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Geothermal contexts of River Basin Management Plans and other (transboundary) groundwater management initiatives

Status of implementation of the Water Framework Directive in the EU Member States (ec.europa.eu)

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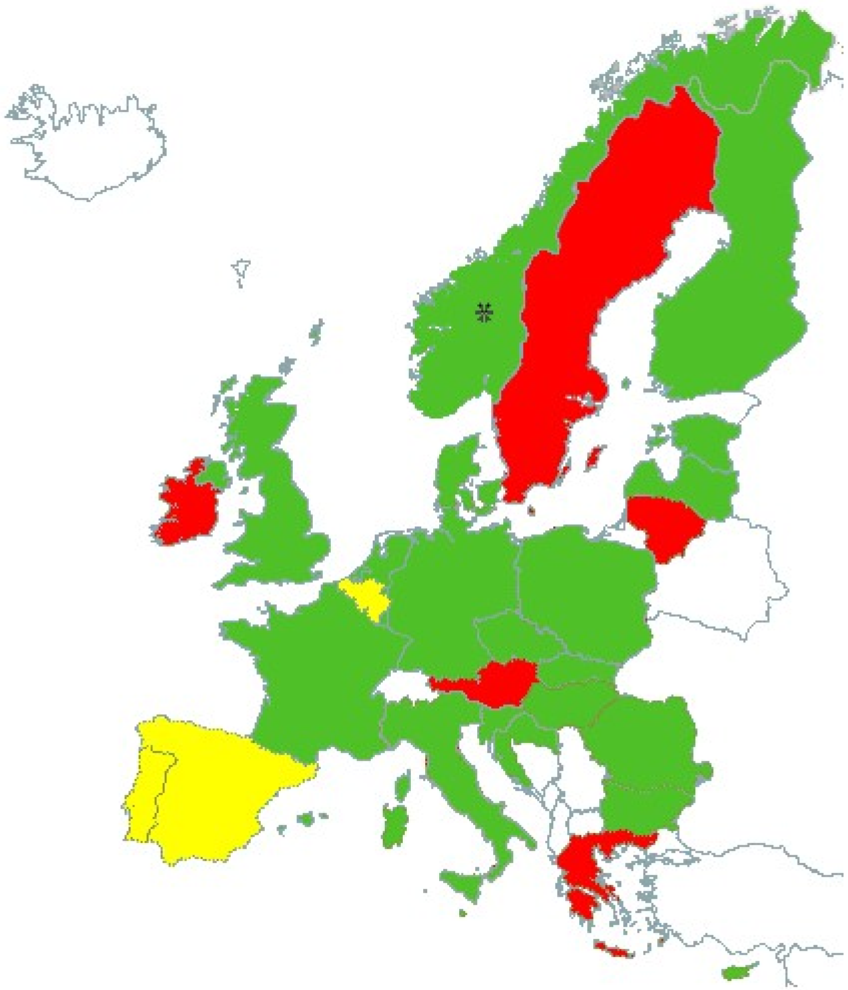

Second River Basin Management Plans

GREEN - all adopted
YELLOW - part of it adopted
RED - not yet adopted

A number of international River Basin Districts have also published River Basin Management Plans

Sturgeon

- Danube
- Rhine
- Elbe
- Ems
- Finnish-Norwegian International River Basin District
- Meuse
- Scheldt / l'Escaut
- Odra
- Sava Commission (ISRBC)

Groundwater body delineation methodologies and assessments

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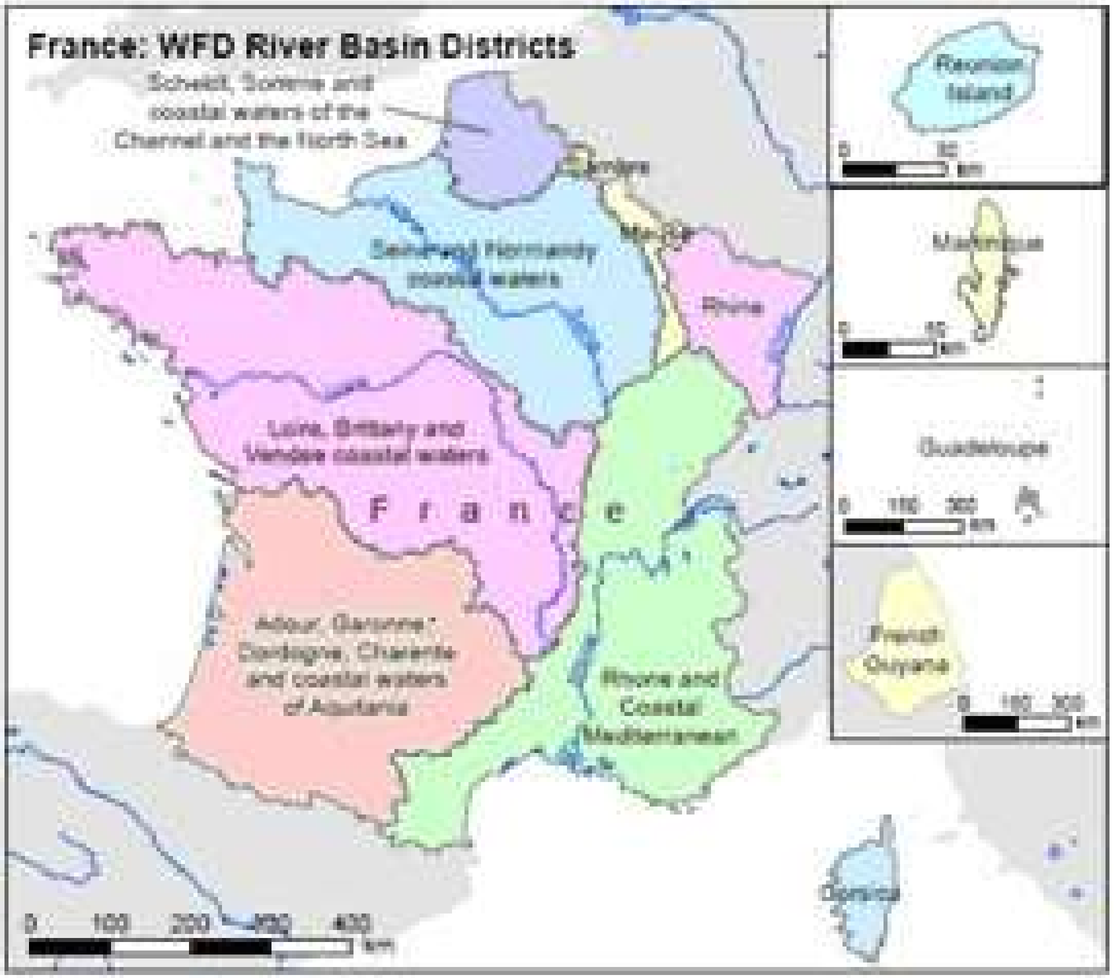
Still huge differences between groundwater body delineation methodologies and assessments

No adaptable management plan

France


France: WFD River Basin Districts
Scheldt, Somme and coastal waters of the Channel and the North Sea
Sambre
Meuse
Seine and Normandy coastal waters
Rhine
Loire, Brittany and Vendee coastal waters
France
Adour, Garonne, Dordogne, Charente and coastal waters of Aquitania
Rhone and Coastal Mediterranean
Corsica
Reunion Island
Martinique
Guadeloupe
French Guyana
0 100 200 300 400 km

France (EU COM(2012) 670 report)

2.1 Main strengths The French RBMPs have gone through an **extensive co-ordination process between the different sectors and stakeholders involved** and a wide process of consultation with the public. Categorisation determined under the EC Comparative study of pressures and measures in the major river basin management plans in the EU (Task 1b: International co-ordination mechanisms). There are a number of national guidelines that have been extensively developed for most of the WFD topics (monitoring, ecological and chemical assessment methods, groundwater assessment, exemptions). **Substantial efforts have been made to integrate the WFD principles into the water management.** A good understanding of the work needed for the proper implementation of the WFD has been demonstrated, and there has been continuous progress after the adoption of the first RBMPs (ecological and chemical assessment methods, designation of HMWBs, monitoring, etc.)

2.2 Main weaknesses There are significant gaps in the development of assessment methods for the biological quality elements in this first RBMP. The biological assessment methods for rivers are significantly more developed than those for other water type. The assessment methods for supporting quality elements on physico-chemical and hydromorphological characteristics are generally only partially developed. For most of the French RBDs, the assessment of chemical status has been based on the Annex I of Environmental Quality Standards (EQS) Directive 2008/105/EC, but not for all. Furthermore, different substances have been used in the different plans (and not all the 41 substances of Annex I) for the assessment of chemical status of water bodies. For these reasons, the methods for the assessment of chemical status are very unclear, including which substances have been used, and the reasons for the selection of certain specific substances. There are a relatively high number of **exemptions under Article 4(4) and 4(5)** based on disproportionate costs, for which no clear justification has been provided in the RBMPs. **Water services have been interpreted differently in the French RBDs.** Some RBDs have a broad approach, which takes into account all possible abstraction, storage, treatment, impoundment etc. In other RBDs the approach has been narrower, taking into account public and self-water abstraction and wastewater treatment for all sectors, as well as irrigation. Finally, in some RBDs, the approach has been even more limited, taking into account only abstraction and wastewater treatment for households, industry and abstraction for agriculture.

France (EU COM(2012) 670 report)

Influence of public consultation in the adopted plans: websites have been established to provide information on the replies received and the assessment of those replies, and to make the opinions of different regional and local authorities publicly available. The main changes that such consultation has brought about relate to changes in the selection of measures, or the modification of a specific measure, and to the provision of additional information. To a lesser extent, the consultation has resulted in methodologies being changed, further research being carried out or commitments being made for actions in the next cycle.

France (EU COM(2012) 670 report)

On international co-operation, there has been some sort of co-operation with Belgium (no agreement or plan made, but existing communication, no information on transboundary groundwater bodies), in the Rhone (France has not identified this RBD as international - it however shares a small part of its basin with neighbouring countries including Switzerland, Italy and Spain - under the CIPEL discussions have taken place on monitoring programme - no details provided), and in the Meuse and in the Rhine (for both, since exchanges between groundwater layers are limited, it was suggested to limit international co-ordination to a bilateral or trilateral technique at the border zones where exchanges are significant: localisation of the sites, the piezometric evaluation at both sides of the boundary, the frequency of measurements is discussed). The level of international co-operation is not clear for the Sambre.

Good example of common management of transboundary hydro geothermal resources Lower Bavaria – Upper Austrian

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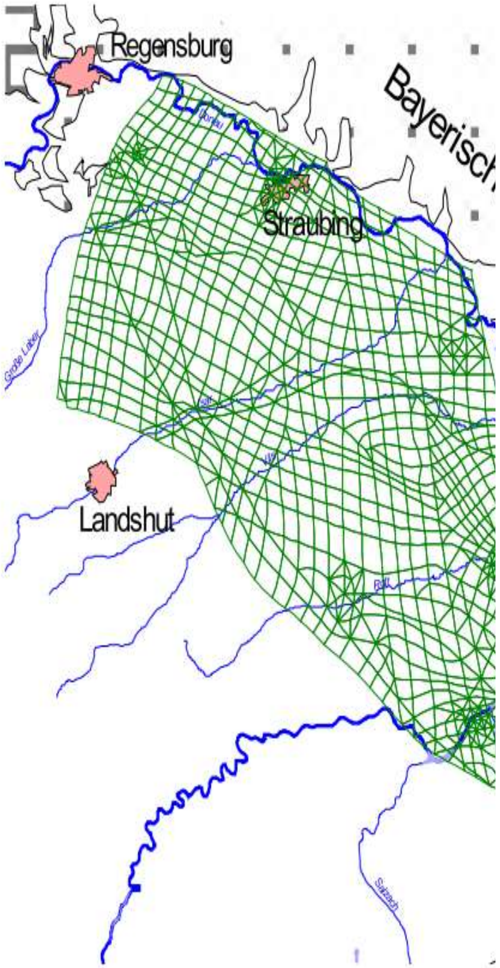

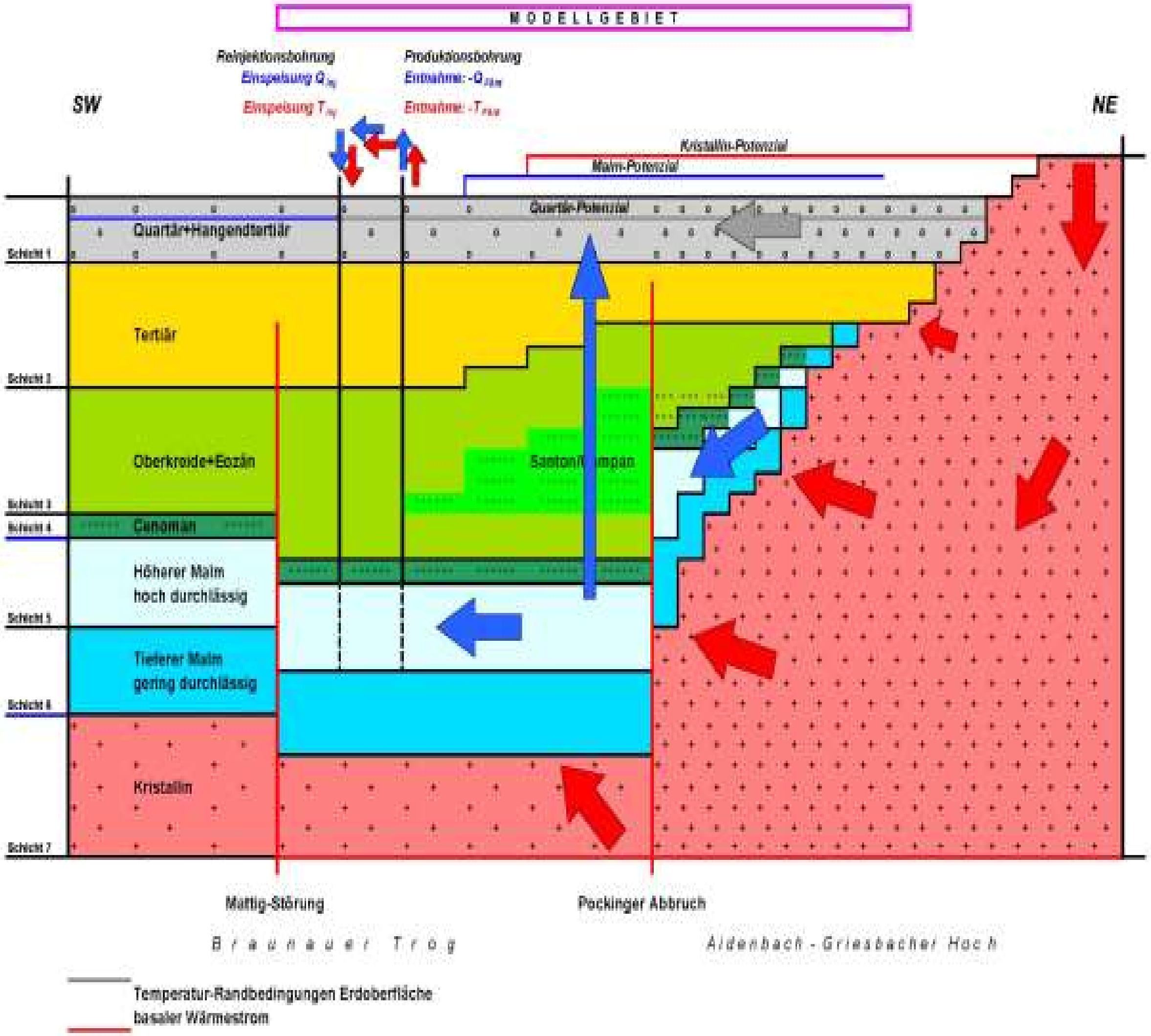

Vollhofer, O. and Samek, M. (2008) German-Austrian Cooperation in Modelling a Transboundary Deep Groundwater Body, IWA World Water Congress and Exhibition, Vienna 2008

Existing initiatives, programmes

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Still huge need for management policy directives

ISMAR9 (June 2016, Mexico City): CALL TO ACTION
SUSTAINABLE GROUNDWATER MANAGEMENT POLICY DIRECTIVES

In spite of the fact

↓

IAH - Strategic Overview Papers
Key messages
Priority actions

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- Food Security & Groundwater
- **The Energy Sector & Groundwater**
- Resilient Cities & Groundwater
- Ecosystem Conservation & Groundwater
- Human Health & Groundwater
- Global Change & Groundwater

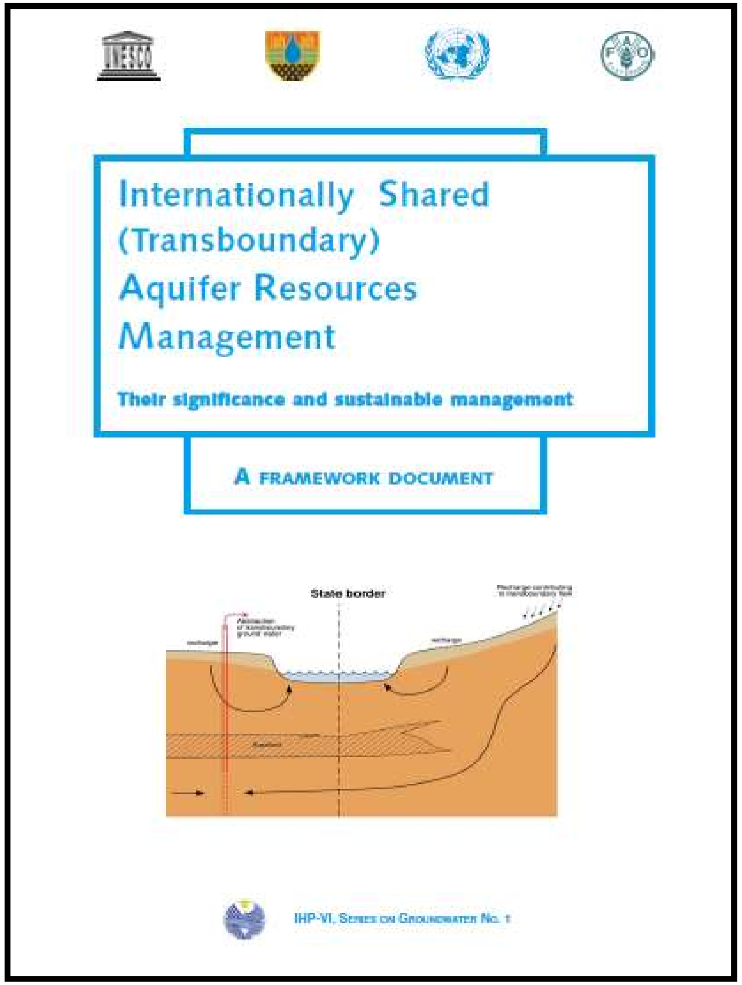
https://iah.org/knowledge/learning-resources

Existing initiatives, programmes

UNESCO-IHP- Intergovernmental Council Resolution XIV-12

**Year 2000
Launch of the
ISARM Initiative**

isarm



**Environmental aspects
Institutional aspects
Socio-economic aspects
National and International Laws
Scientific-Hydrogeological scope**

Transboundary Water Assessment Programme

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TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

GEF

United Nations Educational, Scientific and Cultural Organization
International Hydrological Programme

A global baseline assessment to identify and evaluate changes in transboundary water systems.

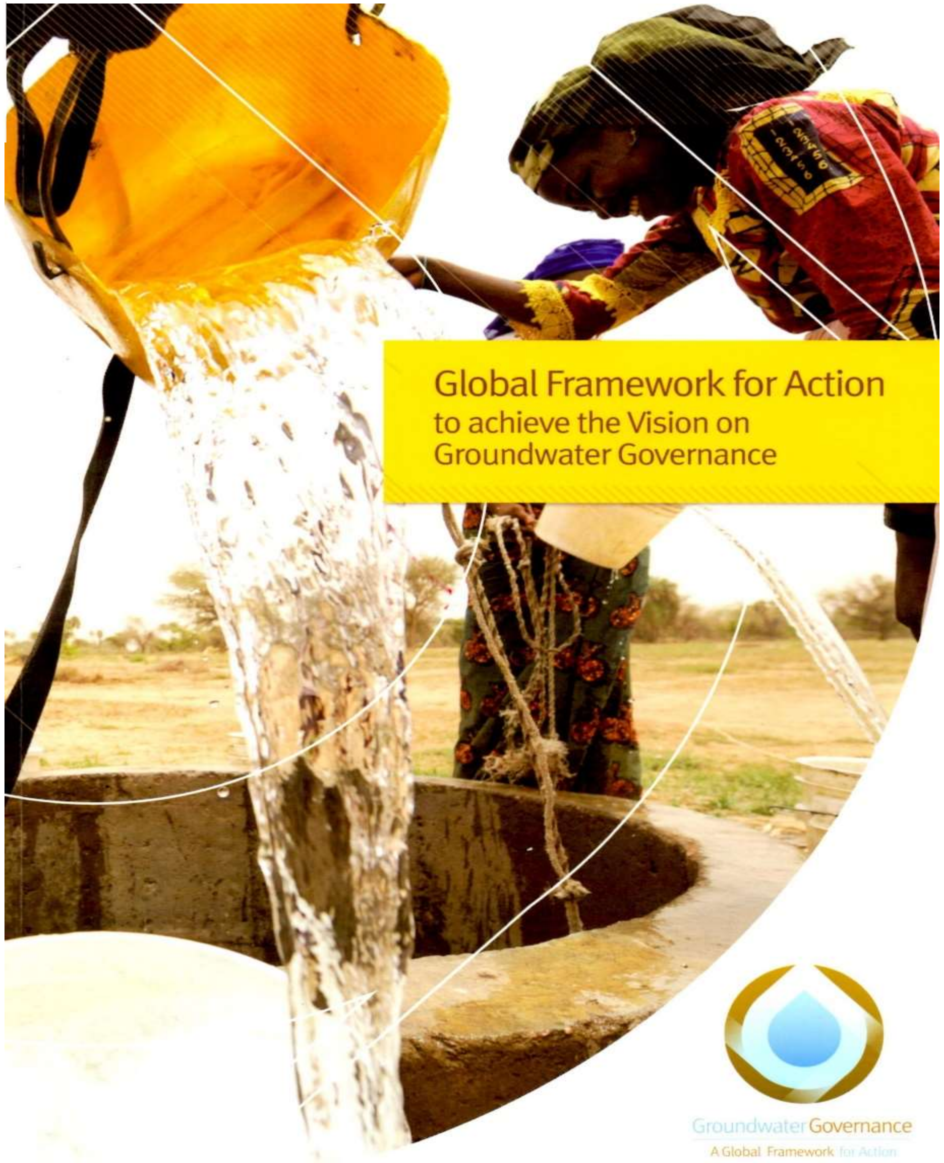
- **First structured & publically accessible database on transboundary aquifers**
- **Participatory approach unlocked groundwater data from national level and triggered cooperation between countries**

Guidelines for multidisciplinary assessment of transboundary aquifers

The final guidelines to be extended with the Benchmarking methodology developed within the Transenergy project

A global framework for country action
Groundwater Governance

- **TAILOR ACTION TO CONTEXT:**
adaptable framework not simple recipe
- **BUILD LINKAGES:**
inside and outside water sector
- **FINANCIAL ARRANGEMENTS:**
productive incentives
- **IMPLEMENT ADAPTIVE MANAGEMENT PLANS:**
with periodic assessment (similar to the WFD)



Conventions dealing with transboundary issues

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Water Convention - Convention on the protection and use of transboundary watercourses and international lakes. Started as a regional convention. It was negotiated by the Member States of the United Nations Economic Commission for Europe (UNECE) and **signed in Helsinki in 1992**. It entered into force in 1996. Promotes cooperation on transboundary surface and ground waters and strengthens their protection and sustainable management.
Signatories obliged to prevent, control and reduce transboundary impact, use transboundary waters in a reasonable and equitable way and ensure their sustainable management. Parties bordering the same transboundary waters shall cooperate by entering into specific agreements and establishing joint bodies. **Since 2013 all UN Member States can join the convention.**

Convention on the Non-Navigational Uses of International Watercourses - At global level. Adopted in New York in 1997. **Not yet in force**! Expanded: ILC Draft Articles on the law of transboundary aquifers adopted in 2008.

Instruments for cooperation

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UNILC Draft Articles of The Law of Transboundary Aquifers

UNESCO-IAH joint effort in support of the UNILC

United Nations A/C.6/71/L.22

General Assembly

Distr.: Limited
4 November 2016

Original: English

Seventy-first session
Sixth Committee
Agenda item 86
The law of transboundary aquifers

Draft resolution

The law of transboundary aquifers

Recognizing that the 2030 Agenda for Sustainable Development[1] includes a goal on ensuring availability and sustainable management of water and sanitation for all,

Noting the establishment of the High-level Panel on Water by the Secretary-General and the President of the World Bank,

1. *Commends* to the attention of Governments the draft articles on the law of transboundary aquifers annexed to its resolution 68/118 as guidance for bilateral or regional agreements and arrangements for the proper management of transboundary aquifers;

2. *Encourages* the International Hydrological Programme of the United Nations Educational, Scientific and Cultural Organization to continue its contribution by providing further scientific and technical assistance upon the consent of the recipient State and within its mandate;

Hydrogeology from legal perspectives

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Starting point … what did hydrogeologists wish to regulate……? …… 'protection of an aquifer… ' Aquifer systems – the basis of the ILC Articles. Key features: recharge – storage – discharge

Legally unable to 'protect an aquifer' ... therefore we can only regulate actions in State A's territory, that might harm the benefit (from a common resource) in State B's territory

Thus the definition of an aquifer in legally binding terms is …. '(saturated) water and the rock, which is the host'

To be legally precise, the aquifer was defined to refer only to the water saturated portion, the rock in which this water is found, and the 'rock' below and above that, giving the upper and lower boundary (in the vertical dimension) and the area, in the horizontal dimension

Aquifers are hosts not only to fresh water, but can be also to minerals, geothermal heat, and can be a medium for quality improvements (filtration), latterly also linked with shale gas

Building the 'science' of aquifer systems into legal articles

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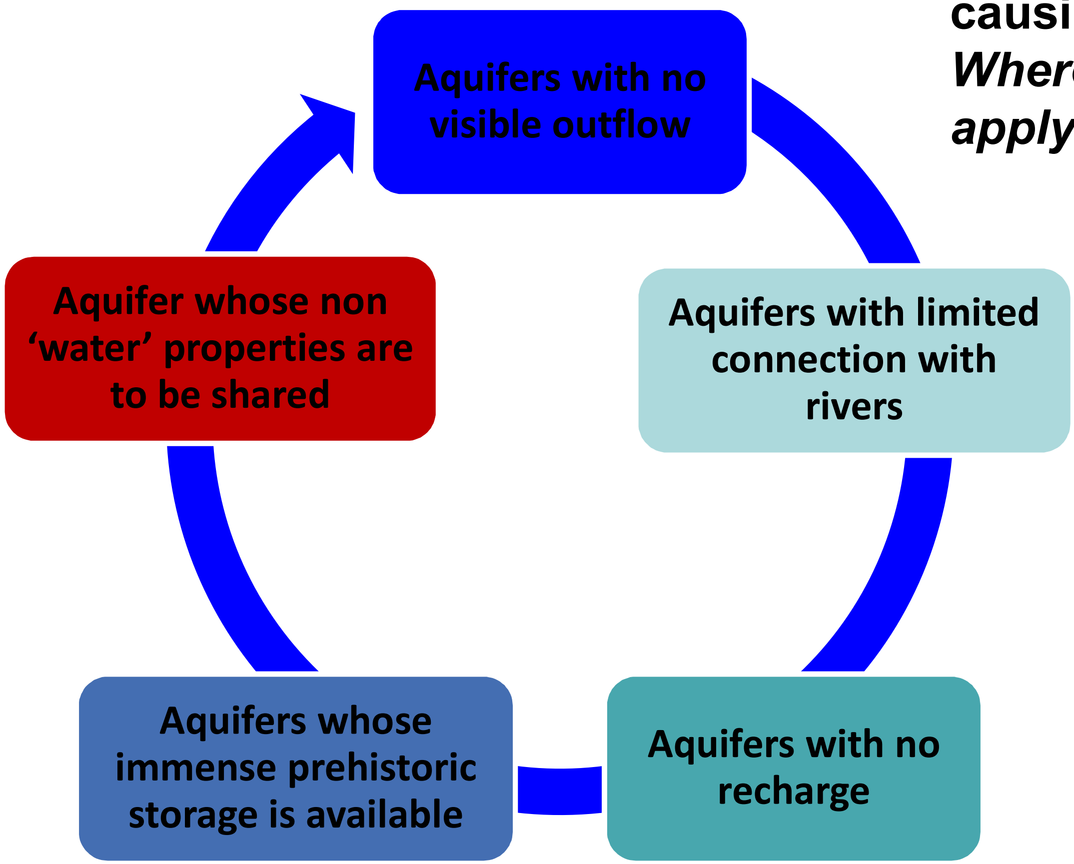
As 'recharge & discharge' areas of the legally defined aquifer cannot or can be only partly 'protected' (DWPAs, NATURA 2000, Ramsar, etc.), then we need to regulate 'other activities' that will affect the aquifer & its processes

Since there never is an ideal aquifer, then make the scope apply to '**aquifer systems'**

With these provisions we can regulate all aspects – the saturated rock medium, the overlying / underlying formations, the recharge areas, the discharge areas & the hydrochemistry

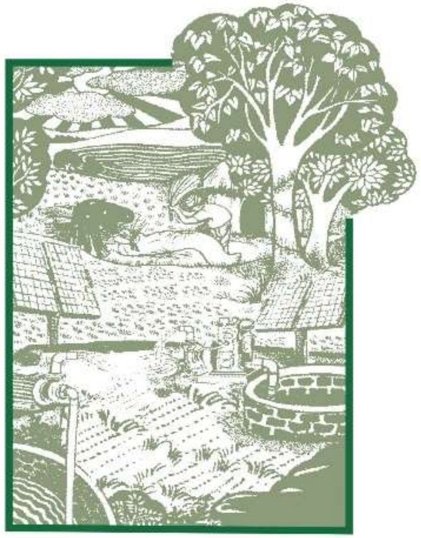
Hydrogeologists perspective concerns over the 1997 Convention



The Draft Articles build on those aspect of the 1997 Convention that were left 'vague' and scientifically incorrect, causing practitioners some difficulty
Where the 1997 Convention does not apply the Draft Articles fill the gap:

- **No visible outflow – Rum-Saq; Nubian Sandstone; Guarani**
- **Limited connection with rivers - Pre-Tashkent; Aral Sea aquifers; Strampriet – Karoo**
- **No contemporary recharge - North Sahara Aquifers, Tadjoeni**
- **Prehistoric volume in storage –**
- **'Non water' properties – geothermal & saline aquifers – Pannonian Basin, Rift Valley Aquifers, North Sea submarine aquifers**

10
2016



IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Solar Power as Remunerative Crop

Tushaar Shah, Neha Durga, Shilp Verma and Rahul Rathod

Anand, the small Gujarat town that gave India its dairy cooperative movement, has now spawned a new cooperative that may well grow into a genre of its own. The Dhundi Solar Pump Irrigators' Cooperative Enterprise (SPICE) provides the proof of concept for promoting Solar Power as a Remunerative Crop (SPaRC). We argue that SPaRC presents the best chance of taming western India's groundwater anarchy, of improving the finances of power distribution companies, of curtailing the carbon footprint of our agriculture and of creating a new, risk-free source of serious cash income for India's farmers.

Download this highlight from http://iwmi-tata.blogspot.in

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Good example

Food – Water – Energy nexus

Incentives at work in reducing abstractions triple win

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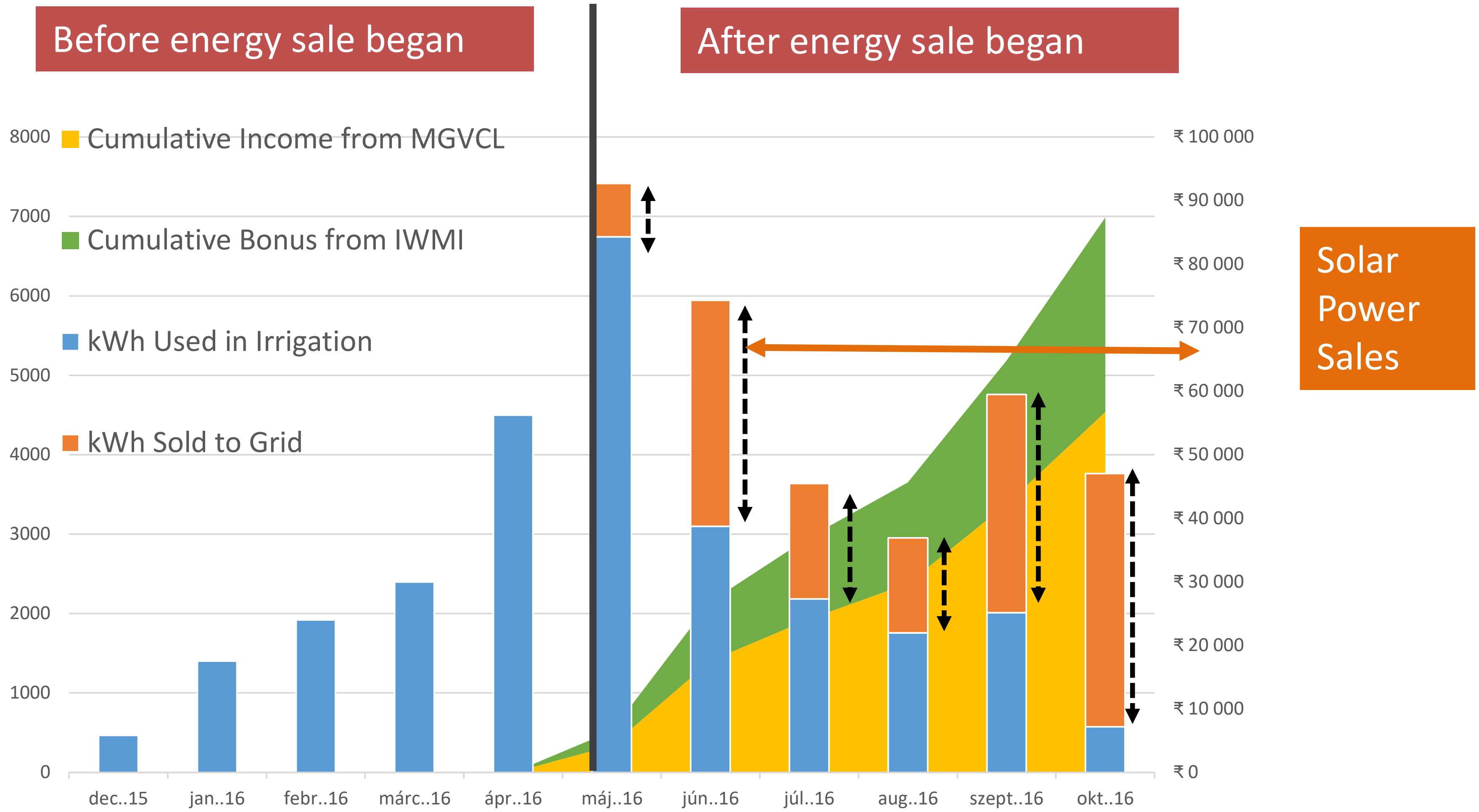

Jeremy Bird International Water Management Institute
Budapest Water Summit
28-30 November 2016

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The benchmark system of the TRANSENERGY project - ways forward in DARLINGe

What is benchmarking?

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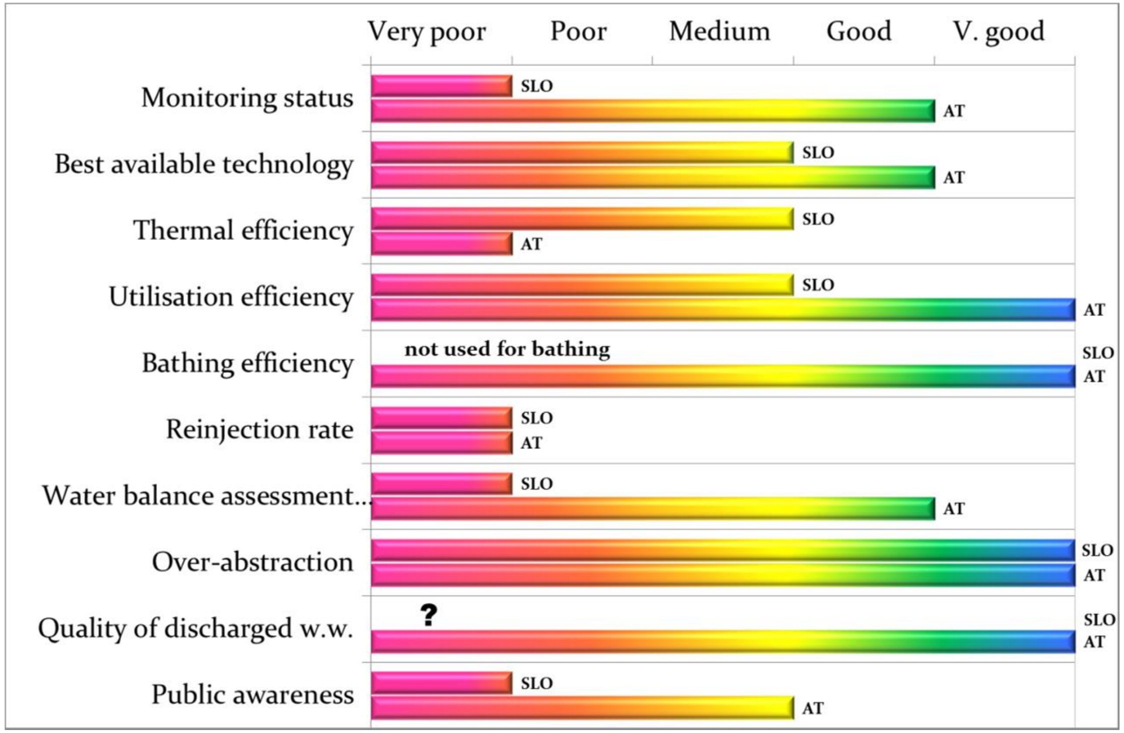
- Tool to quantify and compare the state of geothermal water management at different scales on an unique and harmonised way (Lemano approach)
- Developed for aquifers exploited by multiple users and/or in neighbouring countries to support water permit/concession granting process
- It comprises a set of indicators presented on charts using five categories (from very poor to very good) and being calculated from allocated points based on physical data or metadata information using transparent formulae
- The input requires detailed data on production, monitoring and permits per a well
- The results are generalised and should not have problems with data privacy
- As an Annex it will complement the general IGRAC Guidelines for Multidisciplinary Assessment of Transboundary Aquifers

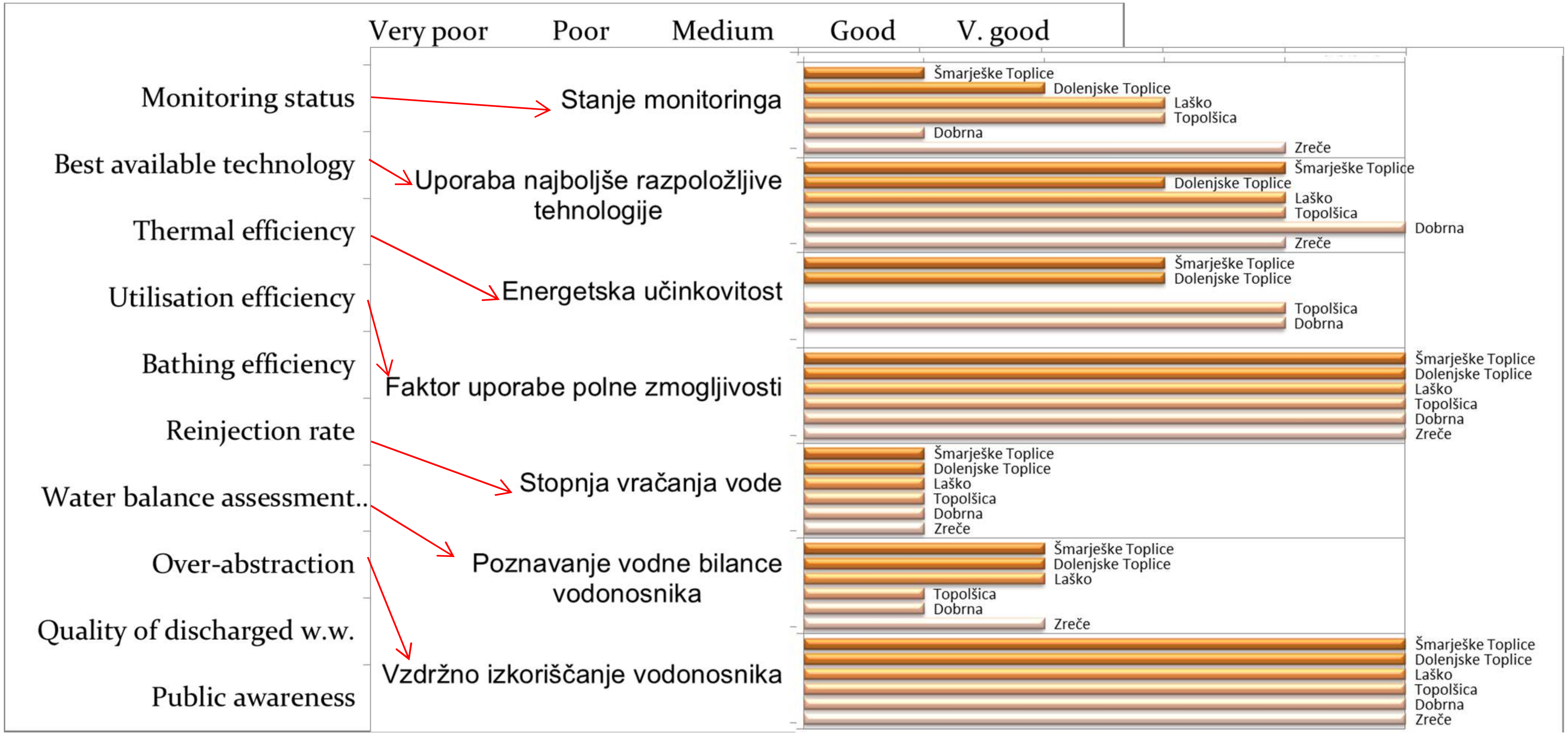
Existing indicators

1. Monitoring status,
2. Best available technology,
3. Thermal efficiency,
4. Utilisation efficiency,
5. ~~Bathing efficiency,~~
6. Re-injection rate,
7. Status of water balance,
8. Over-abstraction,
9. Quality of discharged thermal water,
10. ~~Public awareness.~~



How can we use it?

- **Users:** **private-only information: comparison to regional evaluation (this is what we can offer to them in return for data – new ideas for improvement of utilisation)**
- **Authorities:** **joint large-scale information: regional, state, cross-border – improvement of policy**



Who can use it?

Target groups:

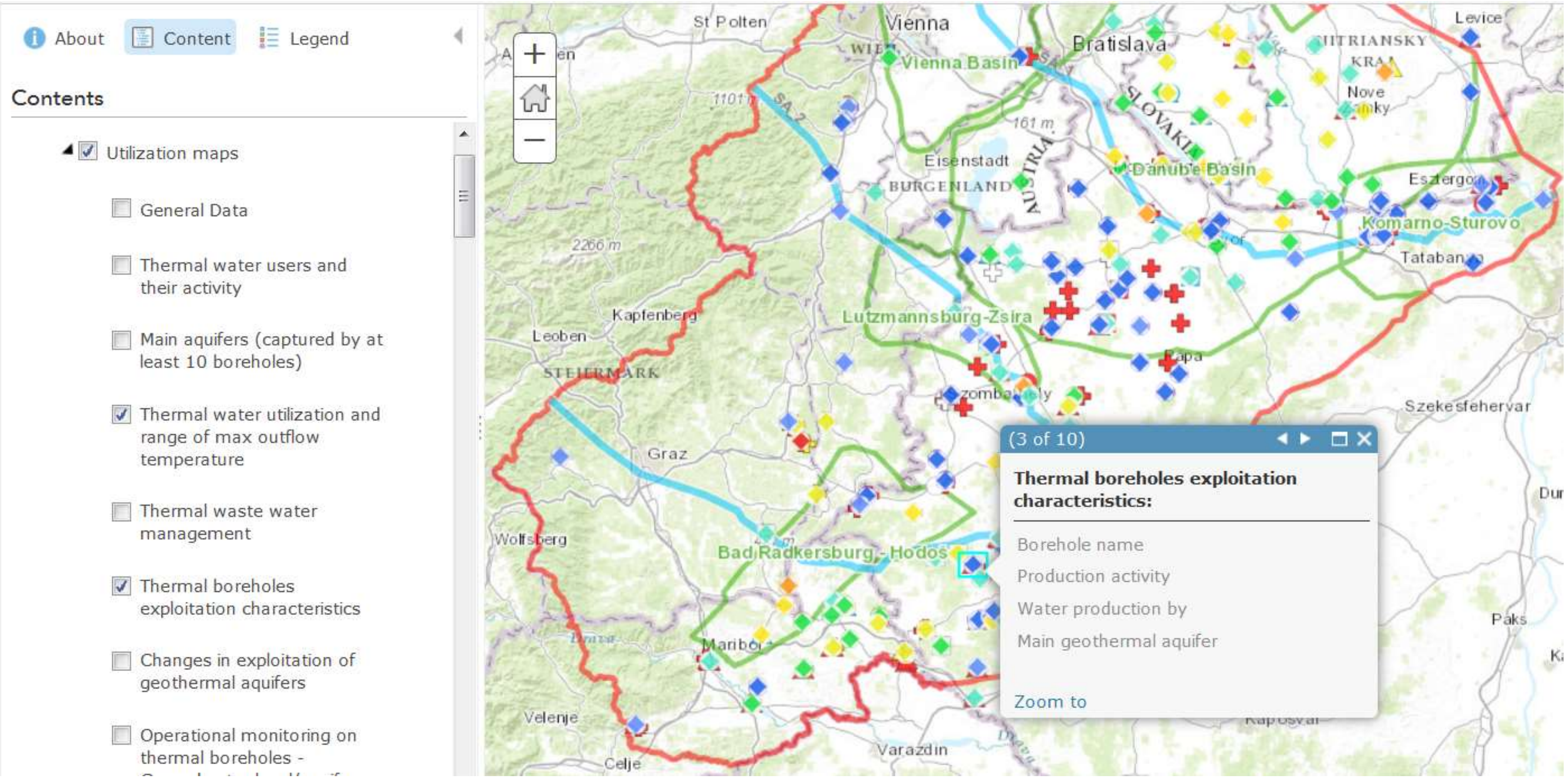
- **Users (possibilities for improvements, savings…)**
- **Authorities (granting water concessions, policy planning,…)**

- **Research institutes (availability of data, need for research,…)**

- **Business (free water quantities, providing monitoring equipment,…)**
- **Tourists/inhabitants (choose the most ‚green' user, foster improvements…)**

What can be a result?

- A manual on the use of toolbox (methodology)
- A summary report with charts on 3 pilot areas and transnational evaluation
- Point data categories at the portal (as TRANSENERGY, user database)
- Individual calculator and chart drawer at the portal (per aquifer, region, area)



Data gathering and policy

Datasets

- Water Framework Directive
- Directive on the Promotion of the Use of Energy from Renewable Sources
- National obligations related to monitoring
- EGEC recommendations for geothermal resources management
- Field inspections and interviews with users
- National datasets
- Field interviews with users

Calculation of indicators

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1. **Monitoring status** $I_{MON} = \frac{\sum_{i=1}^{n} P_i}{N_{tot}}$ Monitoring→yearly reports→observation wells
2. **Best available technology** $I_{BAT} = \frac{\sum_{i=1}^{n} P_i \cdot Q_i}{\sum_{i=1}^{n} Q_i}$ WHD, materials, system, documentation
3. **Thermal efficiency** $TE = \frac{\sum_{i=1}^{n} \eta_i \cdot Q_i}{\sum_{i=1}^{n} Q_i} [\%]$ Produced amount, water temp., waste water temp.
4. **Utilisation efficiency** $F_u = \frac{\sum_{i=1}^{n} Q_i}{\sum_{i=1}^{n} Q_{cap\,i}} \cdot 100\ [\%]$ Produced amount, granted amount
5. **Re-injection rate** $RI_Q = \sum_{1}^{n} \frac{Q_{reinj\,i}}{Q_i} [\%]$ Produced amount, reinjected amount
6. **Over-abstraction** $I_{OE} = \frac{\sum_{i=1}^{n} P_i \cdot Q_i}{\sum_{i=1}^{n} Q_i}$ Production changes: GWL, chem., Q
7. **Status of water balance** $I_{wba} = \frac{P_i}{N_{tot}} \cdot 100\ [\%]$ Renewable and available volume, critical point
8. **Public awareness** $I_{inf} = \frac{\sum_{i=1}^{n} P_i}{N_{tot}}$ Public data on monitoring, BAT, status, th. effic.

IP_i = number of assigned points to a geothermal object i
N_{tot} = total number of geothermal objects on the basin level in the investigated country
Q_i = annual production rate of a geothermal object i (m^3/y)

Developing new indicators

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- ‚Environmental' parameters supplemented by economic and social parameters
- Weighted and grouped into Environmental, Economic and Social Capital

1. Thermal water quality (appropriate for type of use – scaling, precipitation)
2. Unwanted bacteria in the system (clogging - Fe, for reinjection)
3. Change in the water abstraction/energy production in the last 5 years
4. Measures for sustainabe use foreseen in the permit
5. Waste thermal water treatment and quality (sewage systems, ecosystems)
6. Supply problems (peak loads, leakage, unknown by-pass)
7. Heat market demand is fulfilled
8. More details on cascade use
9. Price politics for permits, concessions (how are calculated per m^3)
10. Availability of management information (procedures, workshops for users…)
11. Permits from exploration to exploitation phase (number, timing, complications)
12. Waste thermal water monitoring and reporting (existing or not)
13. Public awareness (questionnaires of the user's staff and locals on the resource)

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How to start?

- **Preliminary data collection → Field questionnaire**
- **Definitions of thermal water, geothermal energy resource (doublet system)**
- **The threshold value for geothermal objects to be included (also <u>balneology</u>):**

    - water temperature: 20 °C, 30 °C, 50 °C ???

- **The areal scale of the investigation to make data generalised enough: whole country or <u>pilot areas</u> with adequate number of wells/users**
- **The aquifer scale (3D): all aquifers in the area, only <u>chosen aquifers</u>…**
- **Reference years:**

    - for production and reinjection data (2015, 2016, 2017, all ?)

    - monitoring status, water balance and over-exploitation assessment, publicity of data … (2017, 2018 ?)

- **Inclusion of inactive wells <u>with</u> concession permit (Q)?**

Publications

- SZŐCS et al. 2017: Transboundary Aquifers Guidelines, to be published by IGRAC.
- RMAN et al. 2015: Potentials of transboundary thermal water resources in the western part of the Pannonian basin. Geothermics, 2015, 55, 88-98, doi: 10.1016/j.geothermics.2015.01.013.
- SZŐCS et al. 2015: Long-term impact of transboundary cooperation on groundwater management. European Geologist, 40, 29-33.
- PRESTOR et al. 2015: Benchmarking-Indicators of Sustainability of Thermal Groundwater Management. World Geothermal Congress, IGA, Melbourne.
- NÁDOR et al. 2013: Strategy paper on sustainable cross-border geothermal utilization – TRANSENERGY. http://transenergy-eu.geologie.ac.at/, Results, WP6
- RMAN et al. 2011: Water concession principles for geothermal aquifers in the Mura-Zala Basin, NE Slovenia. Water Resources Management, 25, 3277–3299, doi: 10.1007/s11269-011-9855-5

1. Monitoring status

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- **Requirements are interdependent**
- **If active monitoring exists (5 points), additional points (1 to 3) can be added**

$$I_{MON} = \frac{\sum_{i=1}^{n} P_i}{N_{tot}}$$

Monitoring status	Points
Sporadic observations	0
Active monitoring carried out by water producers: Continuous measurements of discharge (produced water), piezometric level, temperature and regular chemical water analysis of production/operational well	5
Yearly report of active monitoring results submitted by concessionaire/licenser and approved by granting authority	3
Passive monitoring in non-exploited observation well: Regular measurements of piezometric level	1
Passive monitoring in non-exploited observation wells: Temporarily sampling of groundwater for chemical / isotopic analysis to identify global changes	1

P_i = number of assigned points to a geothermal object i
N_{tot} = total number of geothermal objects on the basin level in the investigated country

2. Best available technology

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- **Requirements are independent**
- **Reinjection wells not evaluated**

BAT use	Response	Points
Well-maintained wellheads which are isolated and protected from unfavorable weather conditions and unauthorized persons.	Yes	0
	No	1
Materials installed in and above the well are inert for aggressive water/gas mixtures and higher temperatures. Calcite scaling problems are mitigated by injecting inhibitors.	Yes	0
	No	1
Installations avoid areas of gas or water leaks and include the placement of a water release valve before the degassing unit at the wellhead.	Yes	0
	No	1
Produced water is precisely and continuously following the water demand. If pumping is required computer-managed frequency pumps are used.	Yes	0
	No	1
The thermal water is used based on the principles of a cascade system, with both computerised and individual phases controlled as much as possible.	Yes	0
	No	1
Supporting technical, lithological, hydrogeological and chemical documentation is well-kept and regularly updated.	Yes	0
	No	1

$$\bar{I}_{BAT} = \frac{\sum_{i=1}^{n} I_i \cdot Q_i}{\sum_{i=1}^{n} Q_i}$$

I_i = number of assigned points to a geothermal object i
Q_i = annual production rate of a geothermal object i (m^3/y)

$\bar{I}_{BAT}$ [points]	Result	
	Descriptive	Points [%]
0	Very good	100
0-1	Good	75
1-2	Medium	50
2-3	Weak	25
> 3	Bad	0

3. Energy (thermal) efficiency

- **Ratio between used and available annual heat energy**

$$TE = \frac{\sum_{i=1}^{n} \eta_i \cdot Q_i}{\sum_{i=1}^{n} Q_i} [\%]$$

- **No re-injection applied**

$$\eta_i = \frac{T_{whd} - T_{out}}{T_{whd} - T_o}$$

- **Partial re-injection of thermal water**

$$\eta_{r\,i} = \frac{Q_i(T_{whd} - T_{out})}{Q_i(T_{whd} - T_{out}) + Q_{ww\,i}(T_{out} - T_o)}$$

- **Total reinjection**

η = 100 %

TE [%]	Result	
	Descriptive	Points [%]
> 70	Very good	100
60 - 70	Good	75
40 - 60	Medium	50
30 - 40	Weak	25
< 30	Bad	0

$Q_{ww\,i}$ = annual discharge rate of waste thermal water of a geothermal object i (m^3/y)

4.Utilization efficiency

- **Ratio between average annual water production and maximum possible production (as in water permits)**

$$F_u = \frac{\sum_{i=1}^{n} Q_i}{\sum_{i=1}^{n} Q_{cap\ i}} \cdot 100\ [\%]$$

- **Naturally discharged thermal waters (from springs) are not accounted for**

F_u [%]	Results	
	Descriptive	Points [%]
> 30	Very good	100
25 - 30	Good	75
20 - 25	Medium	50
15 - 20	Weak	25
< 15	Bad	0

$Q_{cap\ i}$ = installed capacity of a geothermal site i (≈ maximum allowed annual production as defined in water permit) (m^3/y)

5. Bathing efficiency

- Not totally developed yet (lack of data); should account for medical effects.
- Production rate for filling pools should not exceed 10 m^3 per bather per day

6. Re-injection rate

$$\overline{RI}_Q = \sum_{1}^{n} \frac{Q_{reinj\ i}}{Q_{abs\ i}}\ [\%]$$

- Ratio between annually produced and reinjected volumes of thermal water used for geothermal energy production

$\overline{RI}_Q$ [%]	Result	
	Descriptive	Points [%]
> 60	Very good	100
40 - 60	Good	75
20 - 40	Medium	50
0 - 20	Weak	25
0	Bad	0

$Q_{abs\ i}$ = annual production rate of thermal water of a geothermal object i used solely for geothermal heat production (m^3/y)
$Q_{reinj\ i}$ = annual reinjection rate of thermal water of a geothermal object i used for geothermal heat production (m^3/y)

7. Status of water balance assessment

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- **Knowledge on the quantity status and reliability of data**
- **One well can have maximum one point**
- **Only one statement can be selected**

$$I_{wba} = \frac{P_i}{N_{tot}} \cdot 100\ [\%]$$

Status of water balance assessment	Points
Not assessed	0
Critical level point is defined (not based upon measurements on the location but from other available data / locations).	0.25
Critical level point is defined (based upon average yearly minimum level value from previous years on the location).	0.5
Critical level point is defined. Renewable and available volume of water is assessed. Critical point of abstraction is defined. Study is made on the base of old / regional data and knowledge .	0.75
Renewable and available volume of water is assessed. Critical point of abstraction and critical level point are both defined. Study is made and updated on the basis of actual measurements.	1

I_{wba} [%]	Results	
	Descriptive	Points [%]
> 95	Very good	100
75 - 95	Good	75
50 - 75	Medium	50
25 - 50	Weak	25
< 25	Bad	0

P_i = number of assigned points to a geothermal object i
N_{tot} = total number of geothermal objects on the basin level in the investigated country

8. Over-abstraction

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- **Quantity status in strong connection with reinjection rate and water balance assessment indicators**

$$\bar{I}_{OE} = \frac{\sum_{i=1}^{n} I_i \cdot Q_i}{\sum_{i=1}^{n} Q_i}$$

Status of the aquifer based on the impact of production	Response	Points
Significant decreasing of piezometric level is showing that new equilibrium could not be reached.	Yes	1
	No	0
Decreasing water quality or temperature are caused by thermal water production.	Yes	1
	No	0
Decreasing of groundwater availability (lower yield, pump lowering).	Yes	1
	No	0
Impact on dependent ecosystems is significant.	Yes	1
	No	0
Strata subsidence caused by groundwater production.	Yes	1
	No	0

$\bar{I}_{OE}$ [points]	Result	
	Descriptive	Points [%]
0	Very good	100
0-1	Good	75
1-2	Medium	50
2-3	Weak	25
> 3	Bad	0

I_i = number of assigned points to a geothermal object i
Q_i = annual production rate of a geothermal object i (m^3/y)

9. Quality of discharged waste thermal water

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- **Not totally developed yet (needed data was not collected)**
- **Not tested properly**

$$I_{Qual\,ww\,i} = \frac{N_{positive\,i}}{N_{tot\,i}} \cdot 100\ [\%]$$

$$\bar{I}_{Qual\,ww} = \frac{\sum_{i=1}^{n} I_{Qual\,ww\,i} \cdot Q_i}{\sum_{i=1}^{n} Q_i}\ [\%]$$

I_{Qual_disc} [%]	Result	
	Descriptive	Points [%]
> 95	Very good	100
90 - 95	Good	75
80 - 90	Medium	50
70 - 80	Weak	25
< 70	Bad	0

$N_{positive\,i}$ = total number of positive samples (which meet the waste water emission requirements) per year of a geothermal object i
$N_{tot\,i}$ = total number of taken chemical samples per year of a geothermal object I
Q_i = annual production rate of a geothermal object i (m^3/y)

10. Public awareness

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- **Overview of users' websites, media and promotion materials**
- **If available, often only in national languages**

$$I_{inf} = \frac{\sum_{i=1}^{n} P_i}{N_{tot}}$$

Information about	Points
Monitoring	1
BAT use	1
Quantitative status (overexploitation)	3
Qualitative status of waste water	3
Energy efficiency	2

I_{inf}	Results	
	Descriptive	Points [%]
> 8	Very good	100
6 - 8	Good	75
4 - 6	Medium	50
2 - 4	Weak	25
< 2	Bad	0

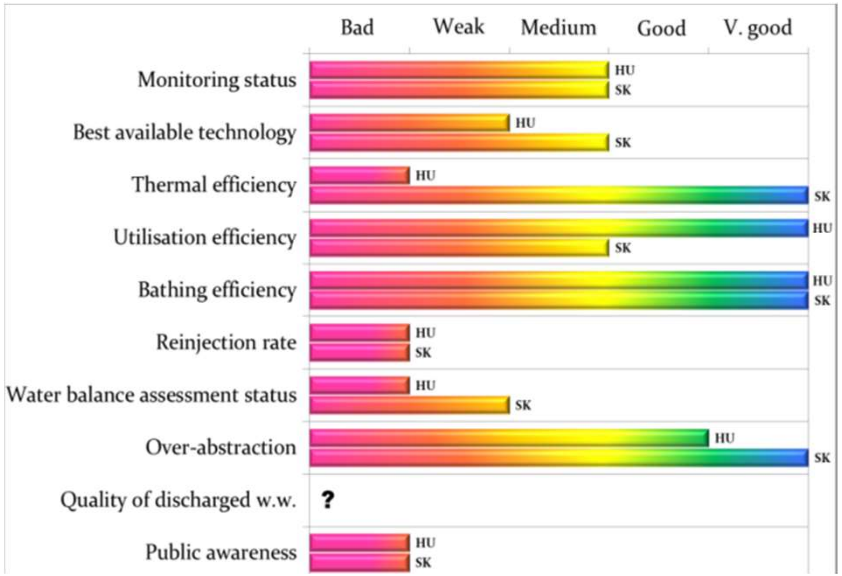
P_i = number of assigned points to a geothermal object i
N_{tot} = total number of geothermal objects on the basin level in the investigated country

Komárno-Štúrovo Pilot Area

Aquifer:
- Upper Triassic limestones and dolomites

Water use
- 23-39 °C water for bathing
- 40-60 °C water for greenhouses heating

Assessment of
- 8 active Slovakian wells (2009)
- 26 active Hungarian wells (2011)

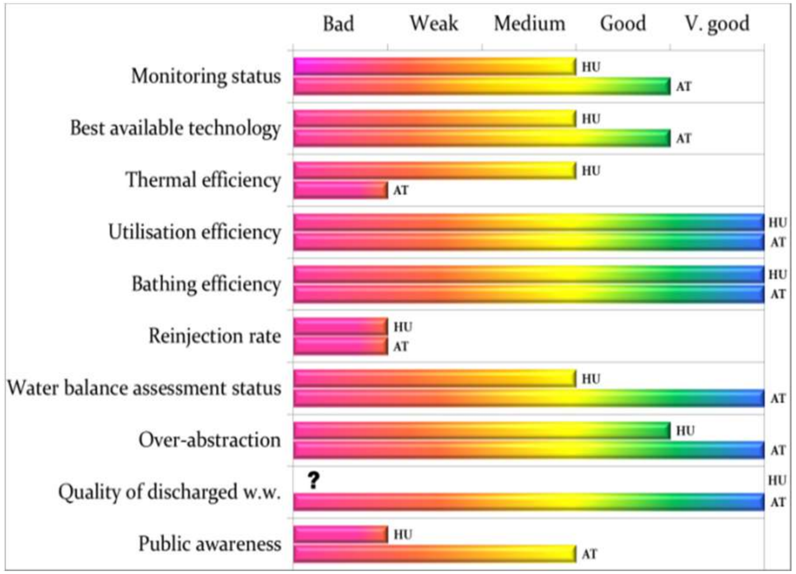


Lutzmannsburg-Zsira Pilot Area

Aquifer:
- Upper Pannonian sand, D dolomite

Water use
- for balneology

Assessment of
- 12 active and 3 inactive Hungarian wells
- 2 active Austrian wells



Some practical aspects and good practices of thermal water direct uses

Optimal use of thermal water

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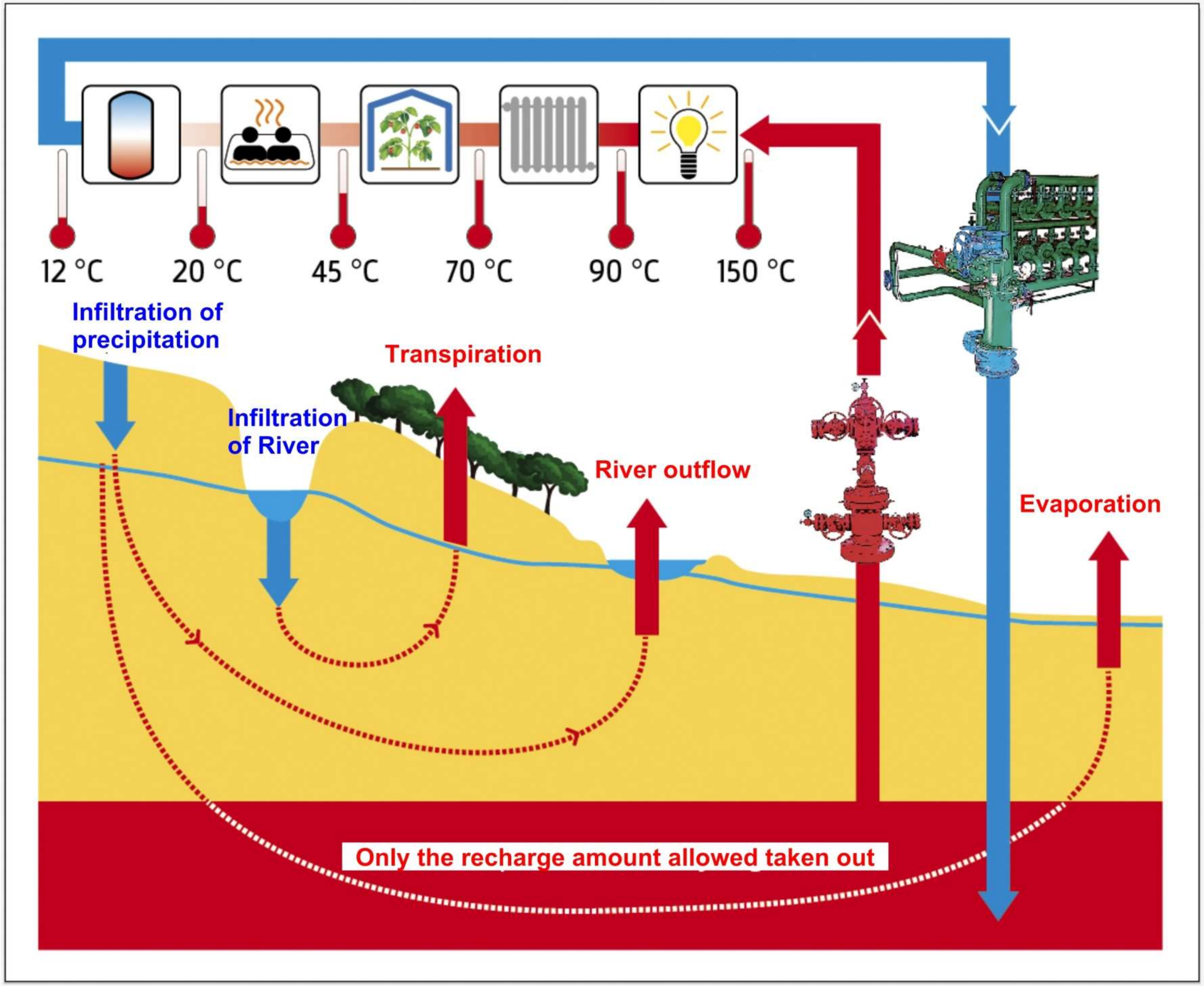
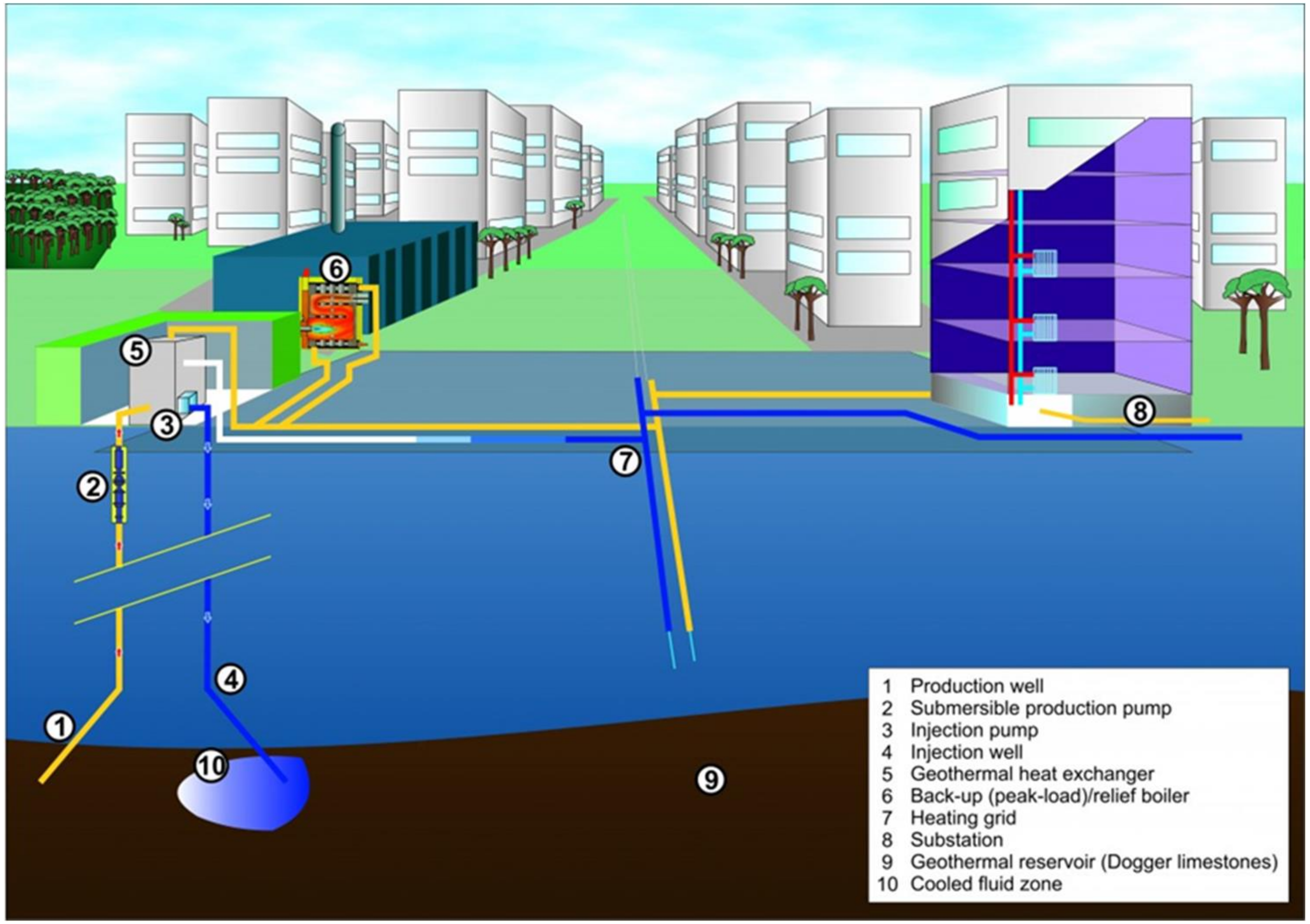


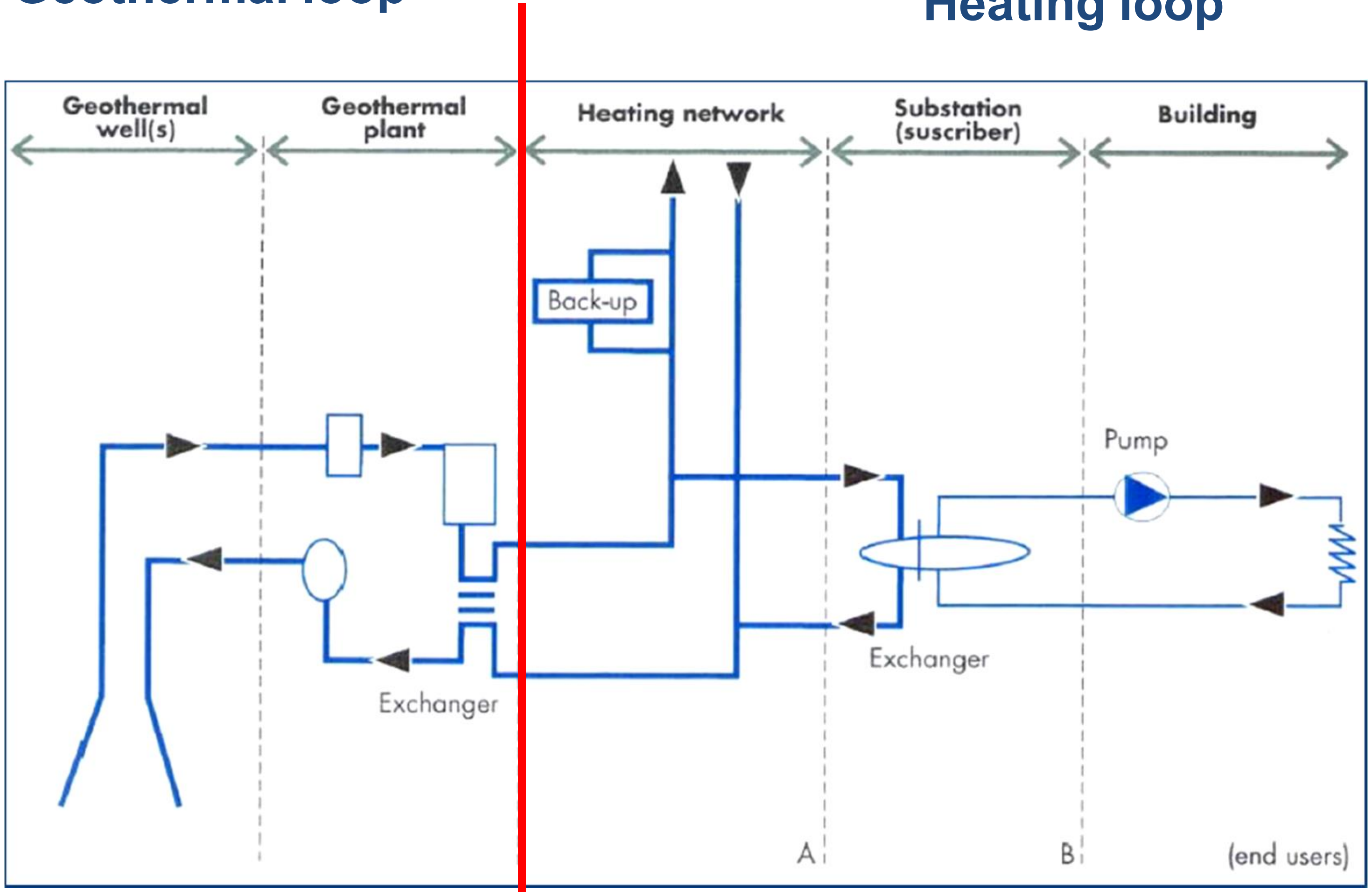
Main components of a geothermal district heating



Source: GeoDH project

Geothermal part of the DH
Geothermal loop

Conventional part of the DH
Heating loop



Source: GeoDH project

A five step analysis is needed to assist an initial evaluation before launching the construction of a geothermal district heating

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1. Analyse Geothermal Heat Production

Information on the characteristics of an identified resource to estimate the heat production from deep geothermal resources.

2. Identify District heating Market Areas

Heating demands in the service area are estimated such as the density of thermal loads and distance from production fields. If the DH already exists, this step will be limited to evaluate the adaptation of the heating loop.

3. Preliminary design of the district network for selected zones inside the town

To consider engineering design options available for the geothermal district heating system, which is dependent on resource temperature, flow rate, geothermal water quality and depth.

4. Analyse the economic aspects

To provide a procedure to estimate capital expenditures, and annual operation and maintenance costs which could be translated into costs per unit of energy for both district heating and conventional systems.

5. Evaluate district heating feasibility

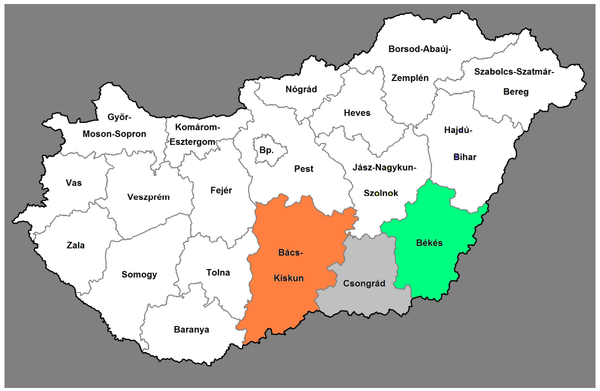
To explain how district heating and conventional costs are compared.
Evaluation criteria are suggested to determine whether district heating is appropriate.

Source: GeoDH project

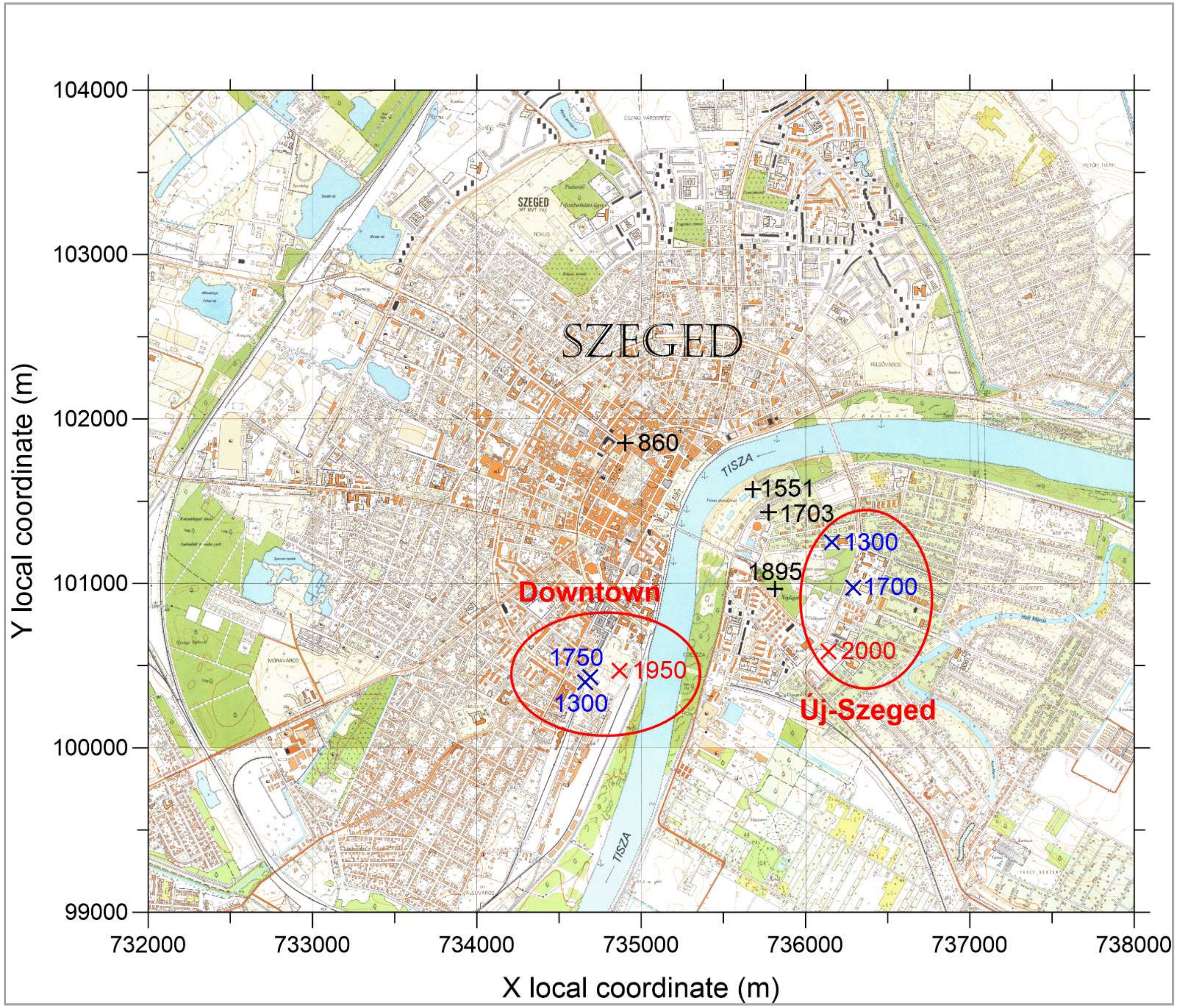
The early 2000's - The South Great Plain region is catching up with geothermal

DARLINGe

- 2008-2010: A brand new geothermal district heating system complete with waste gas utilization is built and starts to operate in Mórahalom
- 2010: Geothermal heating is introduced to a TESCO store in Hódmezővásárhely, and to the building of the Faculty of Engineering at the University of Szeged
- 2012-2013 A non-functioning geothermal district heating system is completely overhauled, expanded and starts to operate in Csongrád
- 2012-2014: Two new geothermal district heating systems are built and start to operate in Szeged
- 2013-2015: A defunct production well is reopened, and a new geothermal district heating system is built in Makó
- 2017- : Integration of geothermal energy is planned in 4 heating circuits of the DH in Szeged



Case study 1: The geothermal projects of the city of Szeged



Case study 1a: Geothermal cascade system in the city centre

Case study 1a: Heat market of Szeged-downtown

Case study 1a: Parameters of the Szeged downtown geothermal circle

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Construction of the 4.4 MW_{th} project

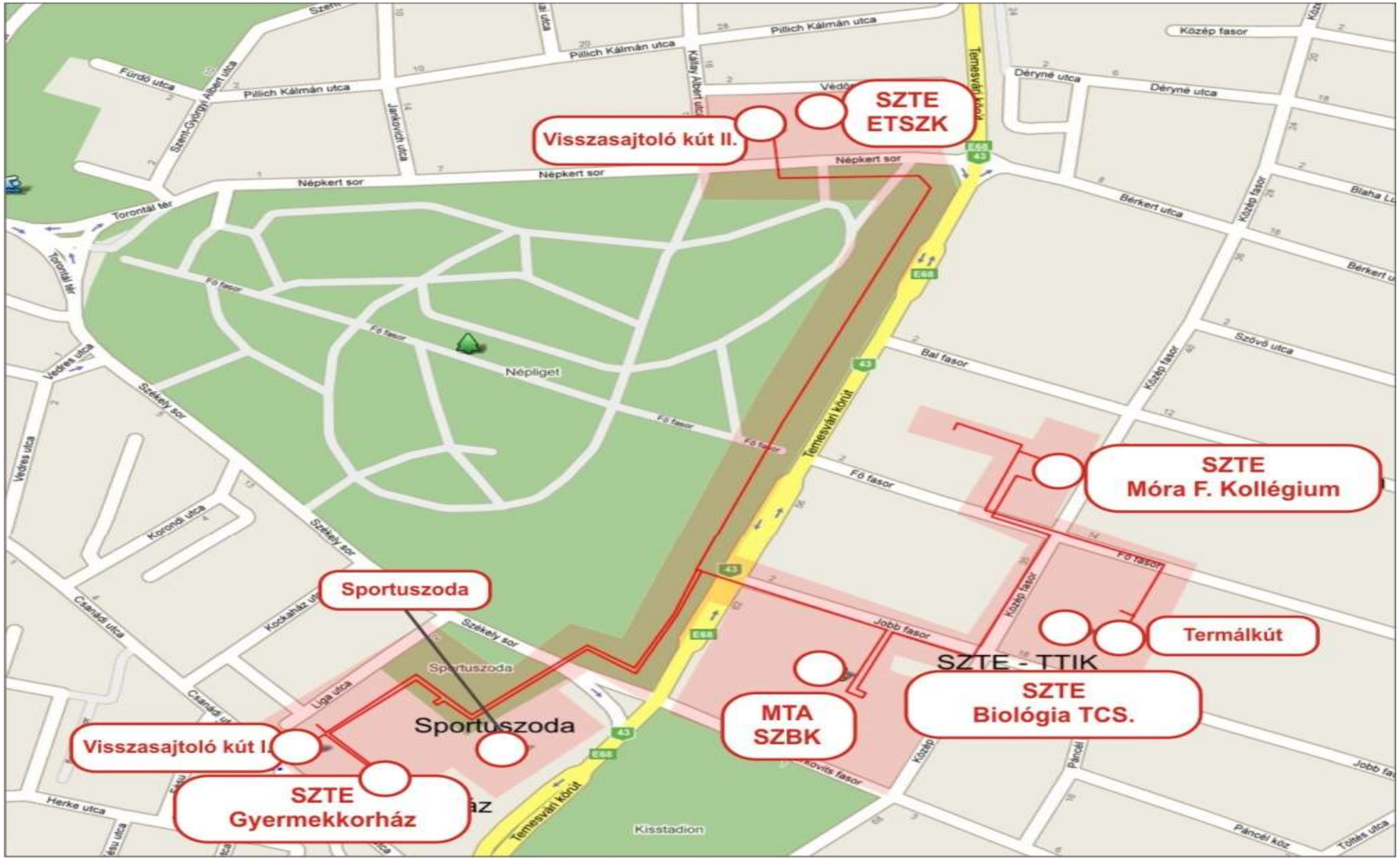
- 1 production well (1,995 m)
- 2 injection wells (1,350 m; 1,750 m)
- pipe line ~ 3,300 m
- 25 new heating centres
- Online PLC control system

Outcomes of the project

- Produced geothermal energy: 55,239 GJ/y
- Natural gas reduction: 1.8 million m^3/y
- CO_2 reduction: 3,633 t/y
- Spending on investment: 6.6 million €
- Investment/produced energy: 1,410 €/kW)
- Specific investment of CO_2 reduction: 1,830
- Maintenance cost: 280,000 €/y
- Profit: 0.45 million €/year

Case study 1b: Geothermal cascade system in New-Szeged

Case study 1b: Heat market of New-Szeged



Case study 1b: Parameters of the New-Szeged geothermal system

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Construction of the 4.5 MW_{th} project

- 1 production well (2,000 m)
- 2 injection wells (1,250 m; 1,700 m)
- pipe line ~ 4,400 m
- 12 new heating centres
- Online PLC control system

Outcomes of the project

- Produced geothermal energy: 37,167 GJ/y
- Natural gas reduction: 1.2 million m^3/y
- CO_2 reduction: 2,343 t/y
- Spending on investment: 4.2 million €
- Investment/produced energy: 860 €/kW)
- Specific investment of CO_2 reduction: 1,780 €/t
- Maintenance cost: 193,300 €/y
- Profit: 0.37 million €/y

District Heating in Szeged

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- Municipally owned DH Company
- Heat and DHW service to 27,000 apartments (4-10 story blocks) and 500 public buildings (schools, kindergartens, hospitals etc)
- Built between 1979 and 1989
- 23 heating centres as hubs of the service and 99 1-5mW boilers
- 215 km pipeline system
- Total yearly gas concumption 28 million m3
- The total capacity of the system is 224mW.
- 150 employees

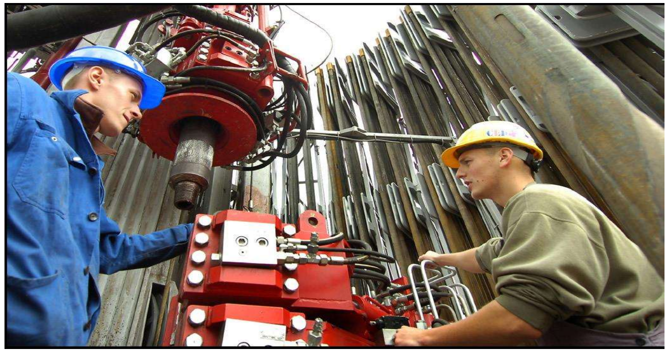
District Heating – the ultimate heat market in Szeged

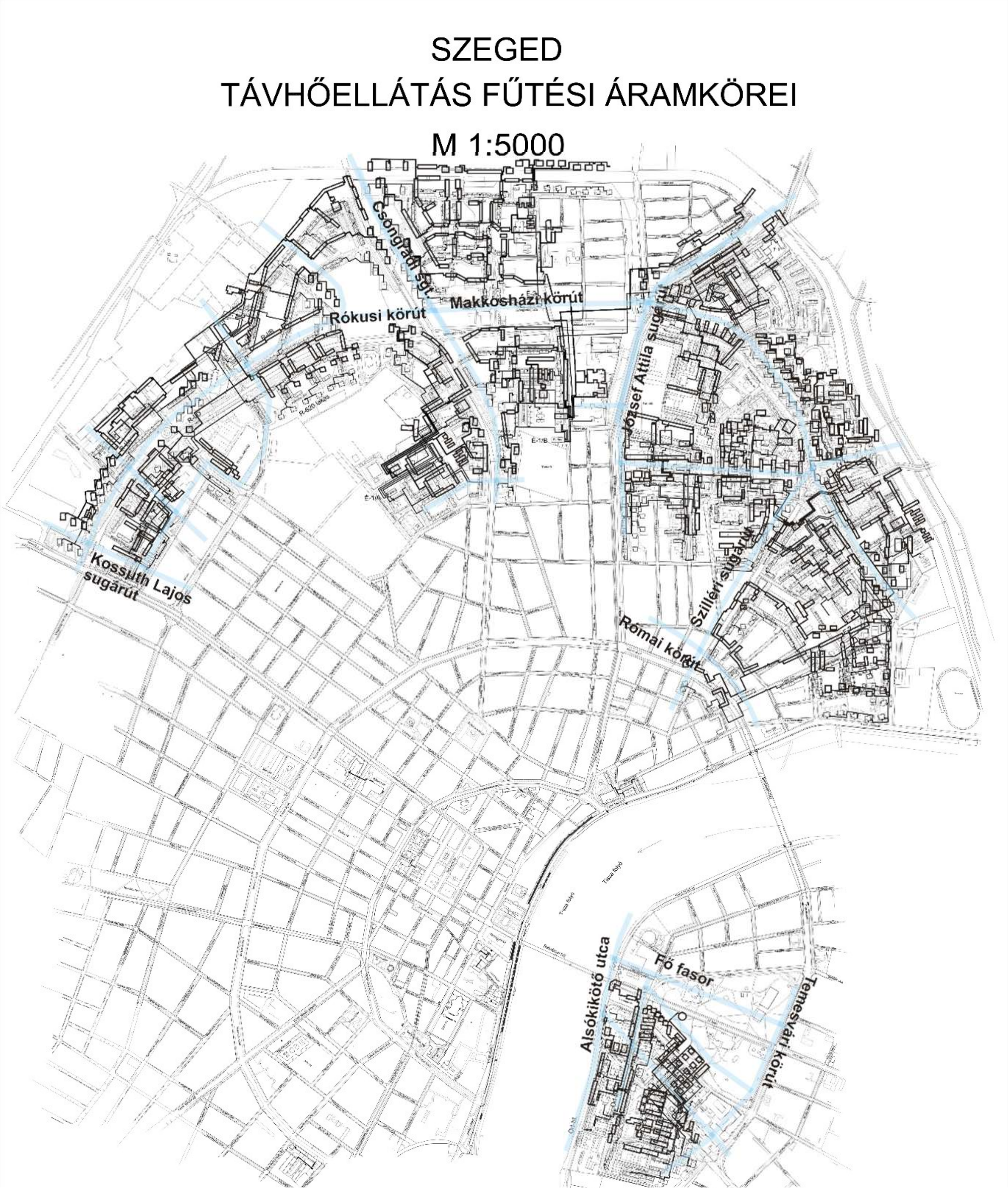
Integrating geothermal at 4 heating circuits

Heat market

Thermal potential

Funding





Case study 2: the Szentes geothermal field

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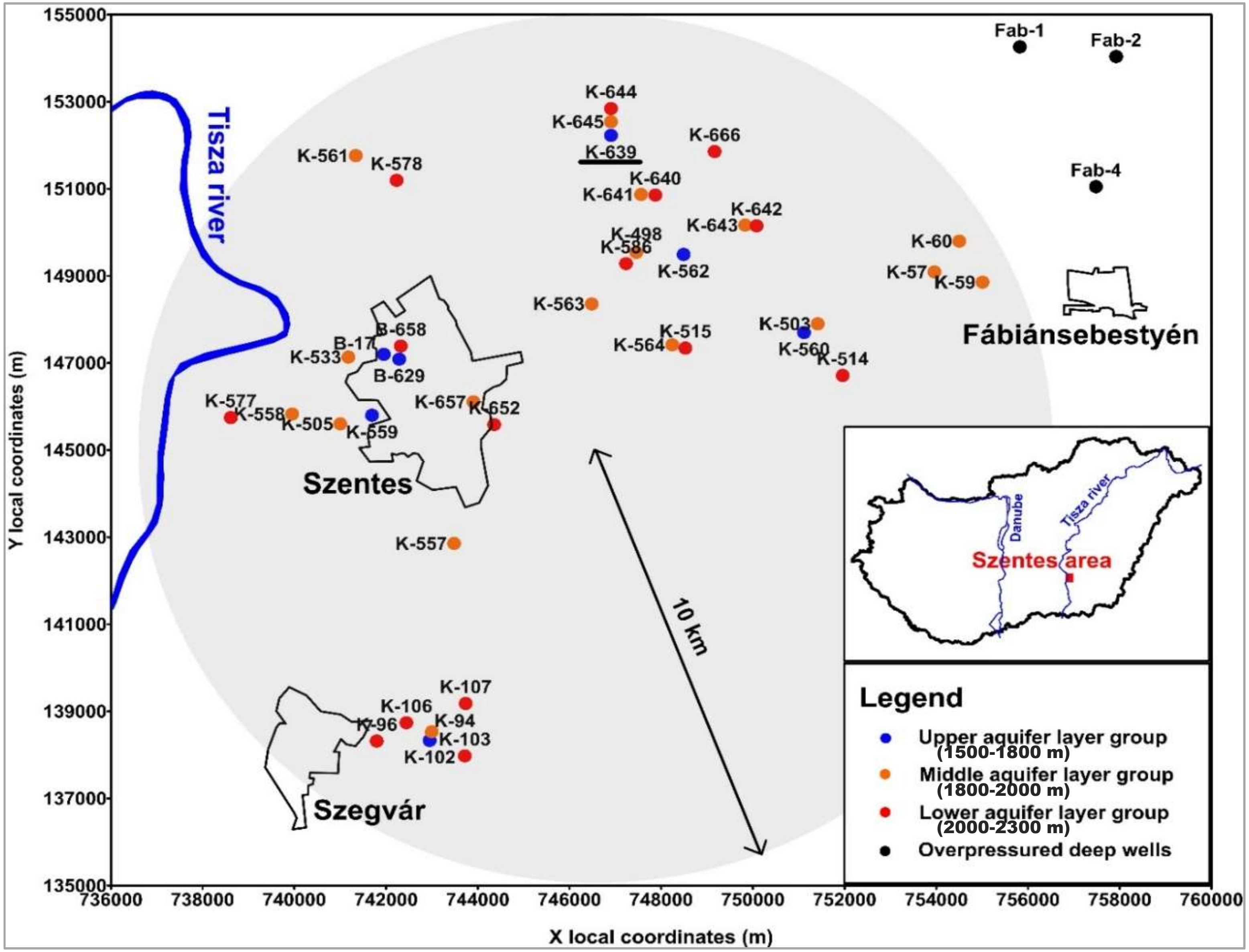

Case study 2: Geothermal energy utilization in the Szentes area

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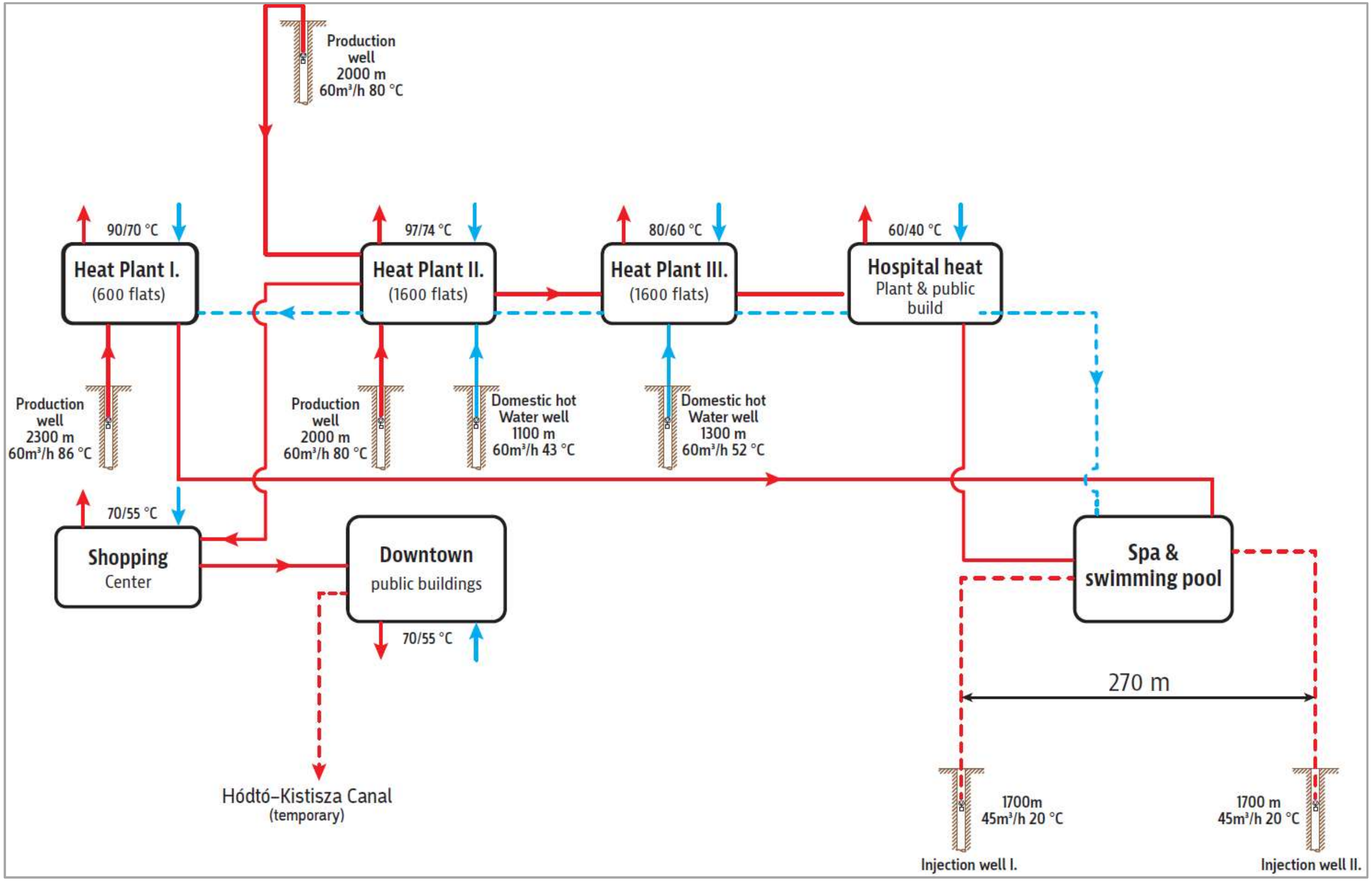
- warm water supply; hospital, balneological use
- district heating system, 1300 flats and communal buildings
- heating 60 ha of greenhouses
- 35000 m^2 poultry yards

Case study 3: Geothermal energy utilization in Hódmezővásárhely



Case study 3: Reinjection technology in Hódmezővásárhely

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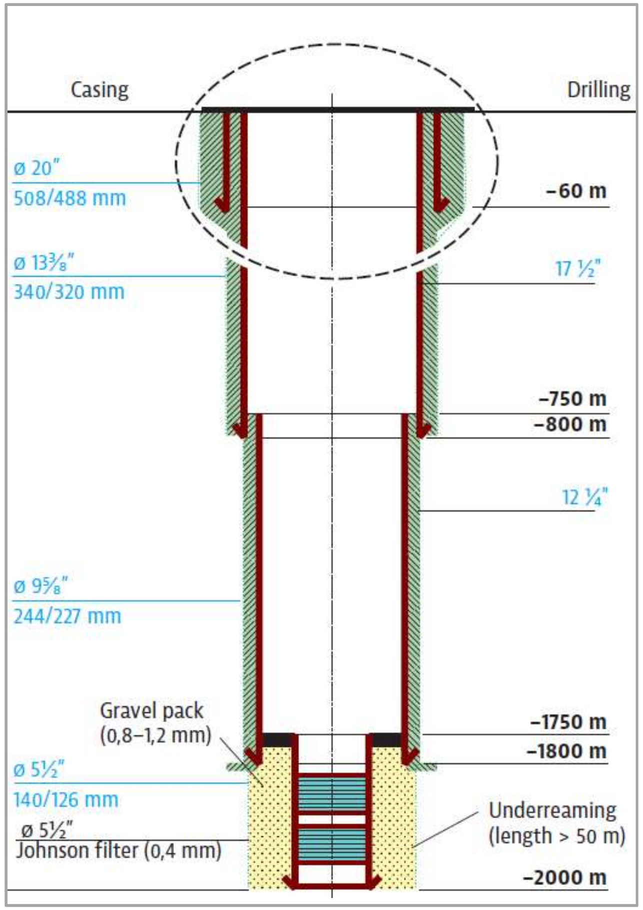
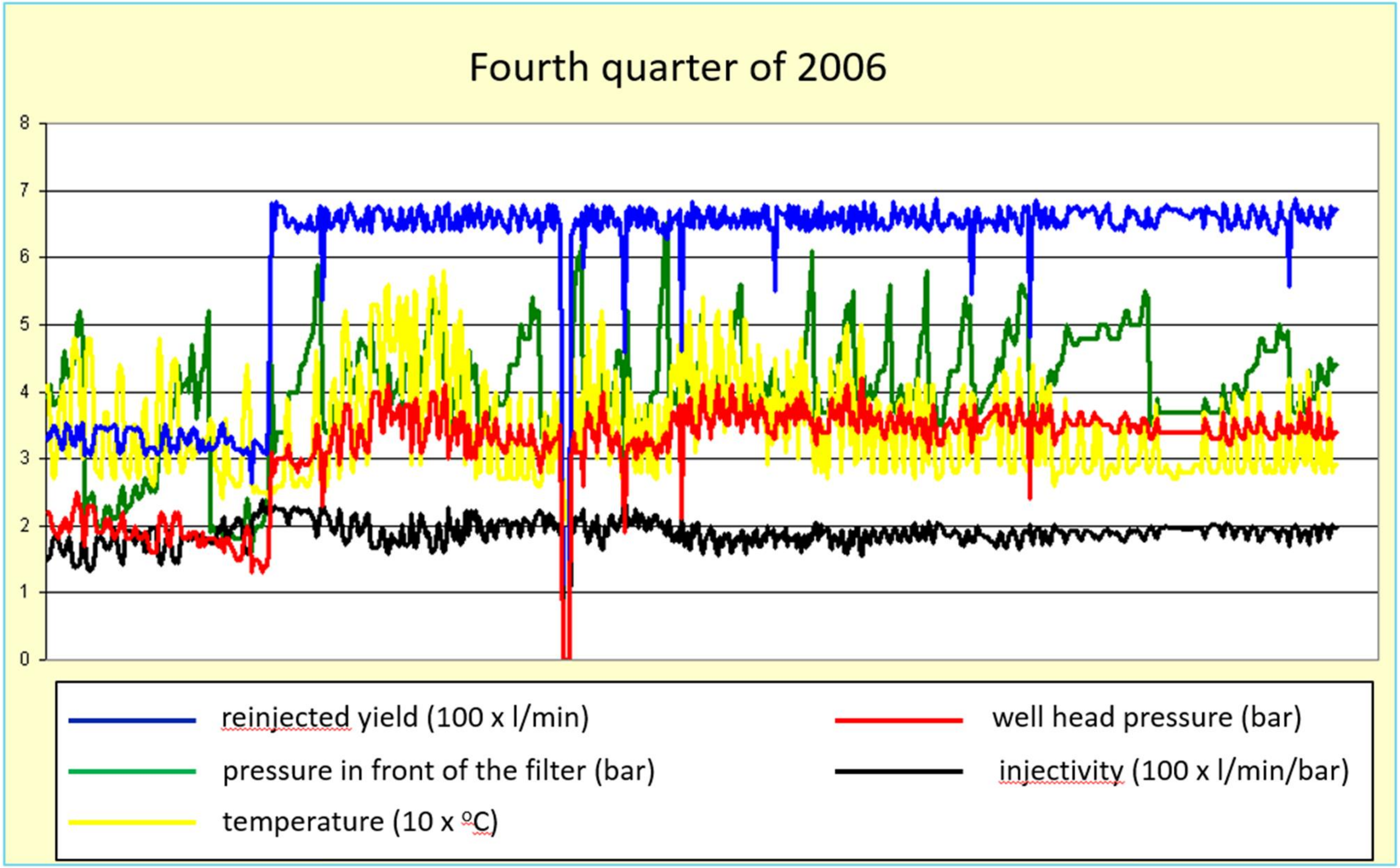


Case study 3: Reinjection data in Hódmezővásárhely



Case study 3: Injection parameters at Hódmezővásárhely

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Aquifer parameters

According to our experience, a sandstone aquifer should
provide(for the injection of 50 – 100 m3/h per well)
minimum: (13-27 l/s)

effective porosity	> 20 %
permeability	> 0.5 μm^2
thickness	> 20 m

in order to achieve an injectivity of > 50 $m^3/(h*MPa)$.
(83 l/min*bar)

GTN INGENIEURE & GEOLOGEN

Peter Seibt

Case study 4: Geothermal Cascade System in Mórahalom

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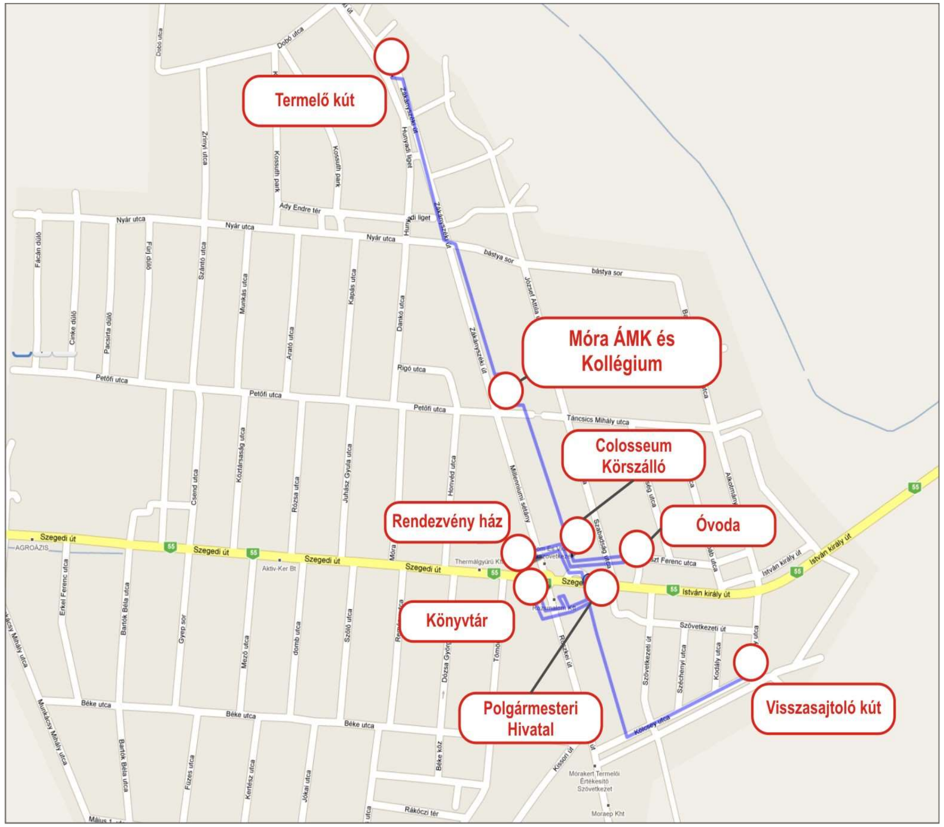
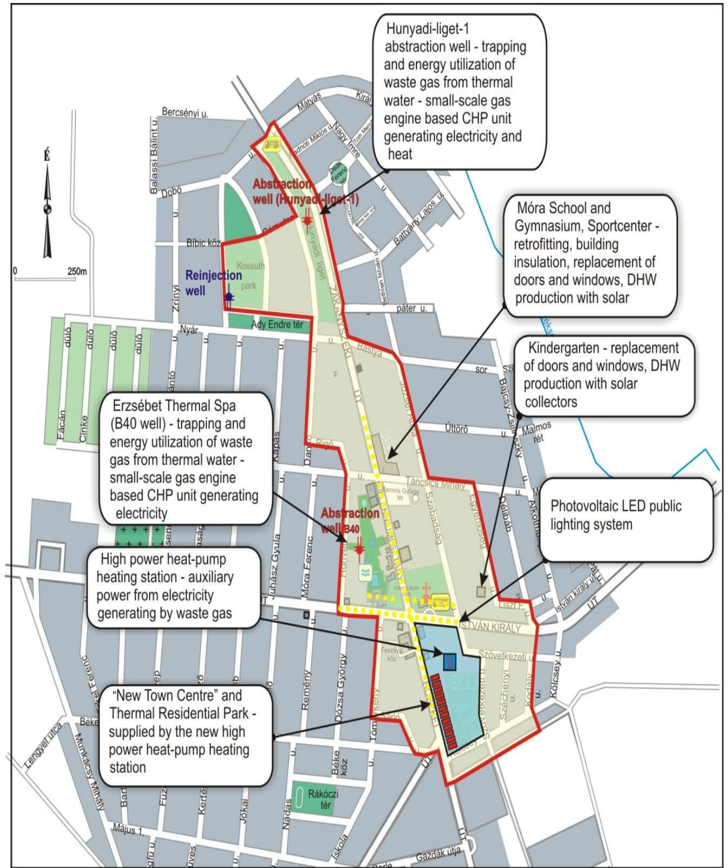
Case study 4: The heat-market of Mórahalom





CONCERTO PROJECT DEVELOPMENT IN MÓRAHALOM
the Concerto Area equals to the operational area of the geothermal cascade system

Case study 4: Activities of the development in Mórahalom

- The establishment of the geothermal cascade system in the public institutions of the town
- The construction of 1 ~1,400 m deep production well
- The construction of 2 ~900 m deep reinjection well
- The establishment of ~ 2,800 m new thermal conduit
- The creation of 7 new heating stations
- The establishment of an up-to-date PLC control system

Case study 4: Indicators of the Mórahalom project

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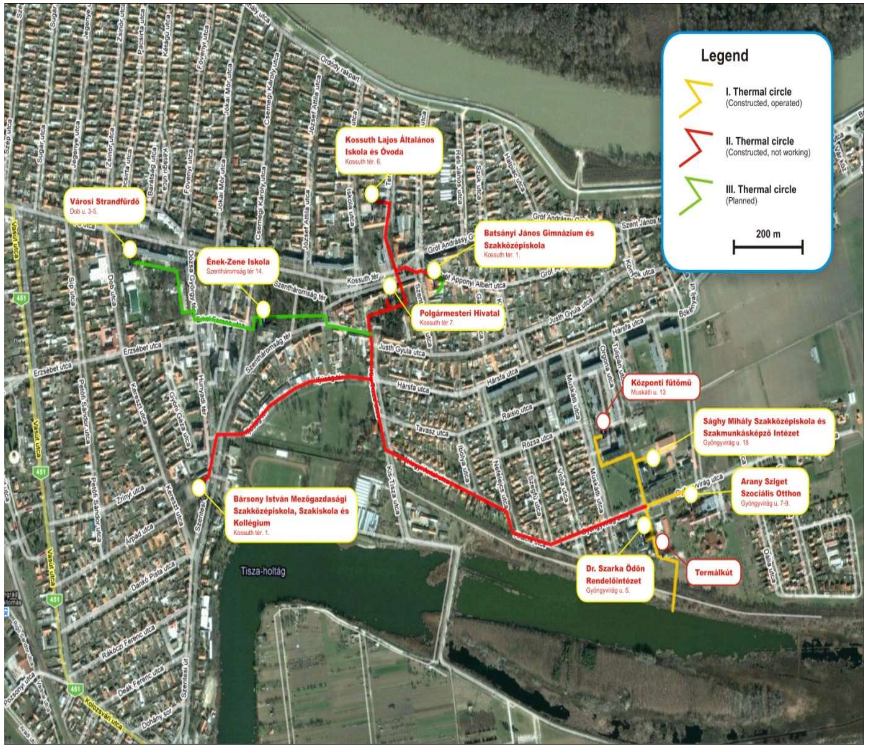
- 2,620 kW installed new geothermal heat capacity
- Geothermal energy usage 0% -> 80%
- 14,441 GJ fossil energy sparing
- 481,907 m3 /year gas replacement
- 866 t CO_2 emission reduction
- 318 kg NxOx emission reduction
- 605 kg CO emission reduction

- Investment cost: net 1.5 M Euro
- EU support: gross 0.75 M Euro (50%)
- Energy generation specific cost 600 Euro/kW
- CO_2 reduction's specific investment cost 60 Euro/t
- Operational cost: net 70,000 Euro/year

Similar heat-markets in the region

Sándorfalva

Csongrád



Main parameters of some last projects

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	Mórahalom	Szeged University	Csongrád	Makó
Produced geothermal energy (GJ/y)	**18 000**	**86 000**	**55 931**	**67 000**
Natural gas reduction (m^3/y)	**482 000**	**2 900 000**	**920 000**	**2 192 000**
CO2 reduction (t/y)	**1 400**	**5 900**	**1 663**	**3 847**
Spending on investment (€)	**1 753 000**	**10 800 000**	**1 384 000**	**3 162 000**
Investment/produced energy (€/GJ)	**97.4**	**125.6**	**24.8**	**47.2**
Maintenance cost (€/y)	**138 300**	**473 000**	**187 000**	**172 000**
Pay-back (y)	**10.5**	**13.5**	**5.7**	**8.1**