

PARAMETRIC STUDY FOR THE LONG TERM ENERGETIC PERFORMANCE OF GEOTHERMAL ENERGY PILES

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07.11.2019 1st Nordic ZEB+, Trondheim A. Ferrantelli, J. Fadejev and J. Kurnitski - Parametric study for the long term energetic performance of geothermal energy piles

MOTIVATION:

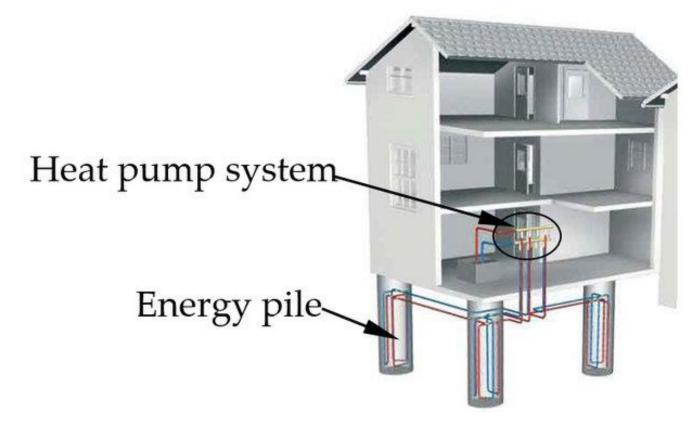
Energetic performance and renewable resources



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 Energy piles (GHE): U-shaped heat exchangers inserted inside the foundation piles of buildings.



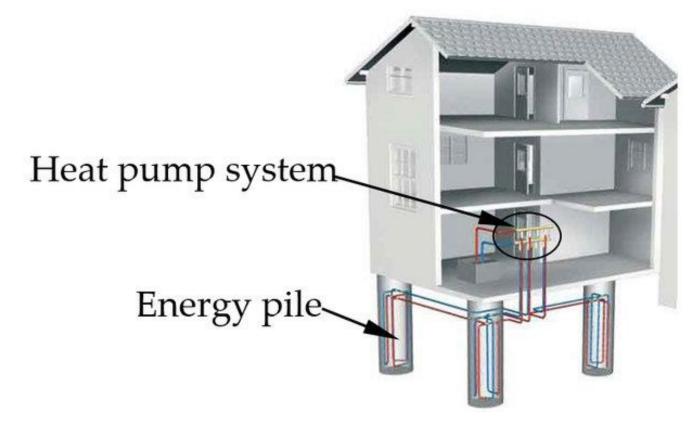
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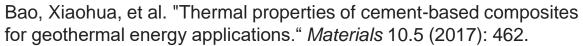


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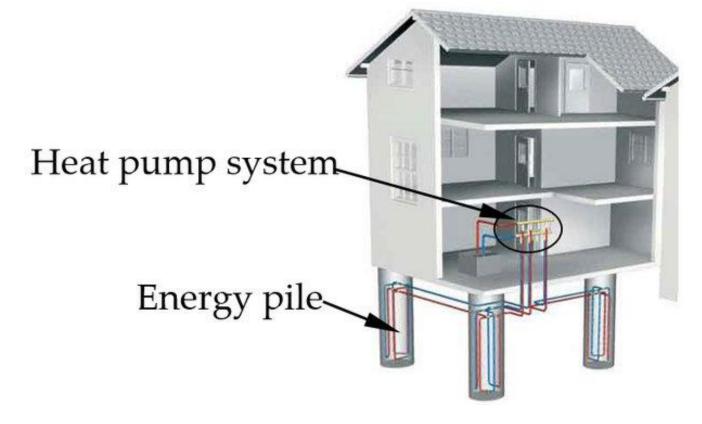




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- Energy piles (GHE): U-shaped heat exchangers inserted inside the foundation piles of buildings.
- Simulations often focus only on heat transfer in the <u>foundation</u> <u>soil</u>.
- A full parametric study <u>including</u>
 <u>the heat pump system above</u>.



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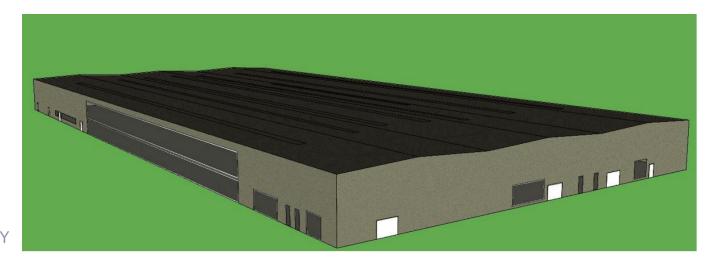


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■ IDA-ICE model for a commercial hall-type building in Finland (Helsinki climate data ~5000 HDD w. Tb=20C), validated in [1].

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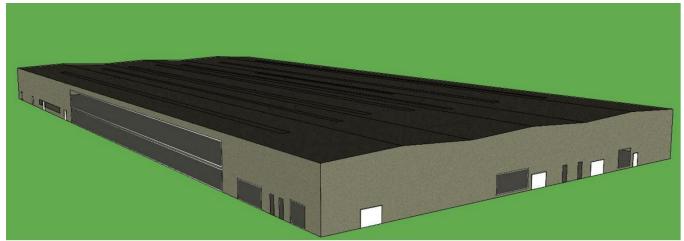


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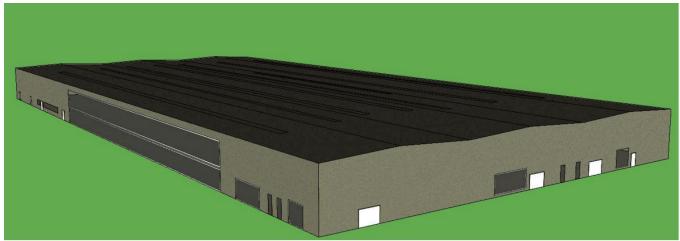


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- Simulations: 20 years. Many different building models depending on heat pump power, total length, specific heat extraction rate (W/m).
- Soil type: <u>clay</u>. No stratification, <u>no thermal storage</u>.

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<u>Technical parameters</u>:

Foundation piles: L=15m-30m

Design heat load: 360 kW.

Annual heating demand: 168 MWh.

Spacing: 6m, 4.5m, 3m.



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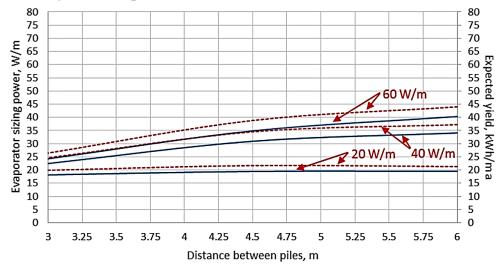
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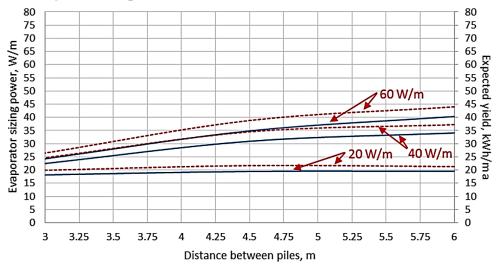
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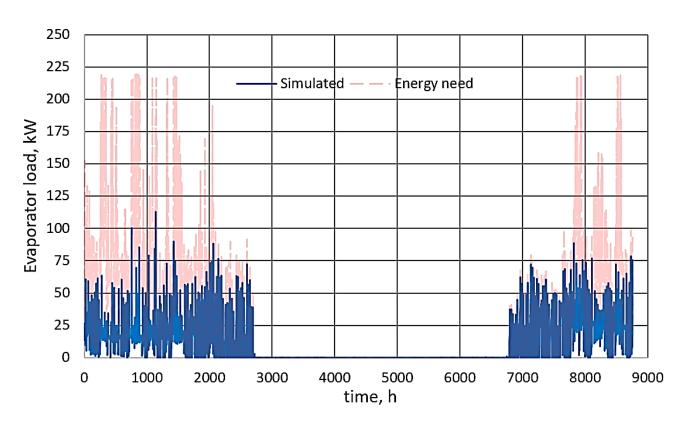
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TAL TECH

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Example: 200 W/m, 6m spacing, L=30m, Heat pump evaporator sized at ca 215 kW.



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			step 3m		step 4.5 m		${f step~6m}$	
			15m	$30 \mathrm{m}$	15m	$30 \mathrm{m}$	15m	$30 \mathrm{m}$
		evaporator sizing power, W/m	20	18	20	19		20
		yield, kWh/m	21	20	22	22	_	21
Initial heat	$20~\mathrm{W/m}$	ground area yield, kWh/m2a	34	62	14	27	- -	20
inclar frede		demand covered by the heat pump	97%	90%	97%	96%		97%
pump		evaporator sizing power, W/m	33	22	37	31	38	34
ovaporator		yield, kWh/m	37	25	41	35	41	37
evaporator	$40~\mathrm{W/m}$	ground area yield, kWh/m2a	57	77	26	43	19	35
Power		demand covered by the heat pump	83%	56%	92%	76%	94%	84%
		evaporator sizing power, W/m	38	24	47	35	50	40
[W/m]		yield, kWh/m	42	27	52	39	55	44
	$60 \mathrm{\ W/m}$	ground area yield, kWh/m2a	65	83	32	48	26	41
		demand covered by the heat pump	63%	40%	77%	57%	83%	66%



(Blank column: oversized system)

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DISCUSSION



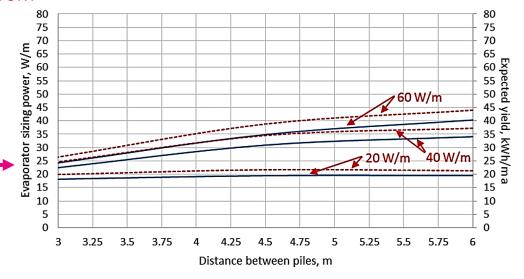
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Evaporator power (solid) and condenser yield (dashed), L=30m

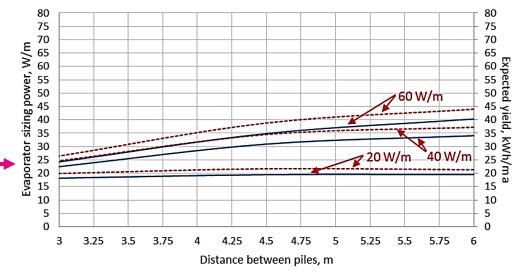




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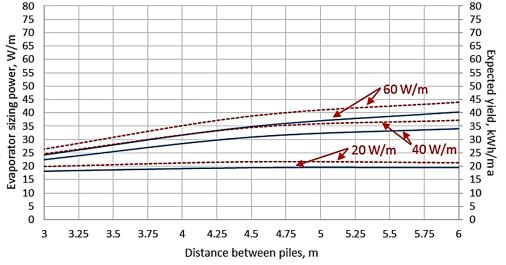


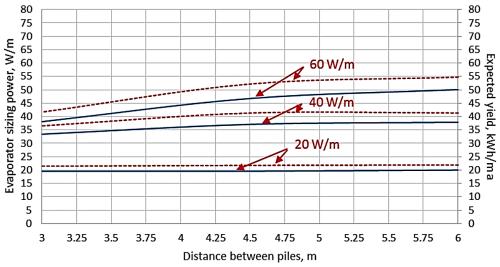


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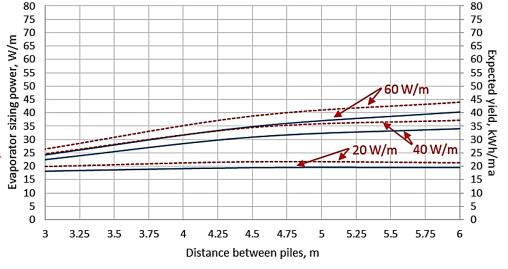


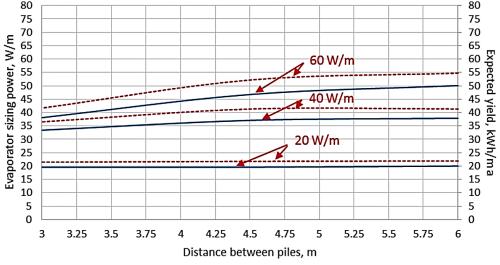
Evaporator power (solid) and condenser yield (dashed), L=15m

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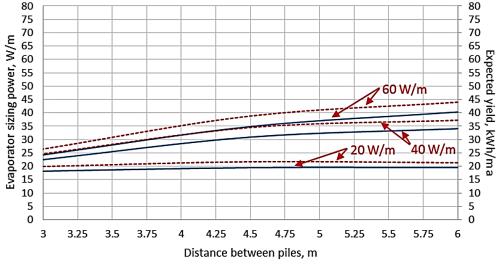


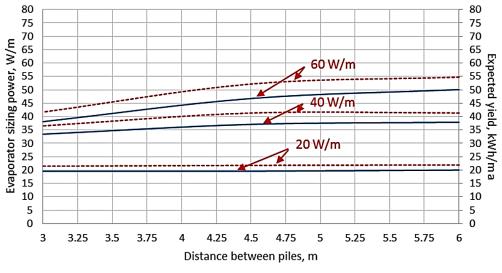
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- 5. Evaporator yield: 20<E<55 kWh/m per year.



Evaporator power (solid) and condenser yield (dashed), L=30m





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Preliminary sizing of the GHE system.

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ALL OF THE ABOVE IS WORK IN PROGRESS





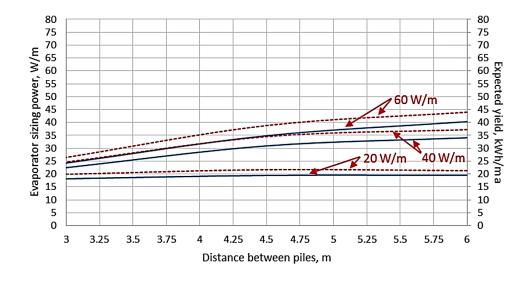
THANK YOU FOR YOUR ATTENTION!

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GEOTHERMAL PLANT SIZING GUIDE

- 1) Determine building design heat load and annual heating energy need: design heat load (design temperature -26°C) Q = 360 kW, annual energy need $E \sim 183$ MWh).
- 2) Size the heat pump evaporator: 180 kW for heat pump condenser, evaporator as Qevap = 140 kW.
- 3) Estimate total pile field length and condenser yield: assume 30m long piles, then <u>simulation results</u> give the specific yield per unit length E/L [kWh/m]. For 60 W/m we obtain 103 MWh for 6m pile step. 103 MWh<168 MWh (demand) -> <u>more piles or thermal storage</u>.





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