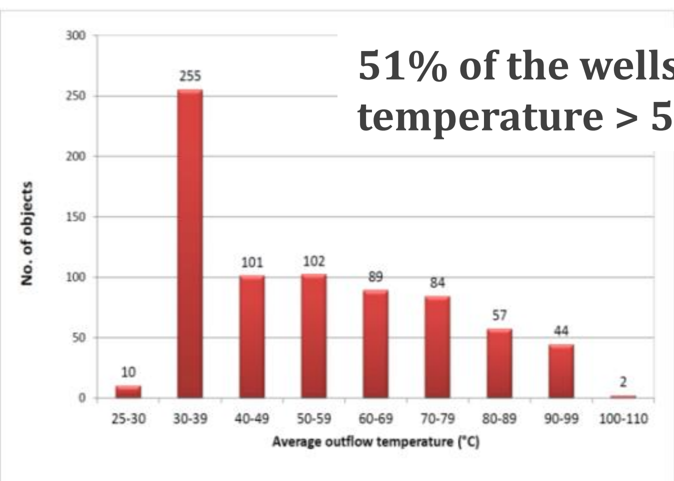
State-of-art: Current utilization

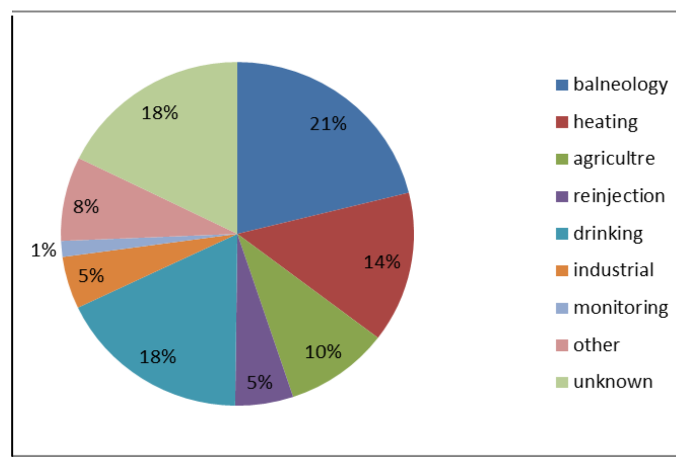
760 geothermal wells and 7 springs (T_{out} > 30 °C)





51% of the wells have outflow temperature > 50 °C





How to identify joint transboundary geothermal reservoirs and make potential assessment at regional scales?

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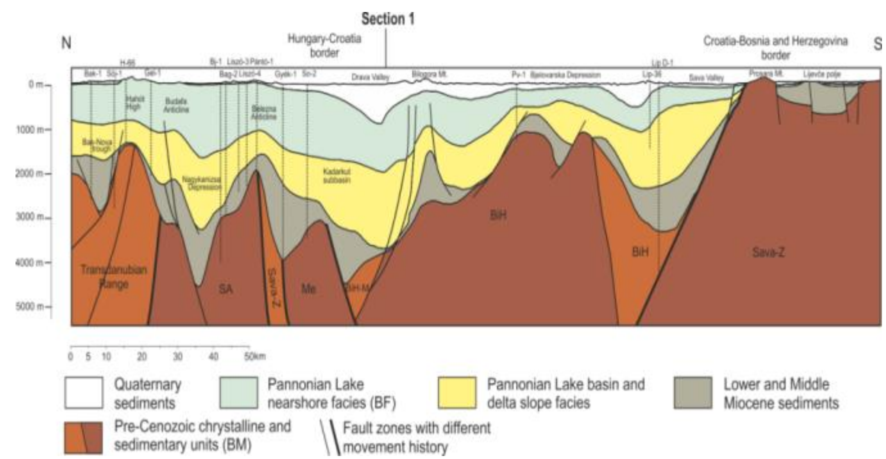
Geothermal reservoir: Subsurface 3D space where the rocks contain hot fluidum which can be exploited economically.

To identify „potential reservoirs” – i.e. geological / hydrogeological units containing thermal water suitable for heating in the Danube Region (1:500 000)

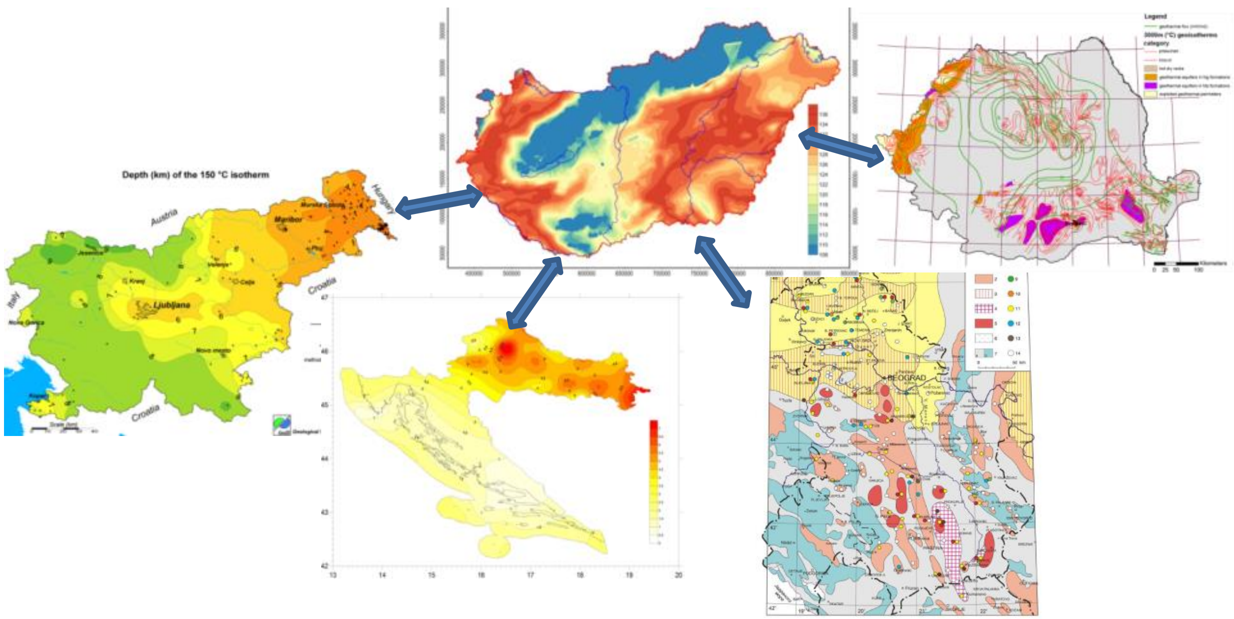
Make a potential asssessment

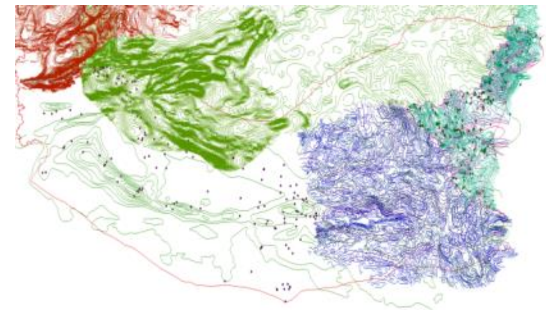
2 main reservoir types:

- **fractured, karstified basement – „BM”**
- **porous basin fill – „BF”**



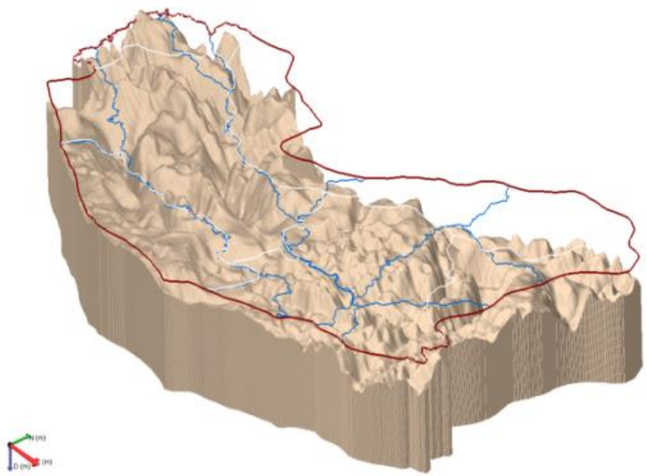
(1) Data collection and harmonization
HU, SI, HR, BiH, SRB, RO



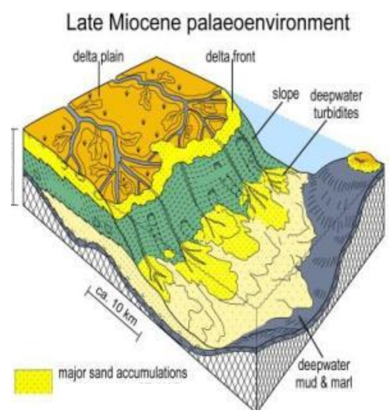


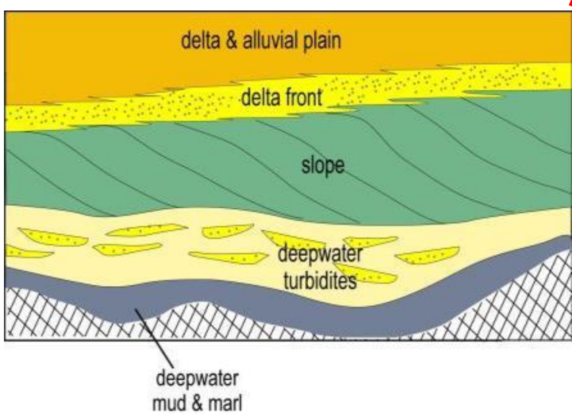
(2) Editing harmonized geological surfaces

Basin fill sediments („BF reservoirs”)

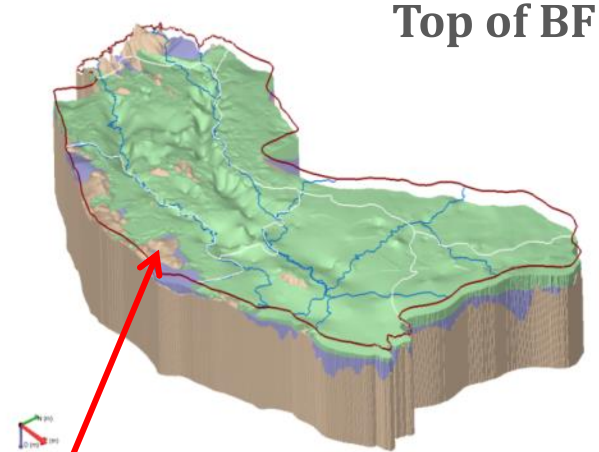


Top of the pre-Cenozoic basement („BM reservoirs”)

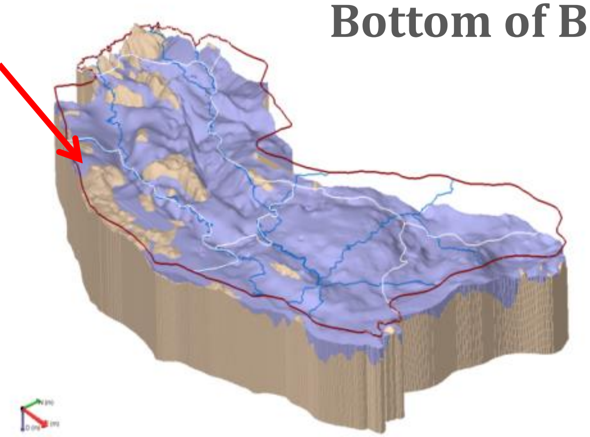




Top of BF



Bottom of BF



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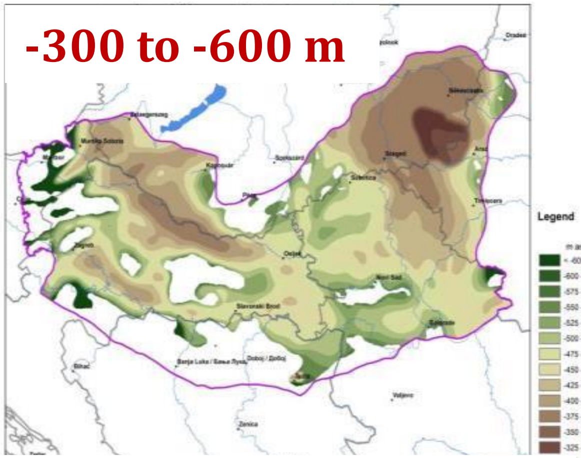
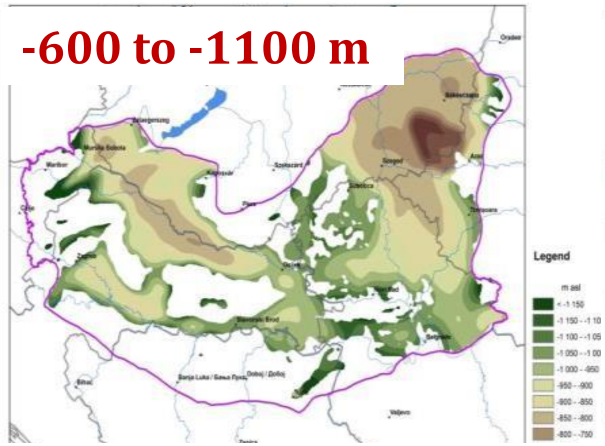
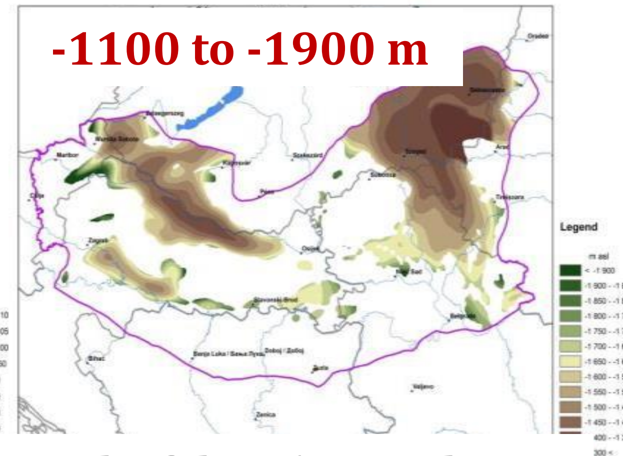
(3) Simplified geothermal model - Harmonized subsurface temperature maps



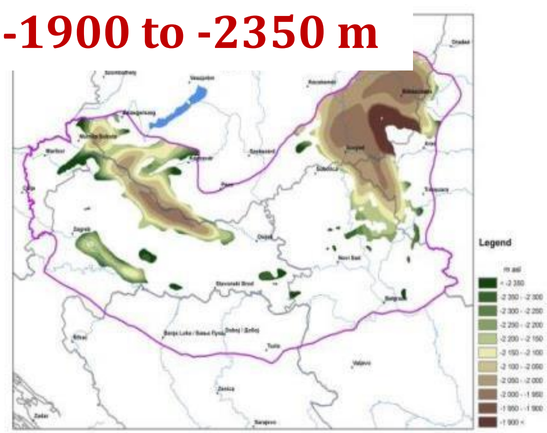
Depth of the 30 °C isotherm



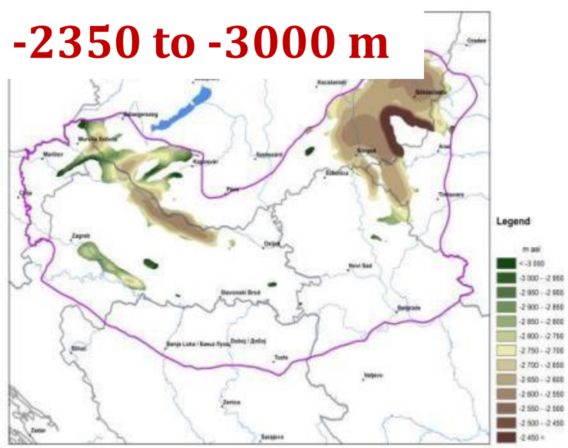
Depth of the 50 °C isotherm



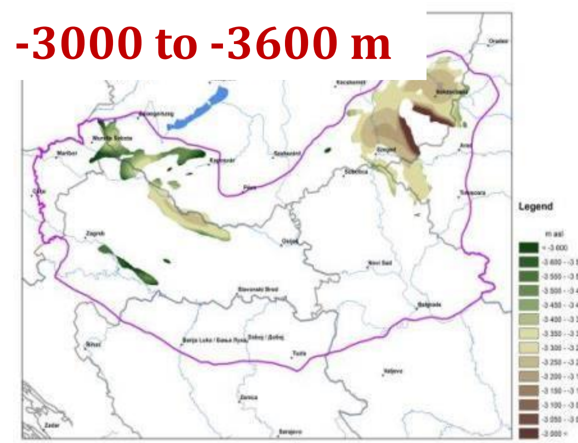
Depth of the 75 °C isotherm



Depth of the 100 °C isotherm



Depth of the 125 °C isotherm



Depth of the 150 °C isotherm

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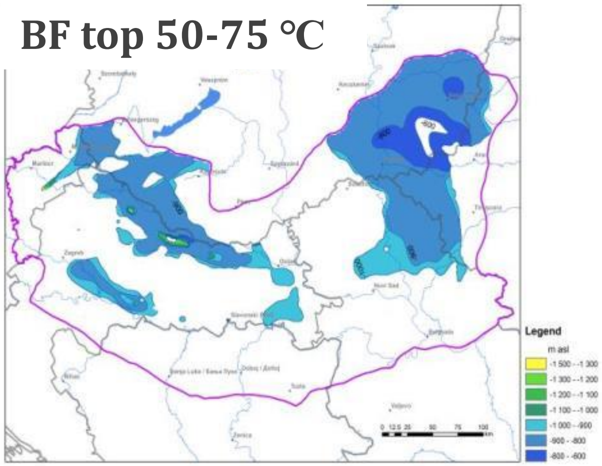
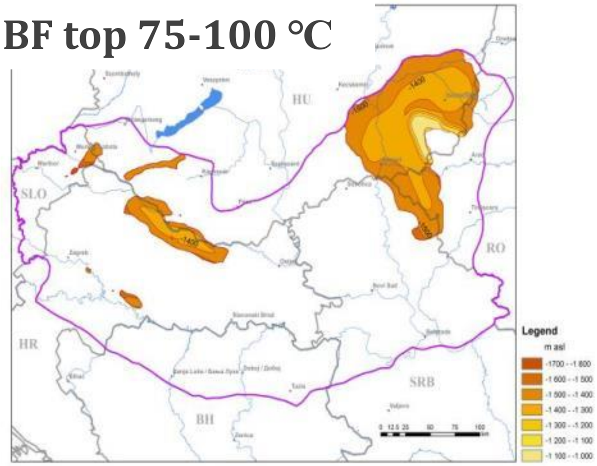
(4) Delineating potential reservoirs: geological bounding surfaces + isotherms

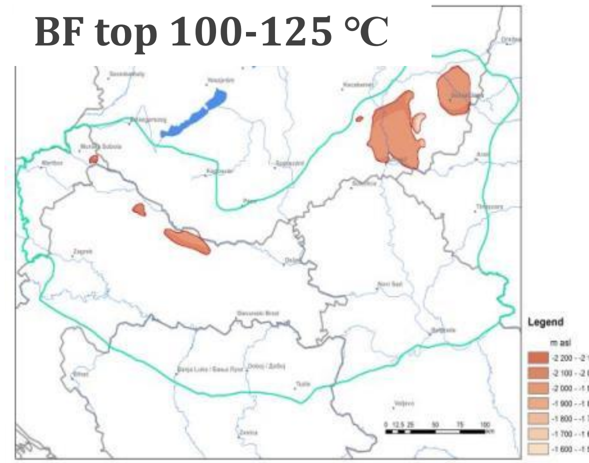
BF top 50-75 °C



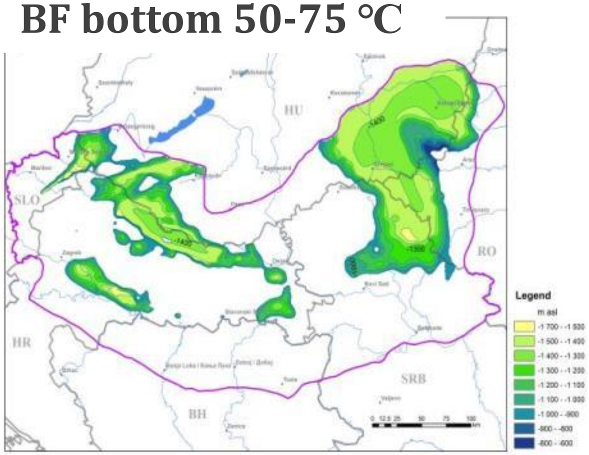
BF top 75-100 °C



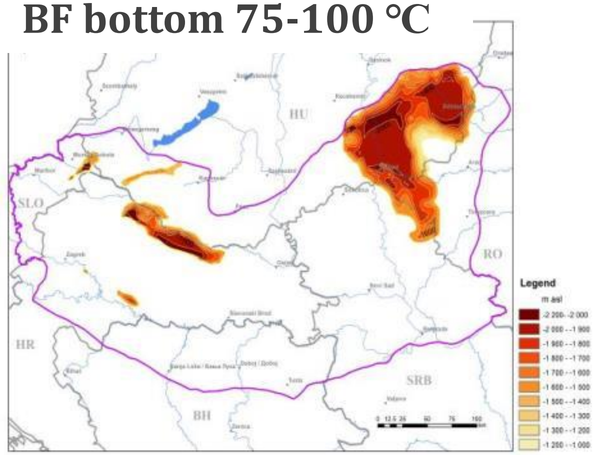
BF top 100-125 °C



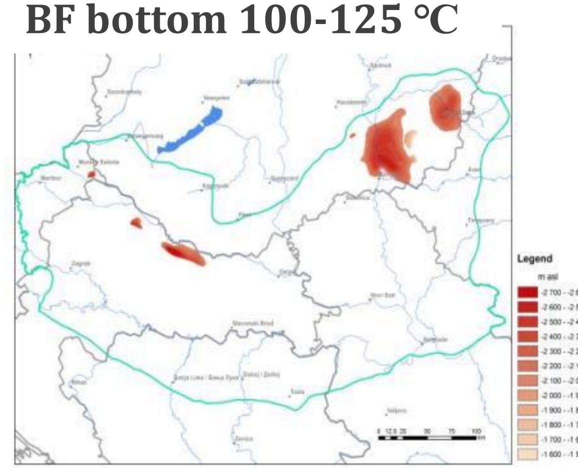
BF bottom 50-75 °C



BF bottom 75-100 °C



BF bottom 100-125 °C



(5) How to assess the geothermal potential of the identified reservoirs?

According to the International Geothermal Association (IGA): geothermal potential = the exploitable amount of geothermal energy during a year → also depends on technical and economical parameters.

Several (and no uniform) approaches worlwide

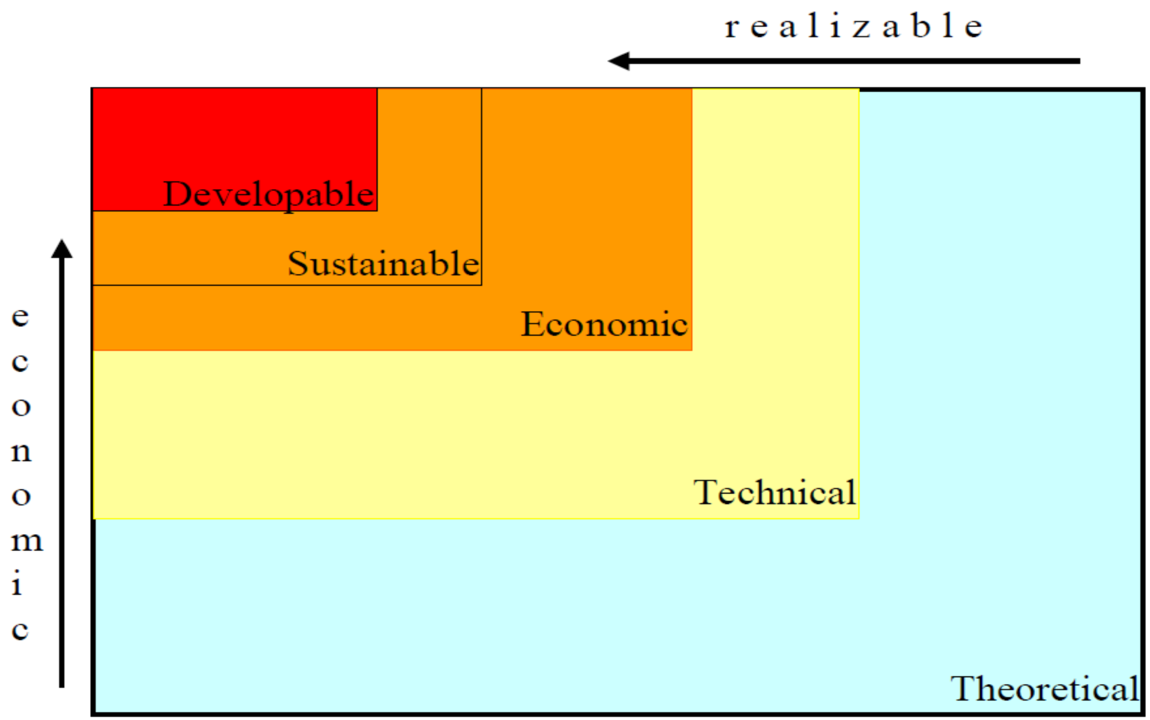
I. **Prediction from production data: extrapolated from the annual production rates**

II. **Static resource estimtion: bsed on Heat in Place calculation (volumetric method) [Muffler és Cataldi (1978), Mufler (1979)]**

H0= c x V x ΔT – huge numbers, not exploitable

III. **Dynamic resource estimation: water and heat recharges also considered (poro/permeability, conductive/convective heat flow)**

Categories of Geothermal Potential



Rybach, 2010

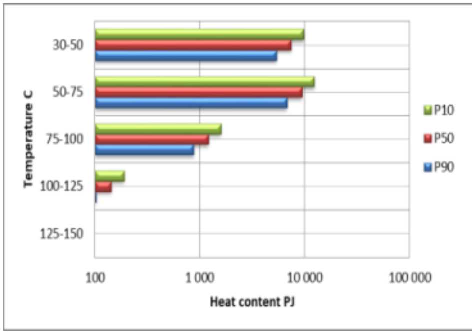
Theoretical = physically usable energy supply (heat in place)

Technical = % of theoretical potential that can be used with current technology

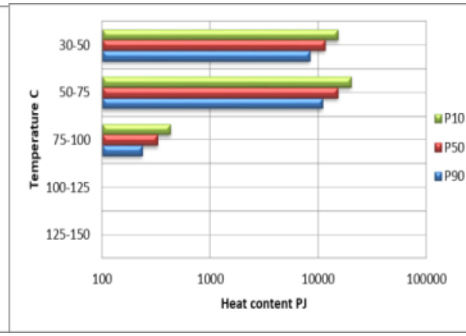
Economic = time & location dependent % of technical potential that can be economically used

Sustainable = % of economic potential that can be used by applying sustainable production levels (regulations, environmental restrictions).

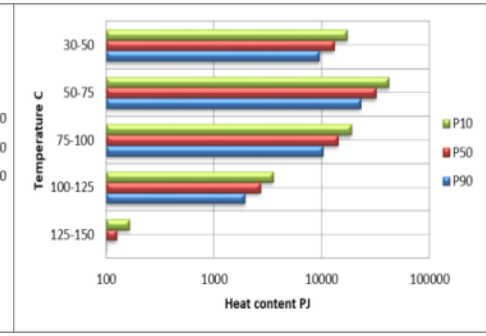
(6) Probabilictic estimation of the recoverable heat



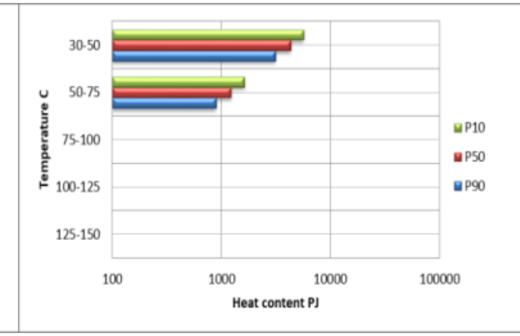
1. Mura-Zala basin (SI-HU-HR)



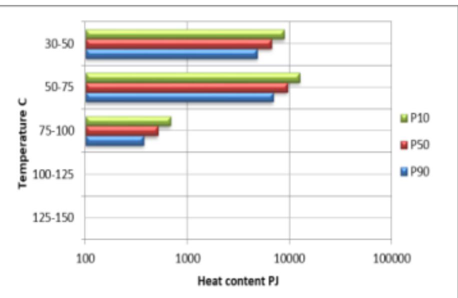
2. Somogy region (HU)



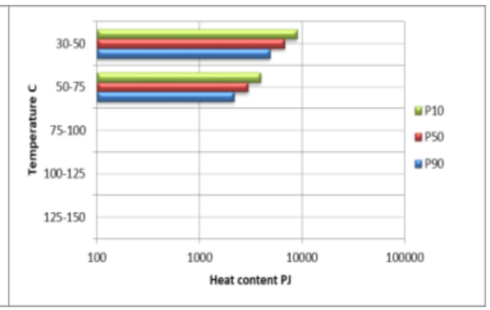
3. Dráva basin (HR-HU)



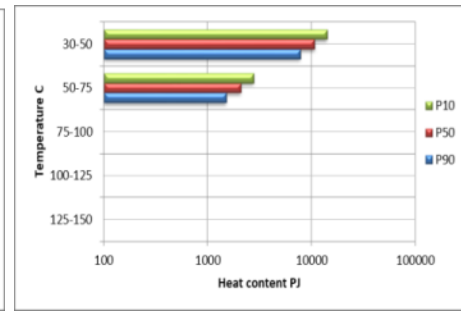
4. Zagreb region (HR)



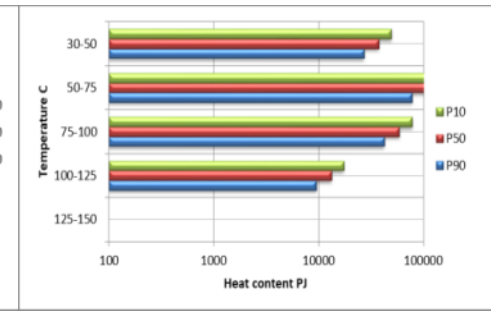
5. Sava basin (HR)



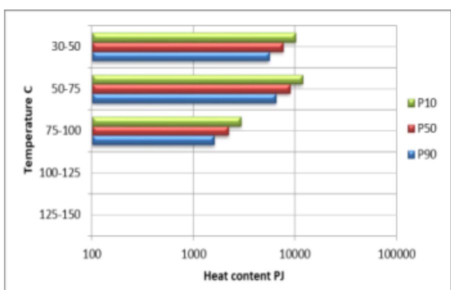
6. East Slavonia (HR-BiH)



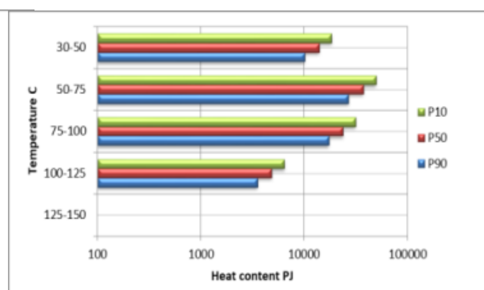
7. Vojvodina (SRB)



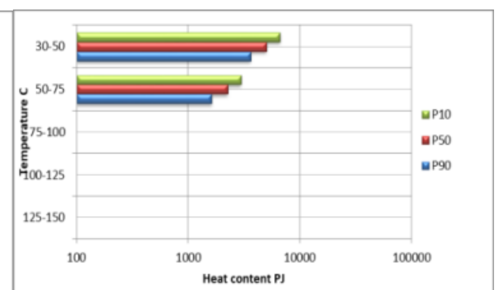
8. Makó Trough (HU-SRB-RO)



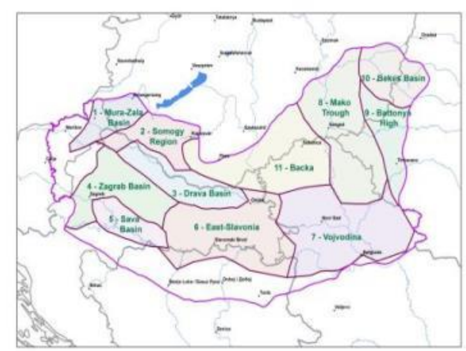
9. Battonya High (HU-RO)



10. Békés Basin (HU-RO)



11. Bácska (HU-SRB)



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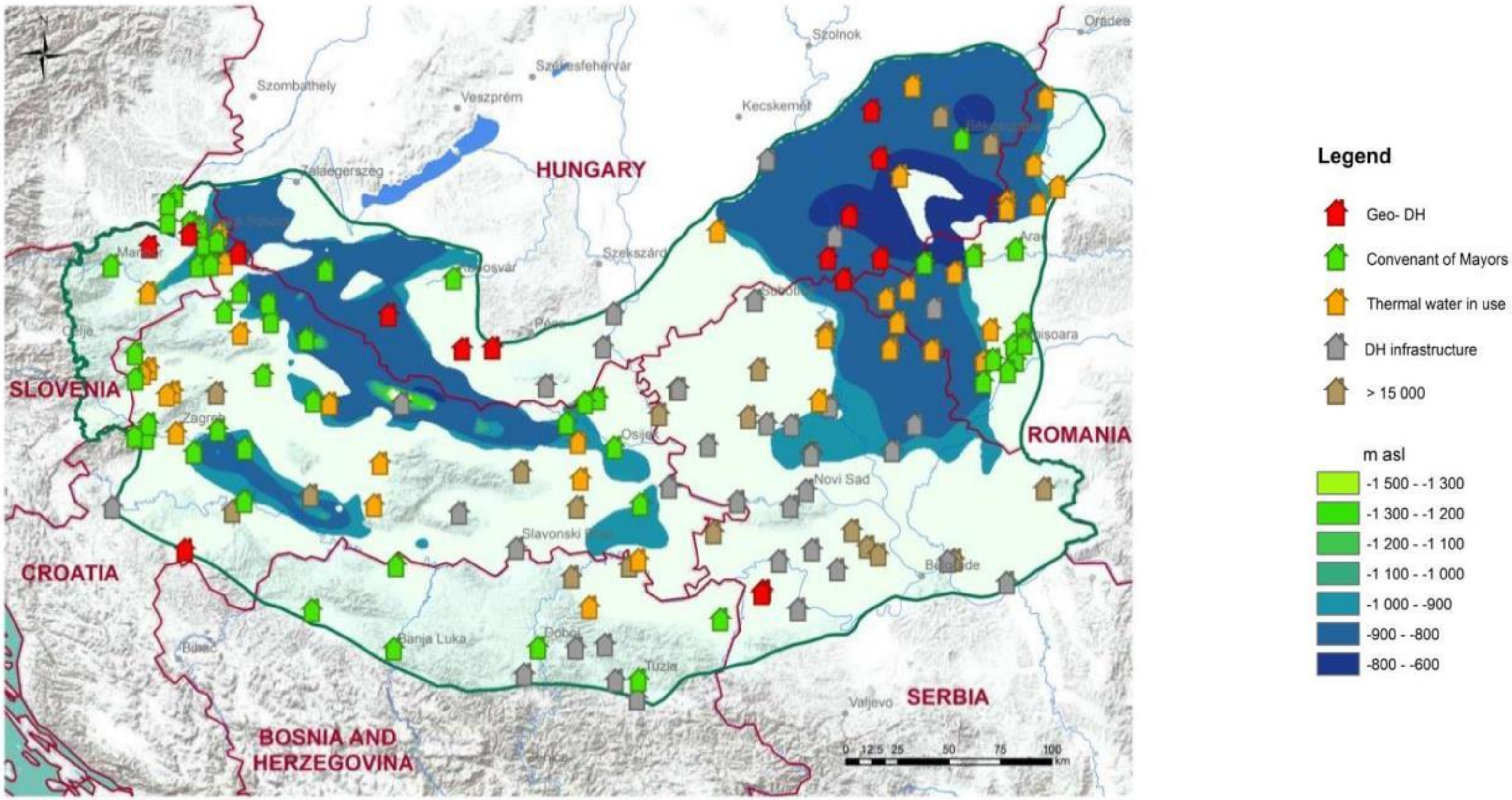
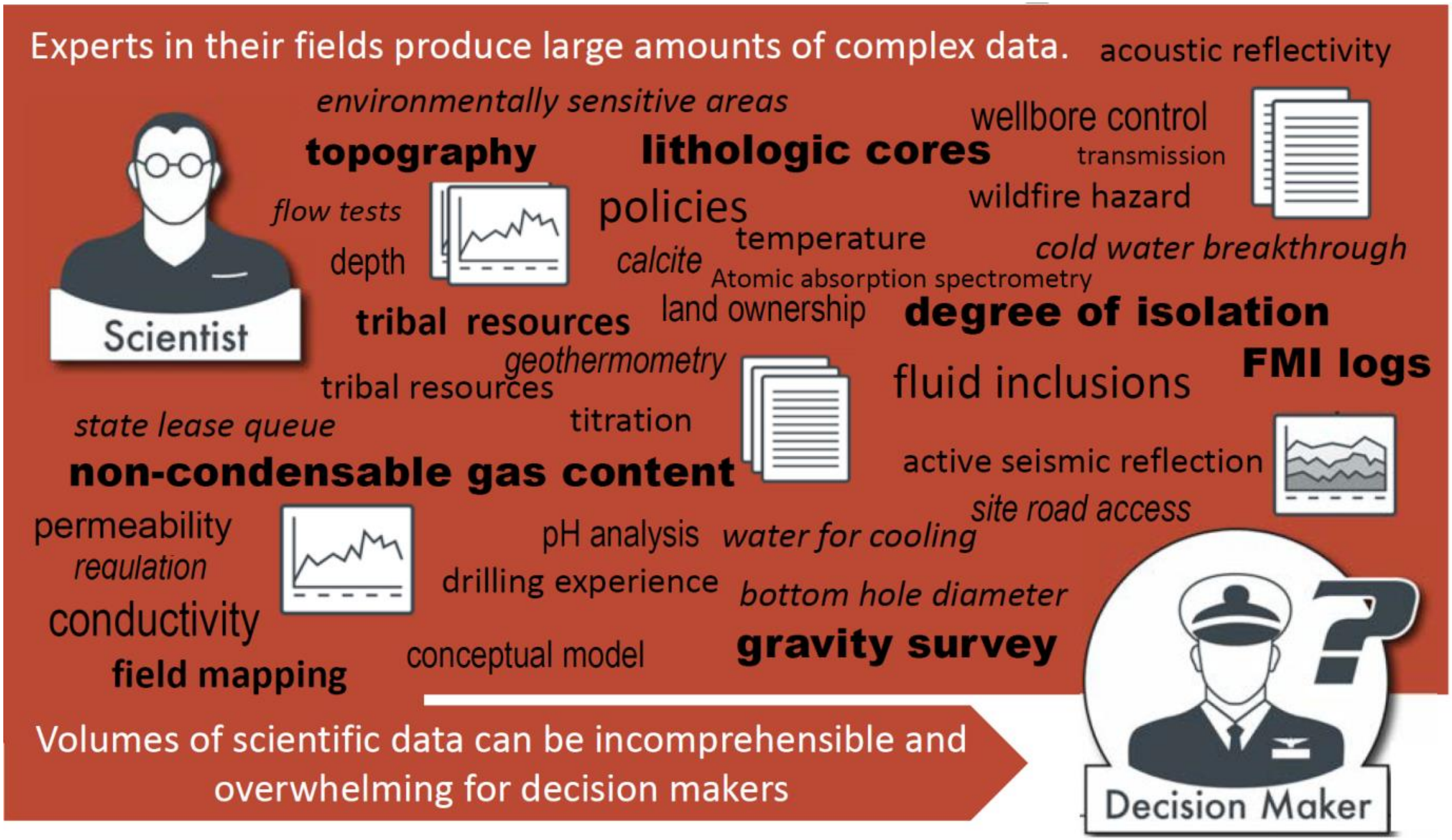
(7) Matching resources with the heat demand: Development of geoDH is a real option!



Based on sophisticated geological and geothermal models delineated transboundary geothermal reservoirs – resource estimations – matched them with heat demands → Science-based recommendations for tangible developments

How to communicate scientific results to non-technical audiences?



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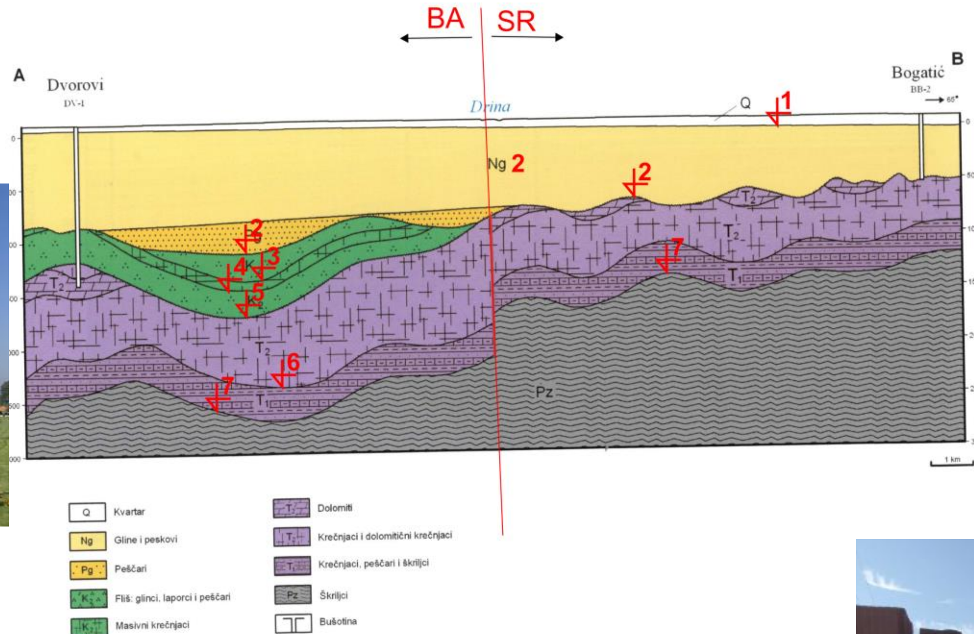
National events and trainings for stakeholders with cross-border field trips – appr. 350 participants

Bogatic (SRB) – Slobomir (BH)



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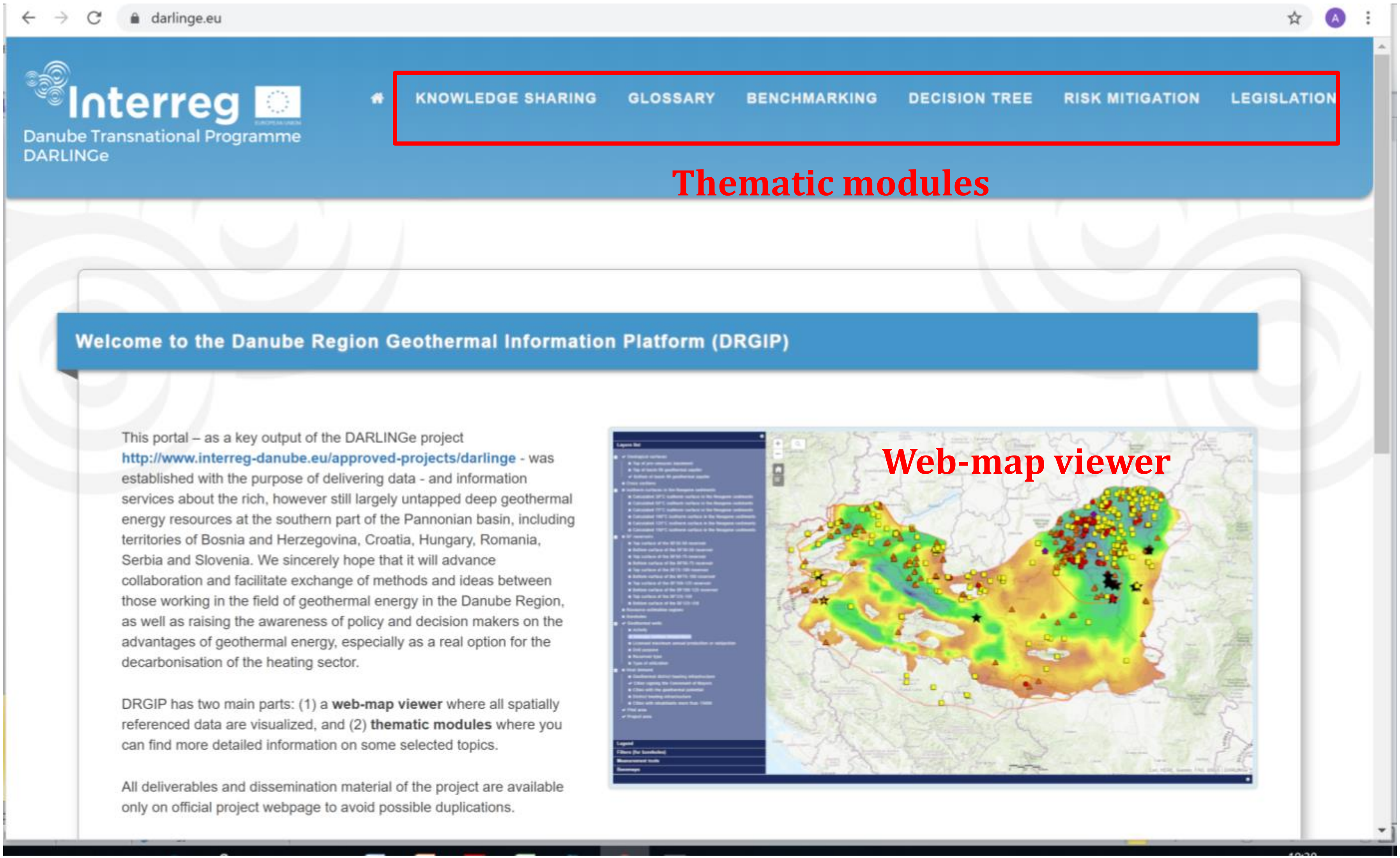
Danube Region Geothermal Information Platform (DRGIP) https://www.darlinge.eu/



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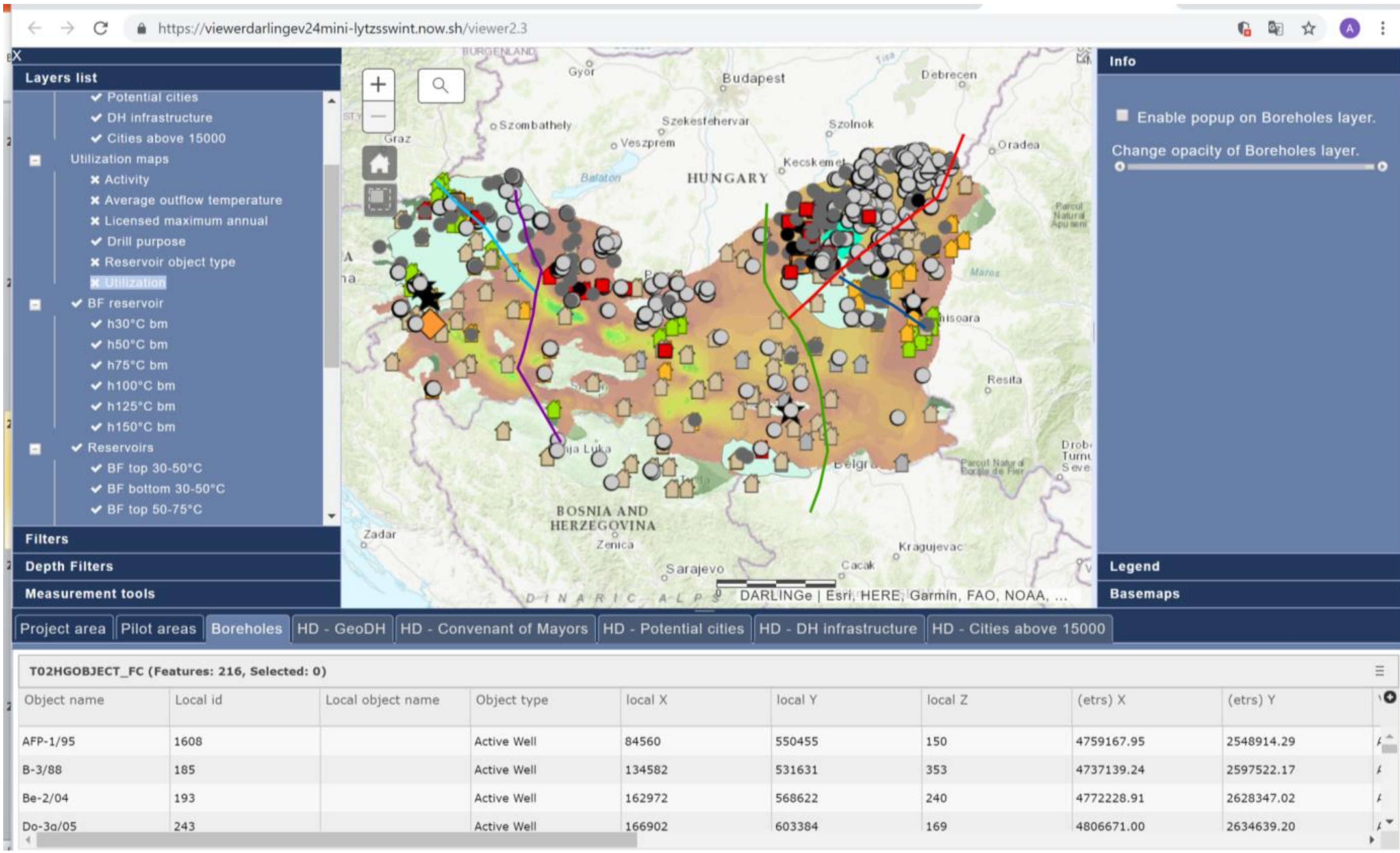

Danube Region Geothermal Information Platform (DRGIP) https://www.darlinge.eu/

Altogether 25 questions on various aspects of legislation/ licensing

Final recommendations: Danube Region Geothermal Strategy and Action Plans

- Large number of data (drillings etc.)
- Long-term experience on exploitation – decreased risks
- Extensive reservoirs, especially 50-75 C at depth 1000-2000 m with rich resources, often matching heat demand (e.g. cities with DH infrastructure)
- Ambitious NREAP targets – to decrease energy-import dependency
- Growing interest of municipalities willing to invest into RES projects

- Concentrated thermal water abstraction – regions with overexplotation
- Insufficient reinjection (porous media)
- Not energy-efficient systems (lack of cascaded uses, high temp. discharge of spent water)
- Unfair competition with (subsidized) conventional sources (e.g. gas), regulated prices
- Obsolete heating systems
- Lack of comprehensive national/regional/local geothermal regulatory framework
- Lack of awareness on advantages of RES / geothermal heating

Final recommendations: Danube Region Geothermal Strategy and Action Plans

Interreg Danube Transnational Programme DARLINGe

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Developments need:

- ✓ Responsive policy environment
- ✓ Raising awareness on advantages of geothermal (at all levels)
- ✓ Knowledge sharing and transfer of best practices
- ✓ Encourage domestic and foreign investments in geothermal projects

Thank you for your attention!

For further information:

http://www.interreg-danube.eu/approved-projects/darlinge/

nador.annamaria@mbfsz.gov.hu