

Možnosti ukládání tepla do horninového podloží (*pomocí vrtů*)

Vít Peřestý (za široký tým)

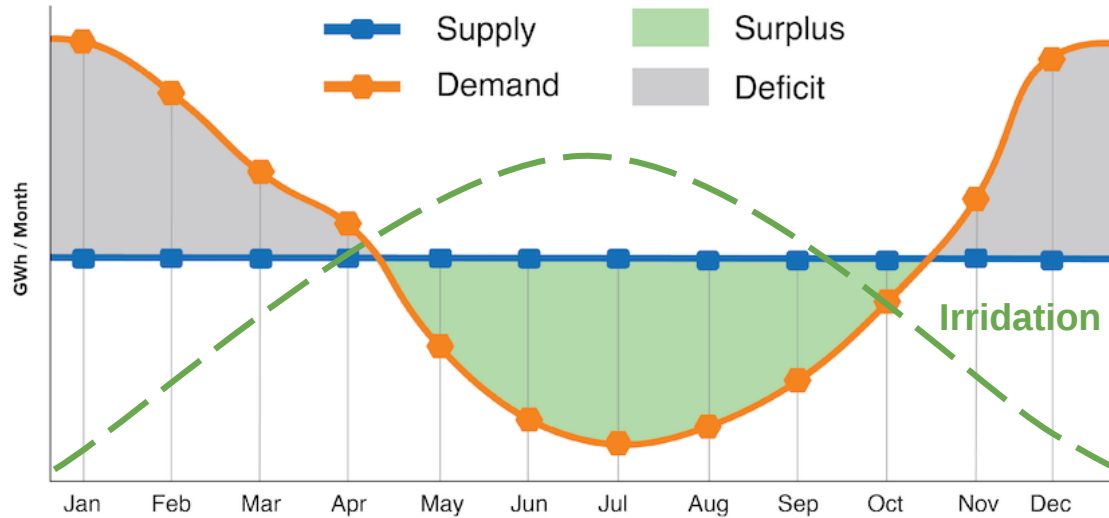


Spolufinancováno
Evropskou unií

Ministerstvo životního prostředí

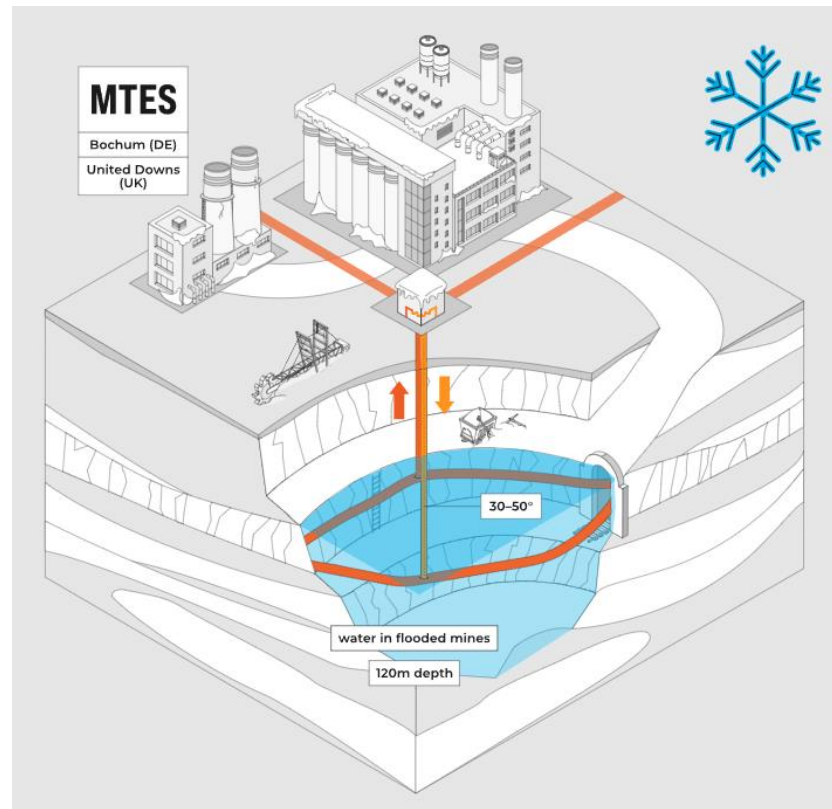
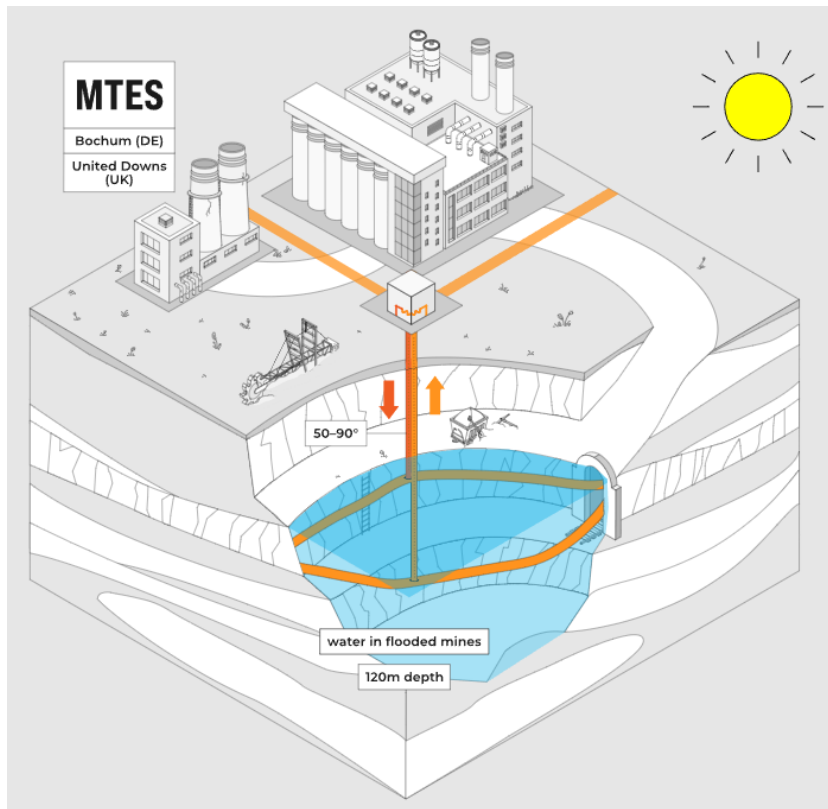


ÚVOD



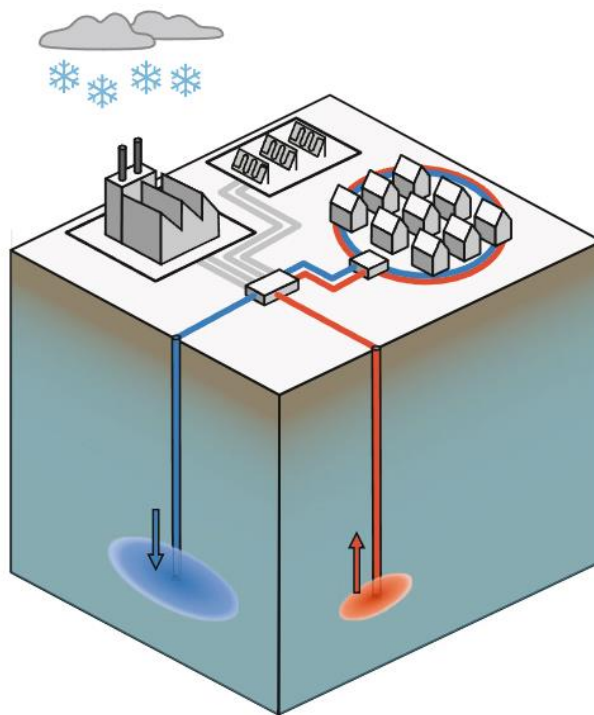
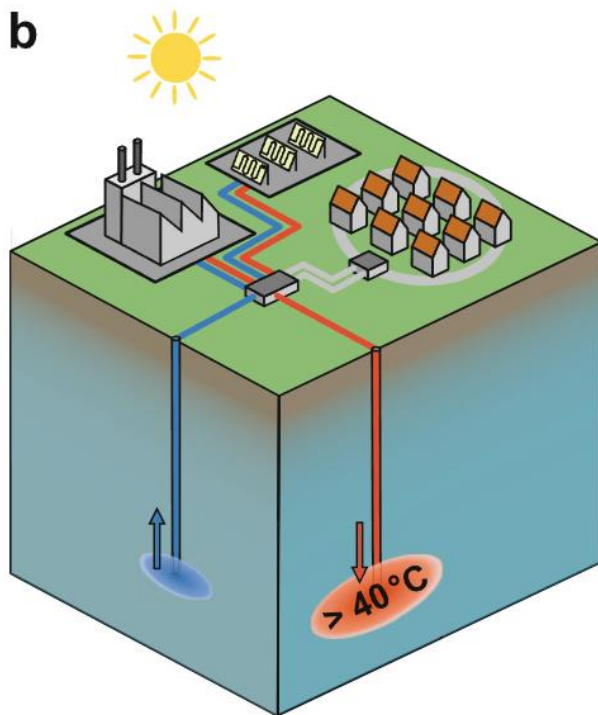
- výzva + potenciál středních zeměpisných šířek - přebytek energie v létě, nedostatek v zimě
- tři způsoby jak lze mezisezónně uložit přebytečné teplo do podloží pomocí vrtů
 - a. MTES - okrajově
 - b. ATES - nejvíce
 - c. BTES - později
- vzájemné srovnání výhody X nevýhody (z hlediska *geologických* podmínek, účinnosti a dalších parametrů)

MTES (M-mine)



ATES (A-aquifer)

b



§ WHG
§ BBergG

ATES

PUSH

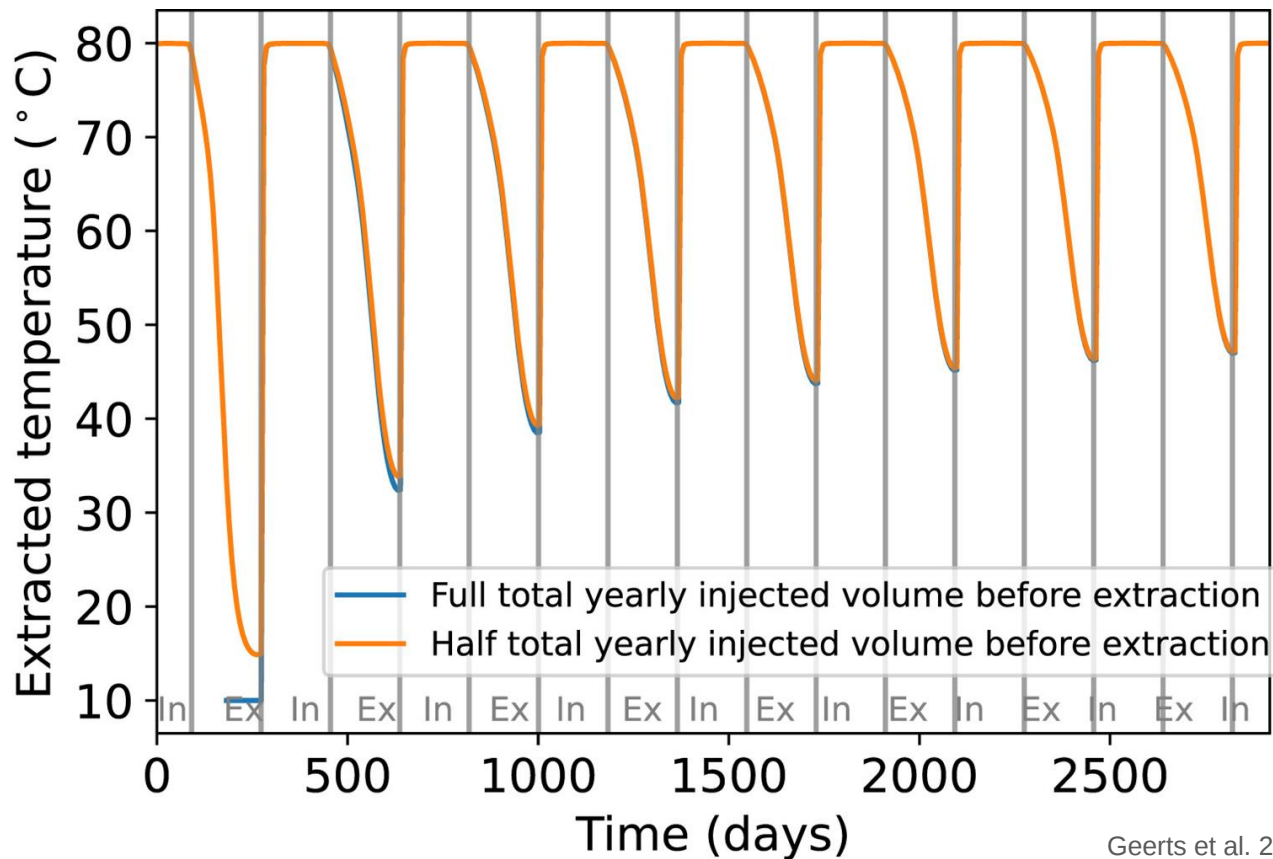


IT



Financováno
Evropskou unií

cycle efficiency: 1st=54%, 2nd=68%, 3rd=70%, 4th... = ...78%



Ground temperature 10°C

Geerts et al. 2025

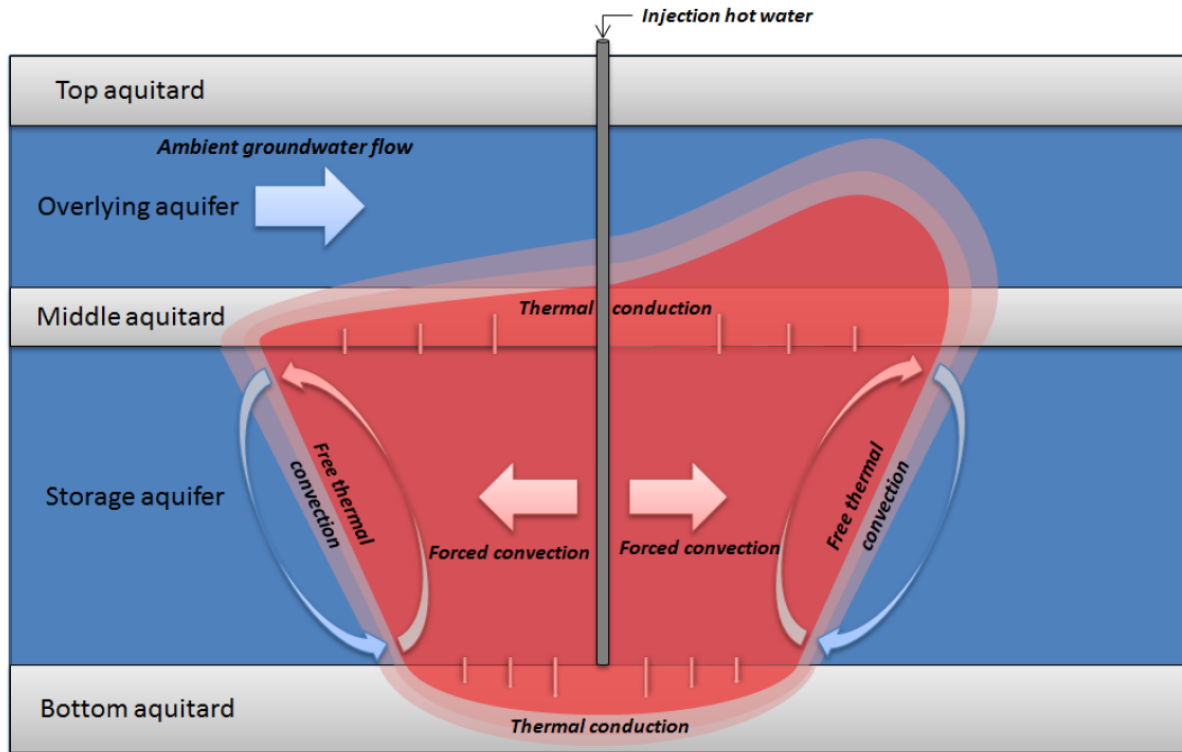
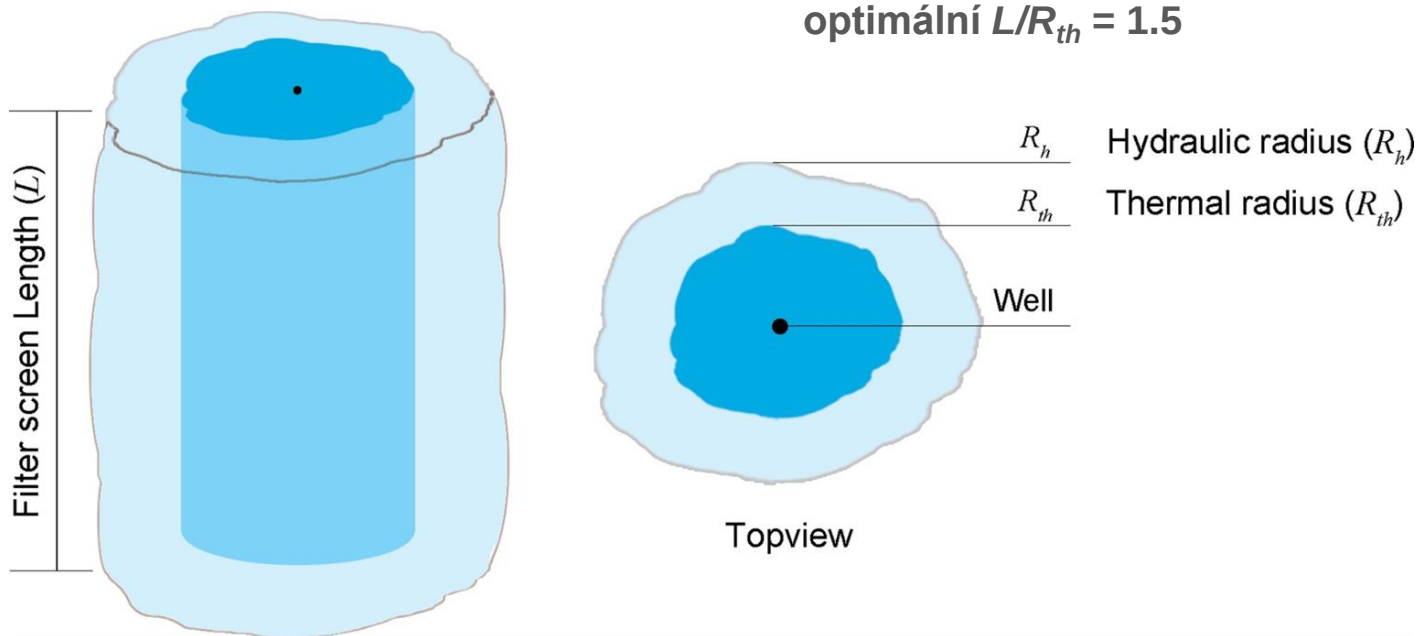
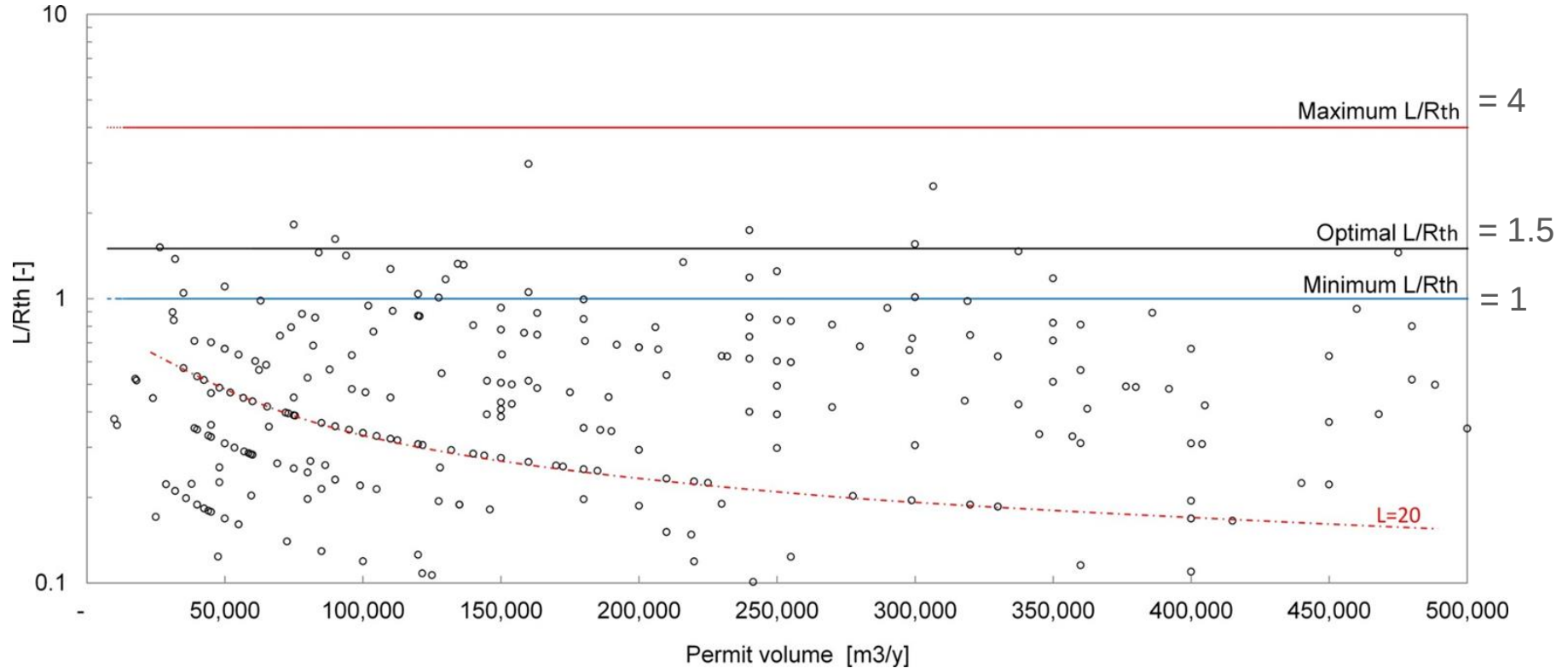


Figure 1 Schematic overview of the situation modelled in this study and the processes present with in this case ambient groundwater flow in the overlying aquifer. Note that the thicknesses of the layers do not correspond with the thickness of the layers modelled.

ATES



ATES - i v Holandsku je optimum od praxe daleko....



ATES - účinnost a citlivost

Efficiency 8th year →

for $V_e = V_i$:

$$\eta = \frac{E_{out}}{E_{in}} = \frac{V_e \Delta T_e}{V_i \Delta T_i} = \frac{\overline{T_e} - T_g}{\overline{T_i} - T_g}$$

hranice “zlepšení” (tj. 100 000 m³) pro $\Delta T = 25^\circ\text{C}$ odpovídá uloženému teplu **c. 10 000 GJ = 3 GWh**
→ tzn. třeba injektovat **c. 6.5 l/s** po 6 měsících

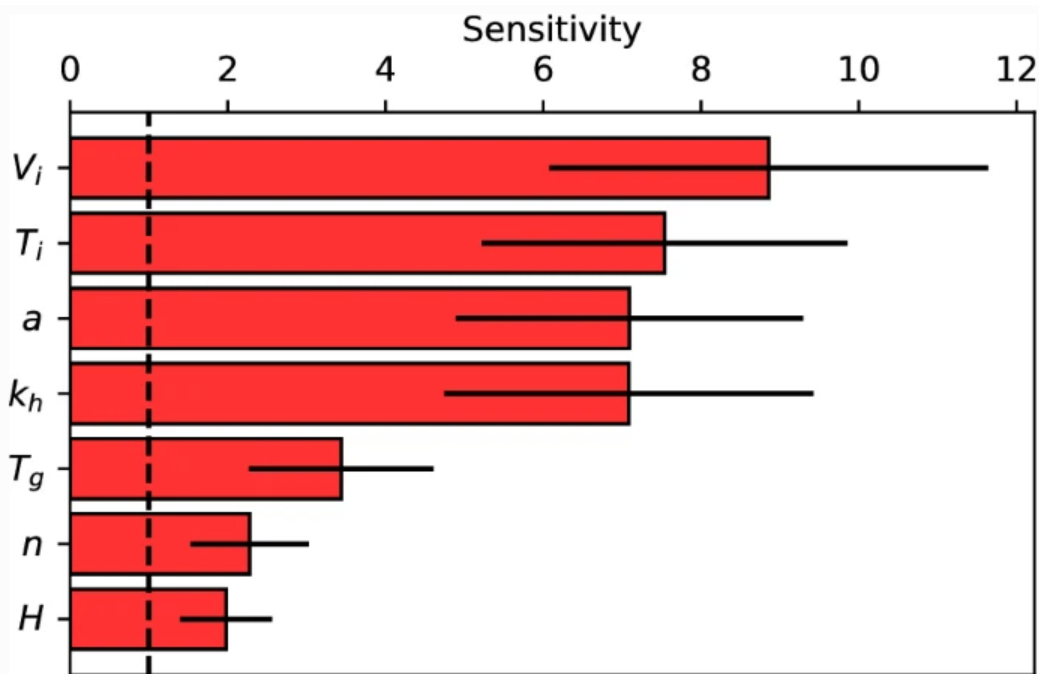
Anisotropy $a = k_h/k_v$

Aquifer thickness (m), hyd.conductivity (m/day), anisotropy

Table 5 η_r (in %) at year eight of the simulation for each design of experiment data point

			H	20												62												105											
				k_h	1			43			85			1			43			85			1			43			85										
					α	1	50	100	1	50	100	1	50	100	1	50	100	1	50	100	1	50	100	1	50	100	1	50	100	1	50	100							
V_i	n	T_i	T_g																																				
0.1	25	10	63	63	63	56	63	63	48	62	63	62	62	62	48	62	62	35	62	62	57	57	57	47	57	57	38	60	57										
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	1e4	10	67	68	70	21	44	55	15	30	42	58	65	65	8	53	60	5	42	53	55	59	59	7	54	57	4	47	54										
		30	68	70	70	23	53	62	17	39	52	62	66	66	9	59	63	6	50	59	57	59	9	56	58	5	52	56											
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0.3	25	10	73	73	73	41	71	72	31	66	71	67	67	67	24	67	67	14	65	67	61	61	28	61	61	17	60	61											
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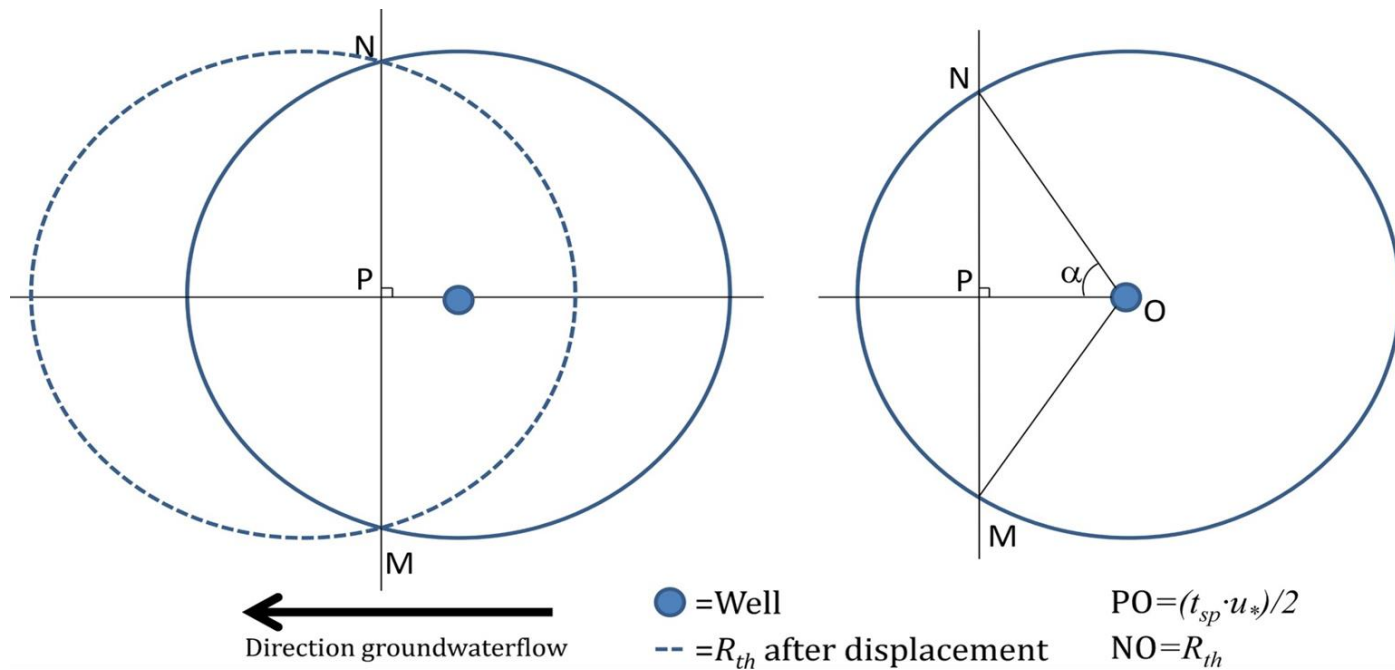
ATES - účinnost a citlivost



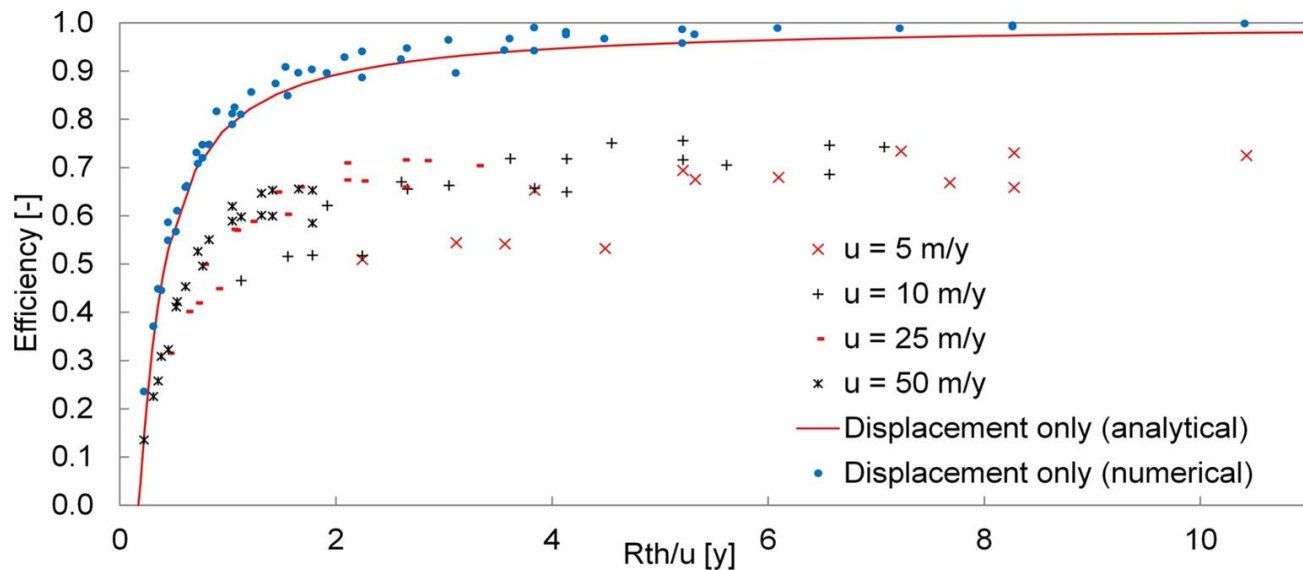
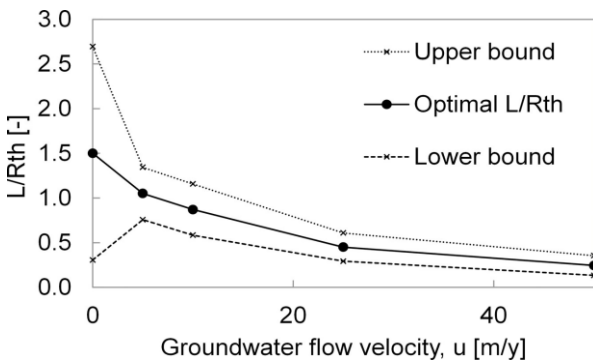
Injected water volume per period
Temperature of injected water
Anisotropy (conductivity hor/ver)
Horizontal hydraulic conductivity
Ambient groundwater temperature
Porosity of aquifer
Thickness of the aquifer

Results of the DGSA with their uncertainty. A value below 1 means that the parameters does not significantly impact the η_r

LT-ATES - vliv proudění vody

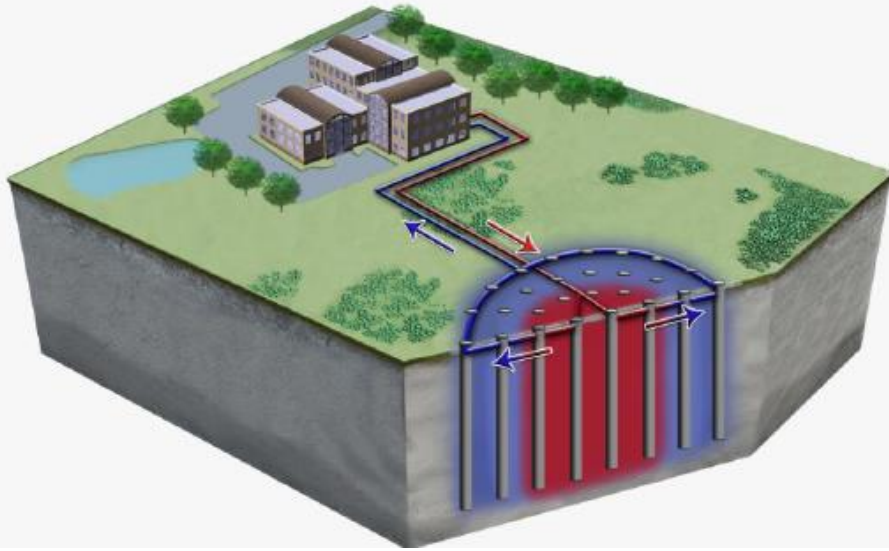


LT-ATES - vliv proudění vody

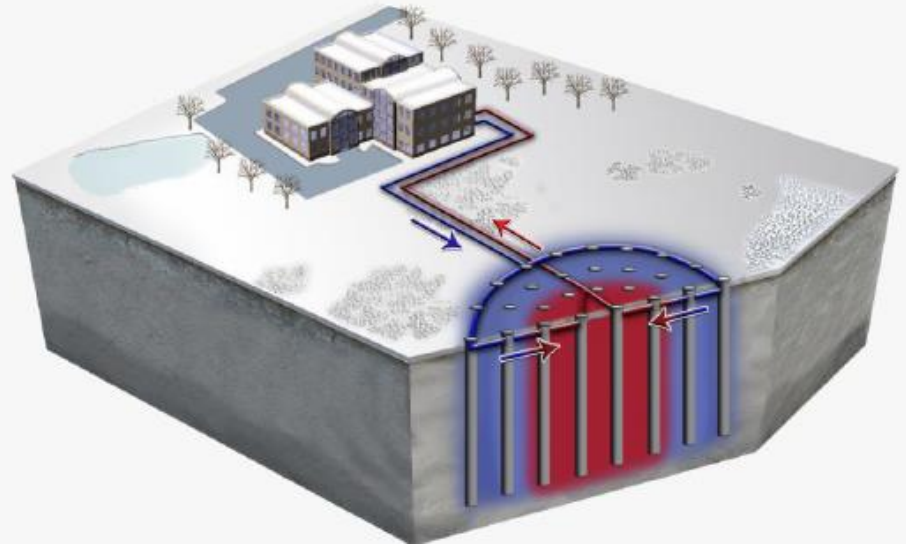


BTES (B - borehole)

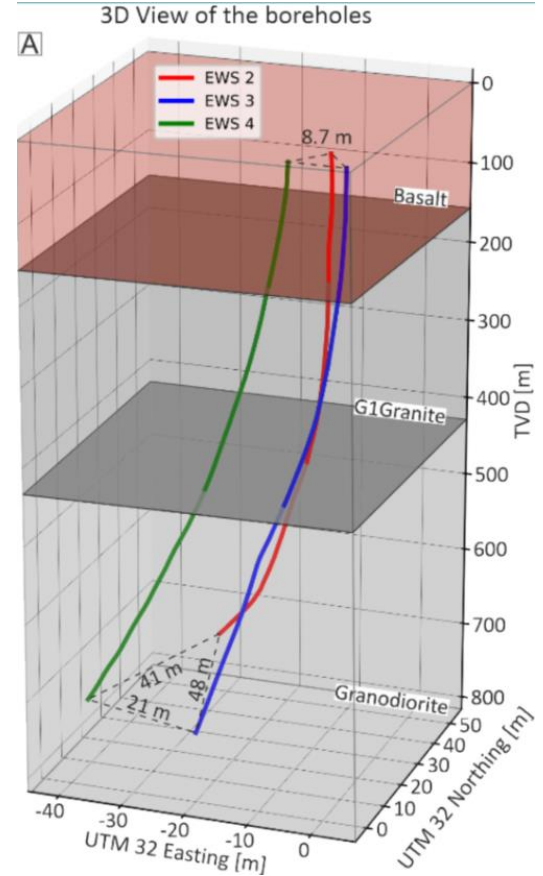
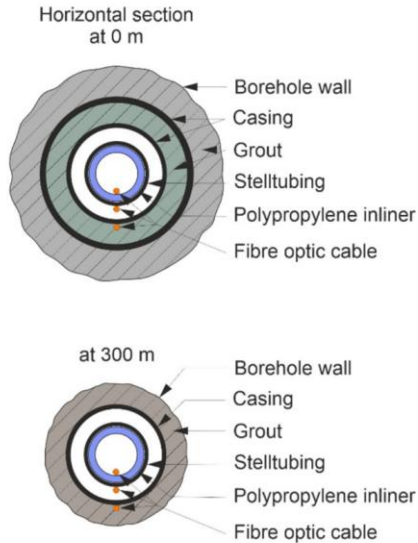
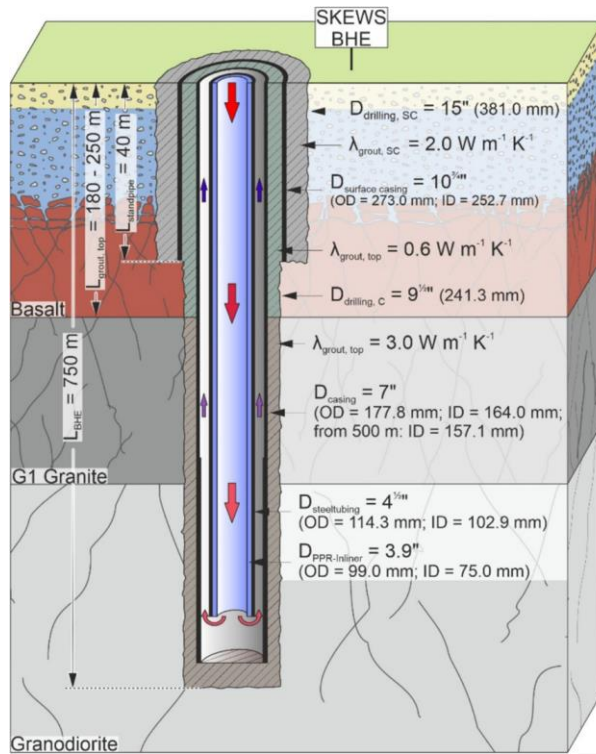
BTES Summer Operation – Cooling



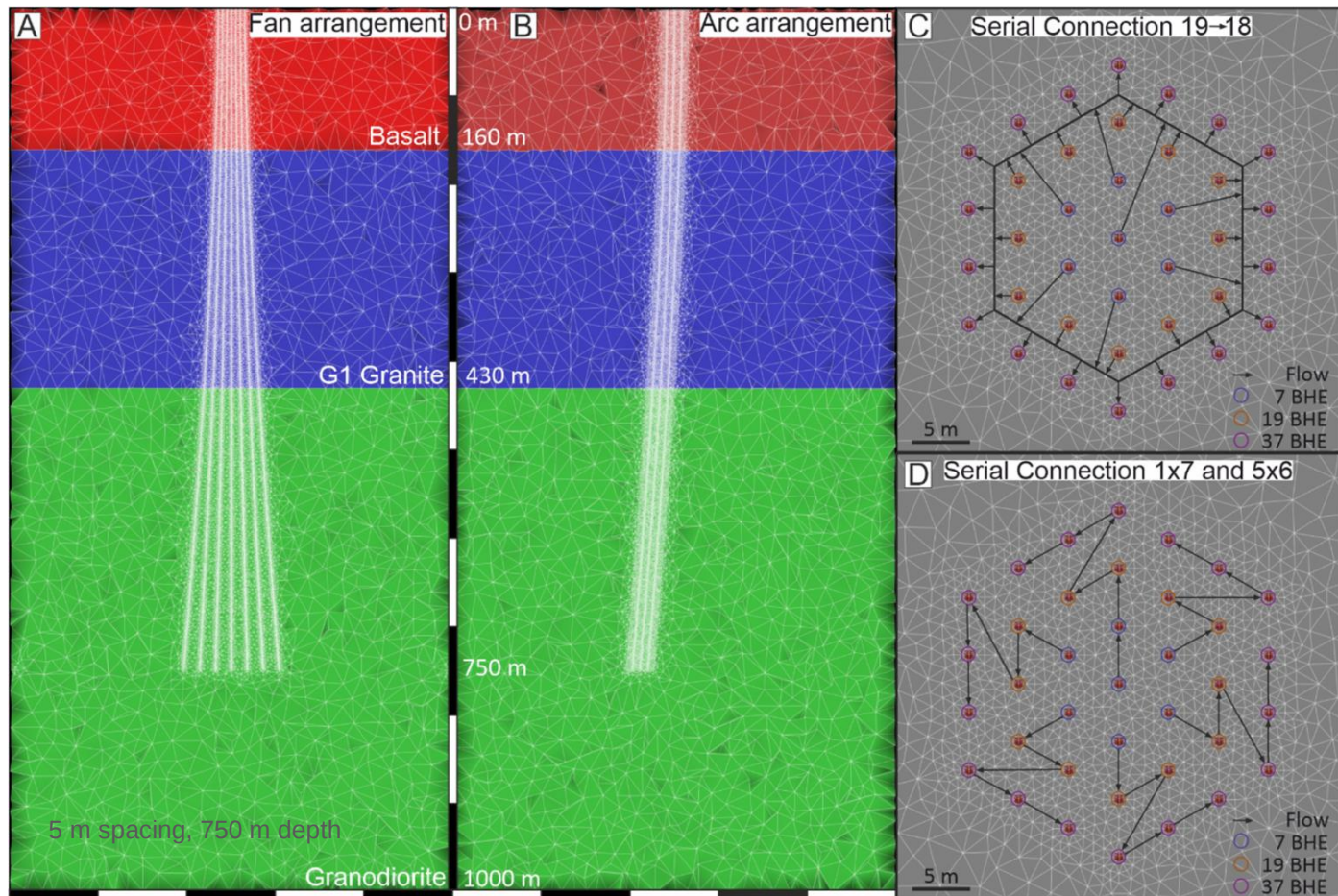
BTES Winter Operation – Heating



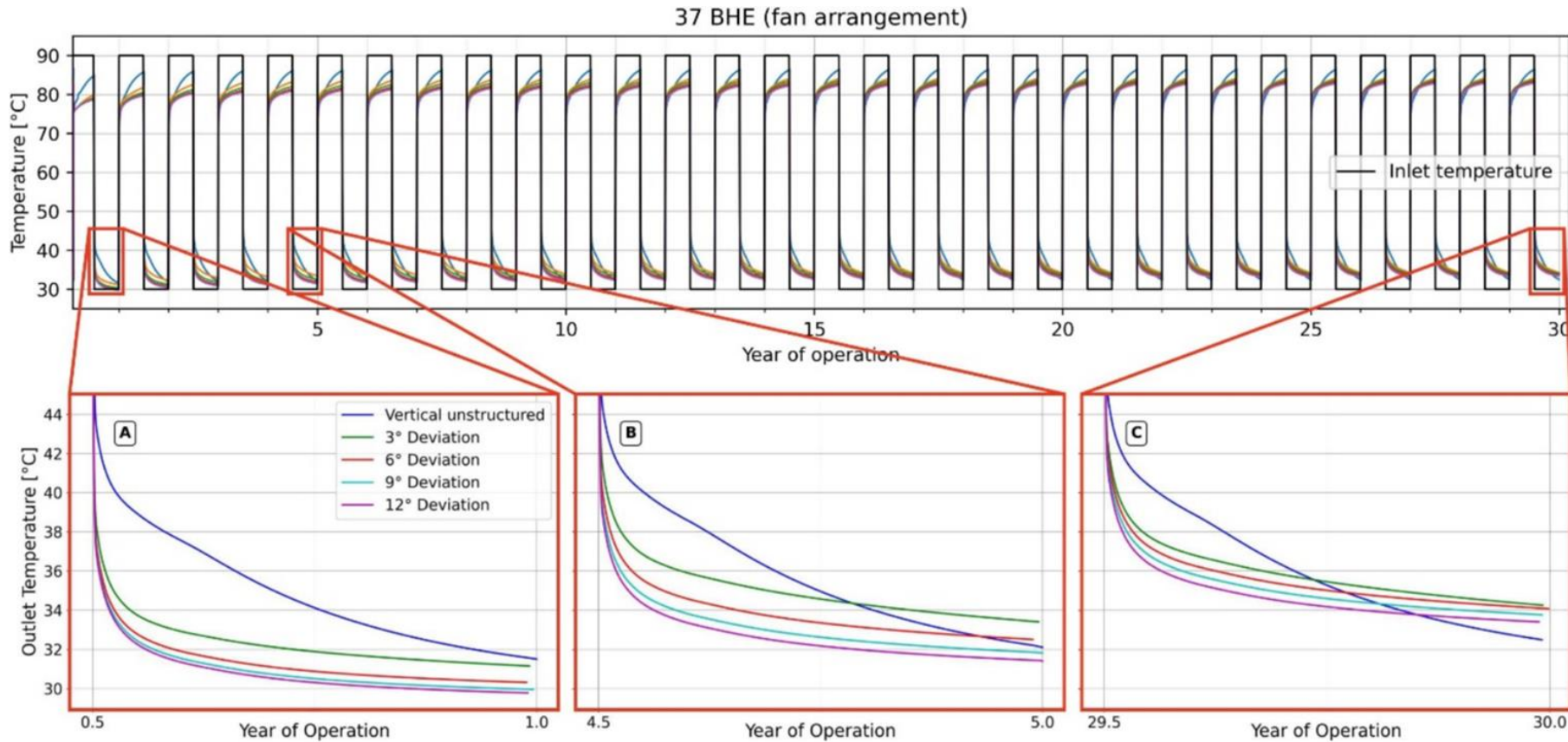
BTES



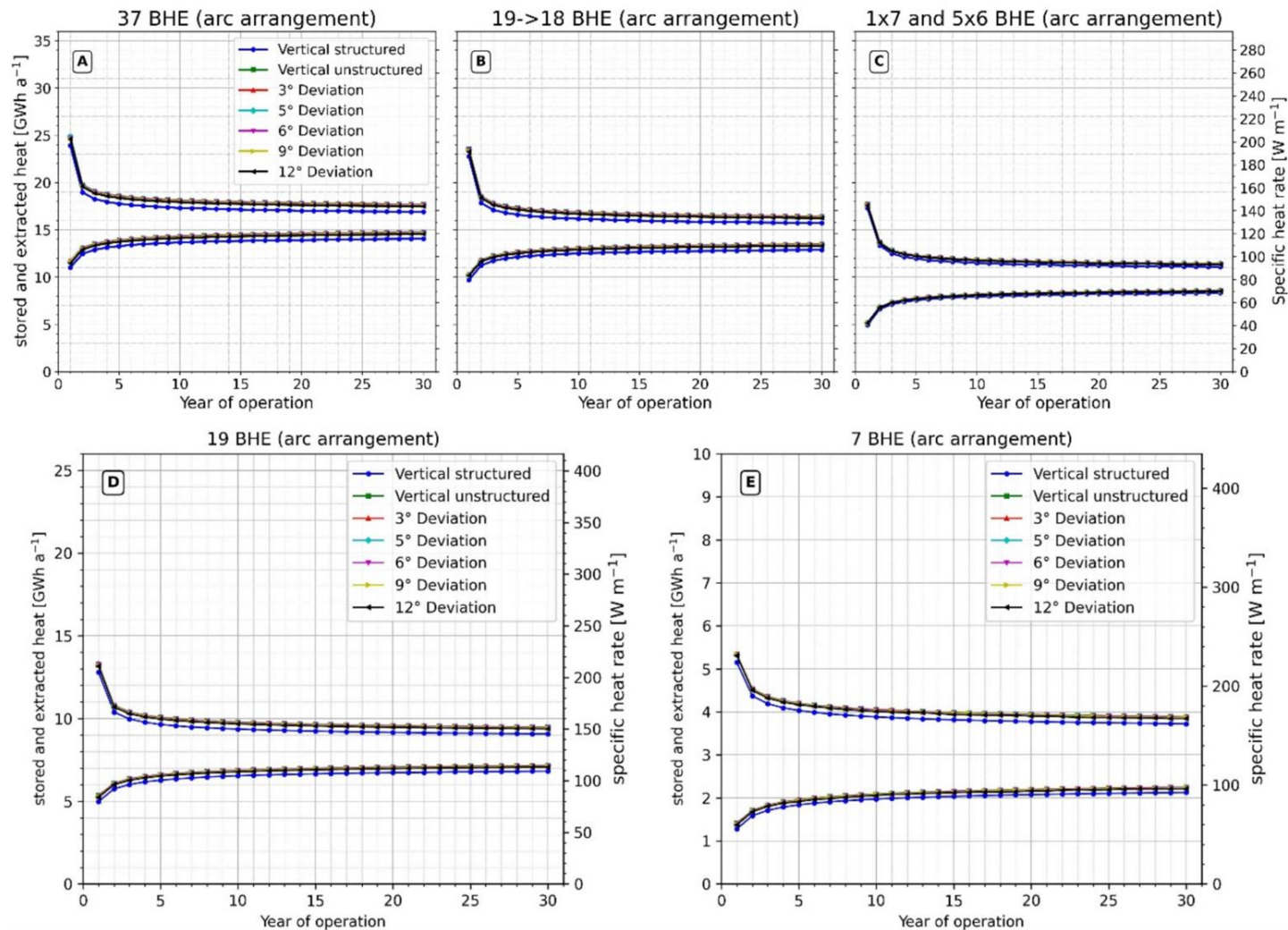
BTES



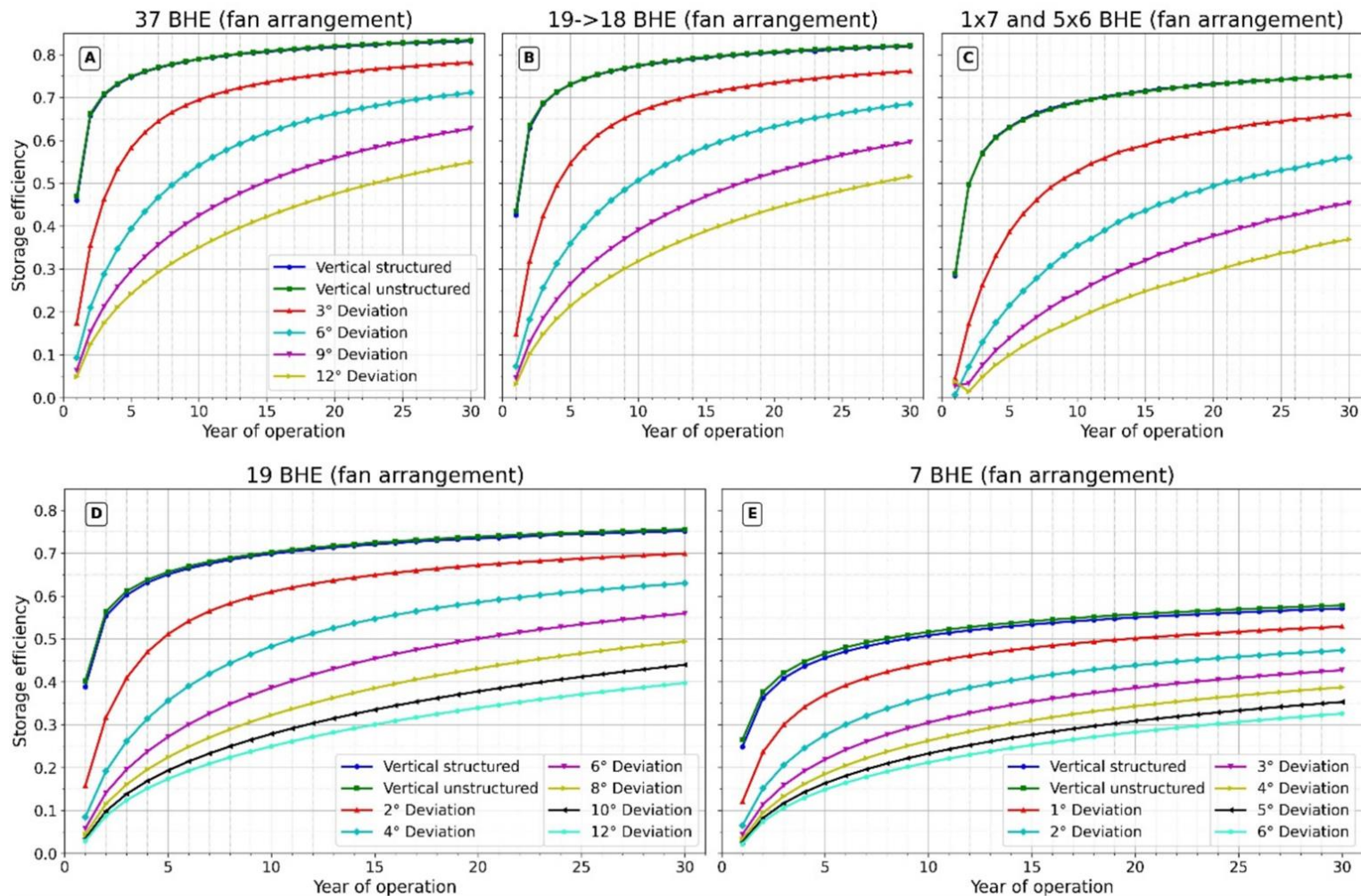
BTES



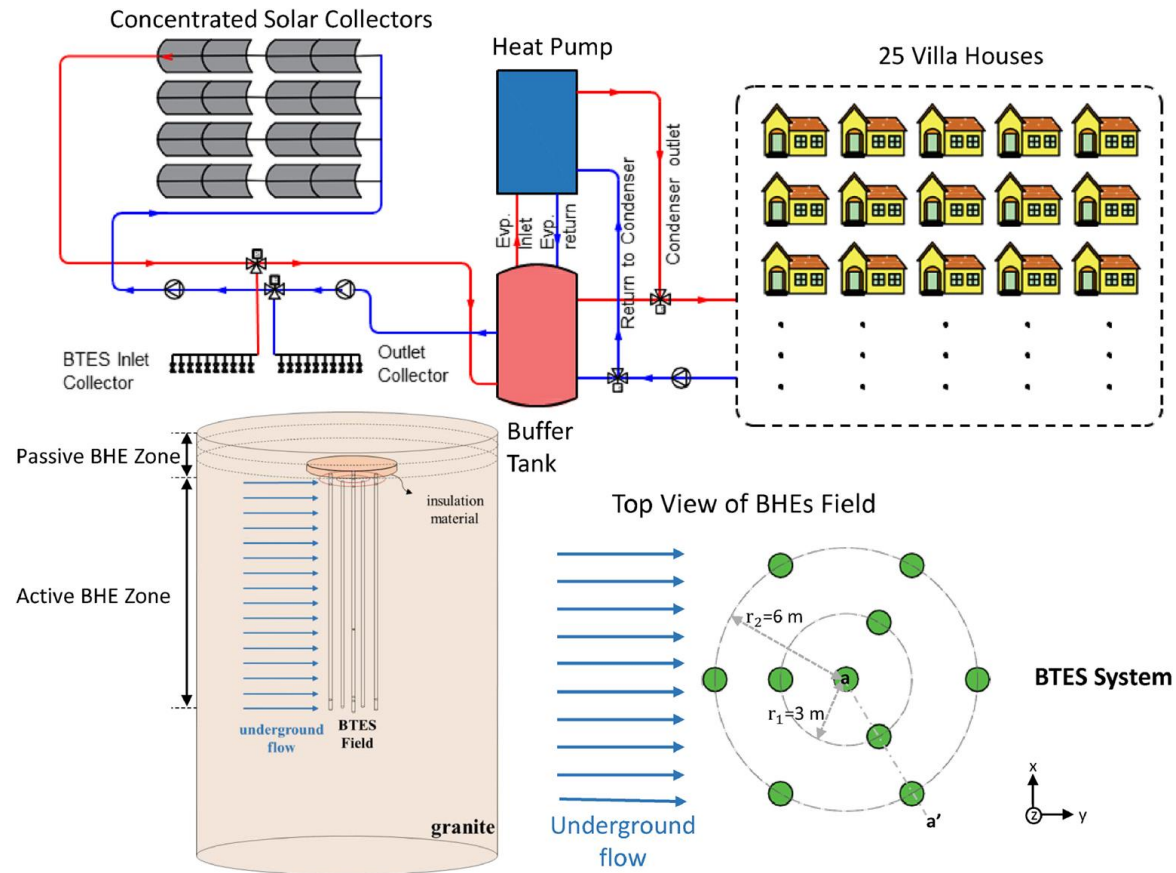
BTES



BTES



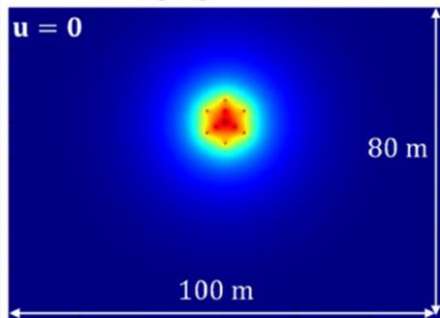
BTES a proudění



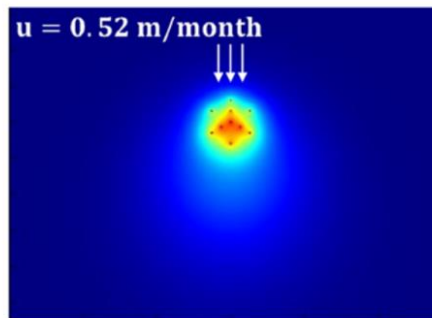
BTES a proudění

5th Year

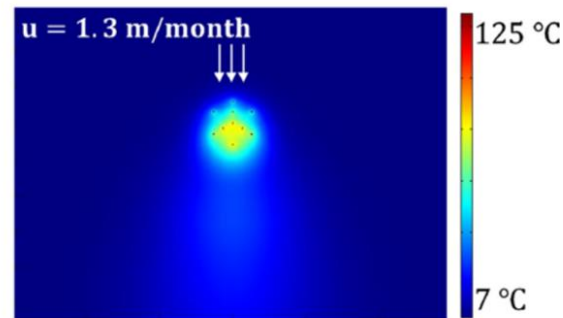
End of charging mode;



(g)

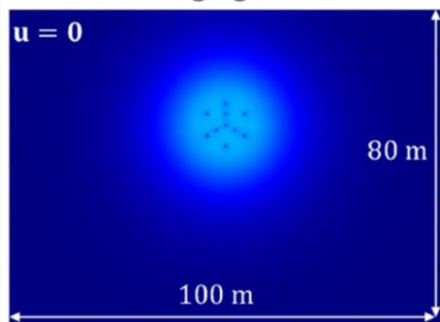


(h)

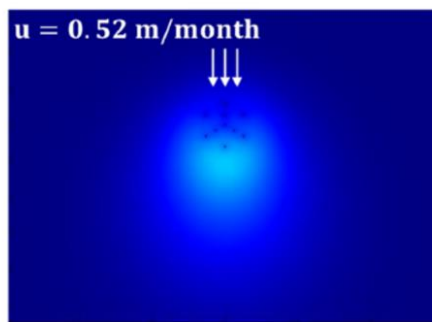


(i)

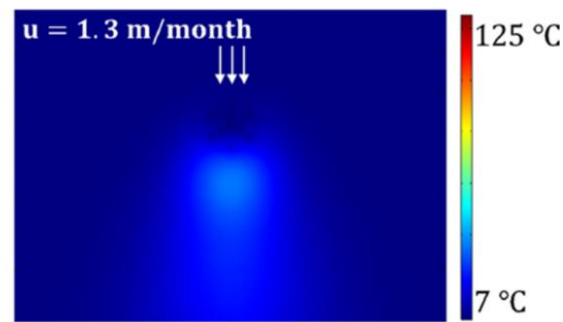
End of discharging mode;



(j)



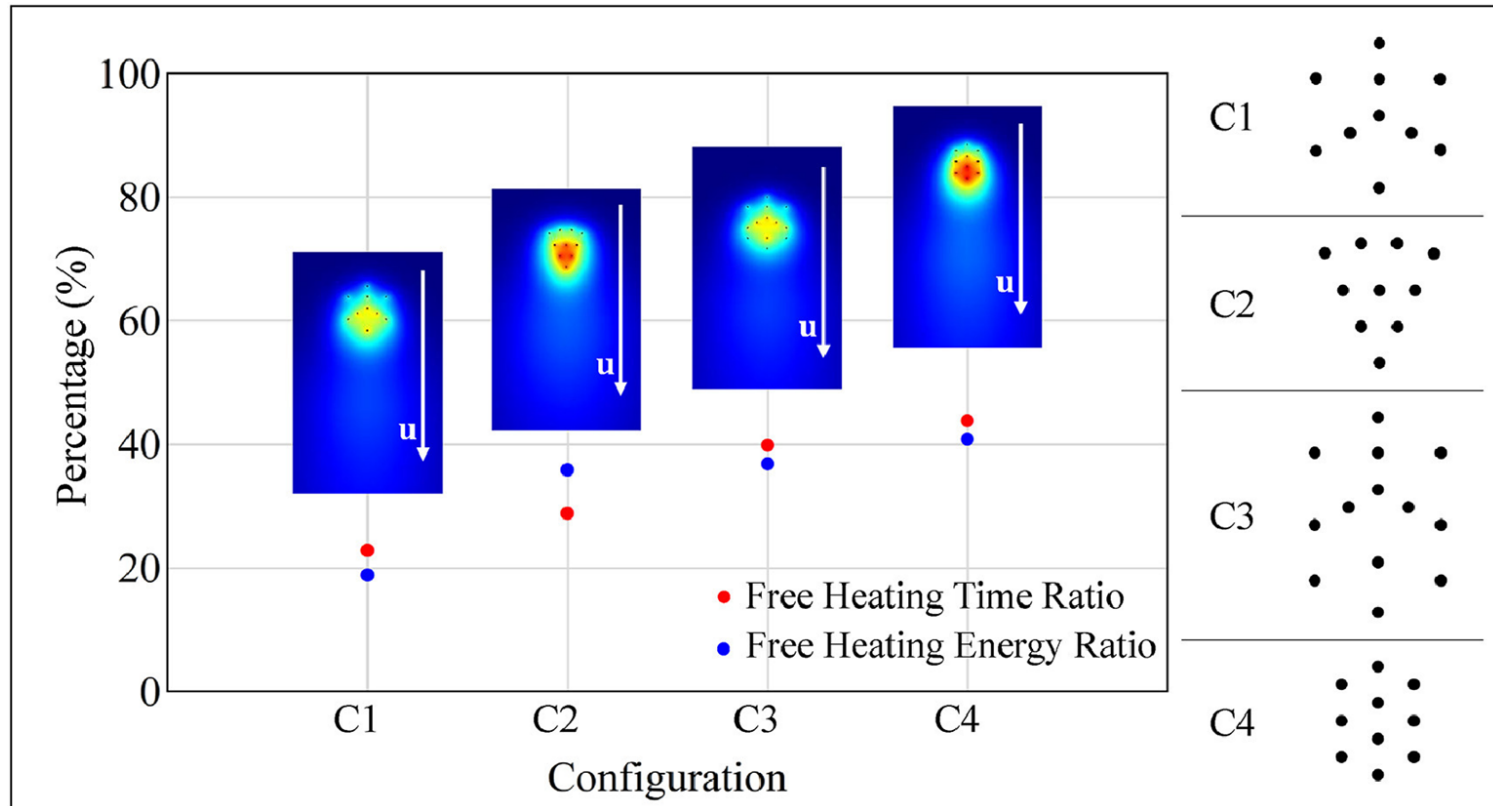
(k)



(l)

For porosity only 1%!

BTES a proudění



BTES nebo ATES?

krystalinikum

pomalé

velké (čím více, tím lépe)

nízká (dosah ovlivnění)

žádná

vertikalita/paralelita

nižší

klesá rychle

podmínky

nabíjení

počet vrtů~cena

environmentální rizika

provozní rizika

vrtná rizika

účinnost

T_{out}

sedimenty

rychlé

malé (min. 2)

kvalita podzemní vody

srážení

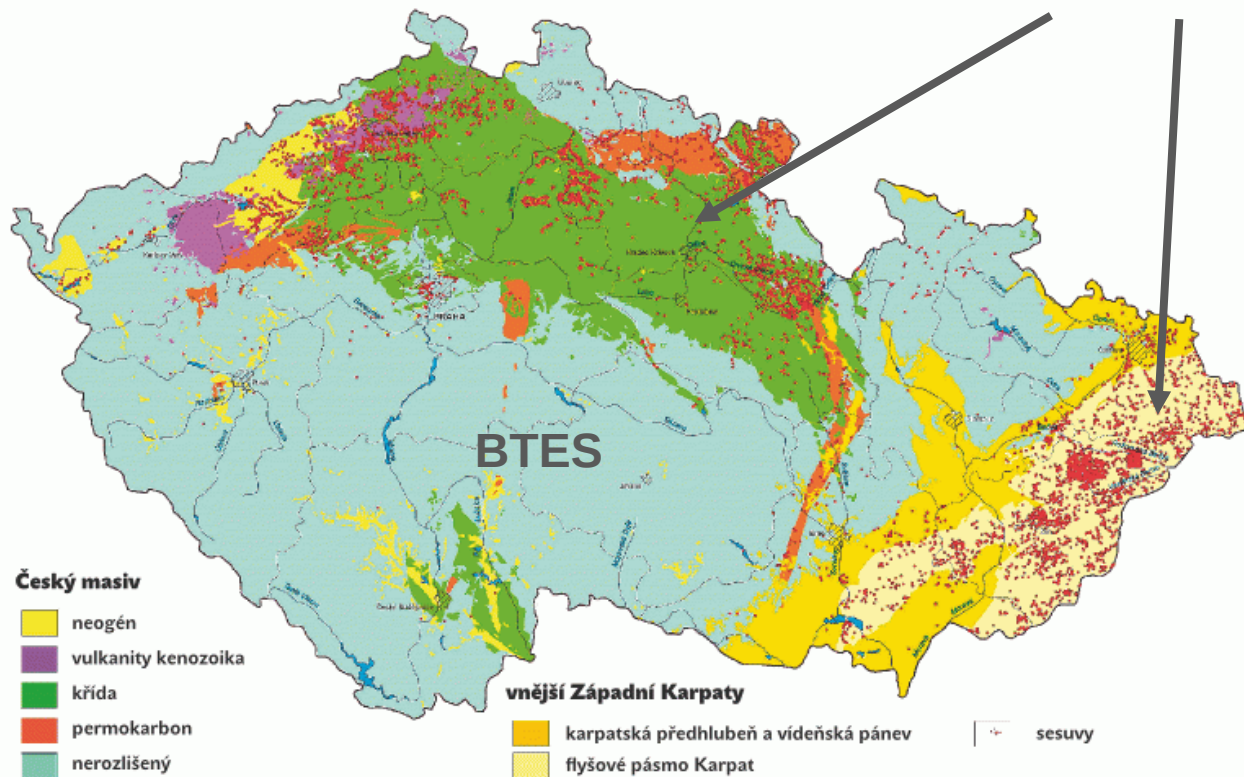
malá

vyšší

klesá pomaleji

BTES nebo ATES?

ATES



ATES - Germany overview

Stemmler et al. 2025

Site	Research project	TES type	Status	TRL ¹	Well depth [m]	Aquifer type	Number of wells	Flow rate [l/s]	Temperature —cold storage [°C]	Temperature —warm storage [°C]	Thermal capacity [MW]	Modeling software
Leipzig—Wissenschaftspark Mannheim ²	KONATES, SpeicherCity	HT-ATES	Test site	4–5	10–15	Sands and gravels	2	0.2	10	70	–	OpenGeoSys
	PotAMMO	HT-ATES	Feasibility	3	150	Quaternary, Upper Tertiary; porous aquifers possibly confined with consolidated and unconsolidated sediments	≥ 2	~55	~40	~90	~15	Petrel, FEFLOW, MOOSE, Dymola
Munich—greater area (German Molasse Basin) Offenbach ²	SpeicherCity	HT-ATES	Feasibility	2–3	2300–2800	Carbonate rocks	2	~100	95	140	~19.5	GOLEM/ MOOSE
	PotAMMO	HT-ATES	Feasibility	3	Up to 1000	Tertiary, Rotliegend; porous aquifers possibly confined with consolidated and unconsolidated sediments	≥ 2	~28	~40	80–120	~10	Dymola, FEFLOW, MOOSE, Petrel
Berlin—Adlershof	GEOFERN, SpeicherCity, GeoSpeicher Berlin, PUSH-IT	HT-ATES	Feasibility	3–4	410	Fine sands	1	~27–42	~20	95	~10	GOLEM/ MOOSE, PHREEQC, FEFLOW