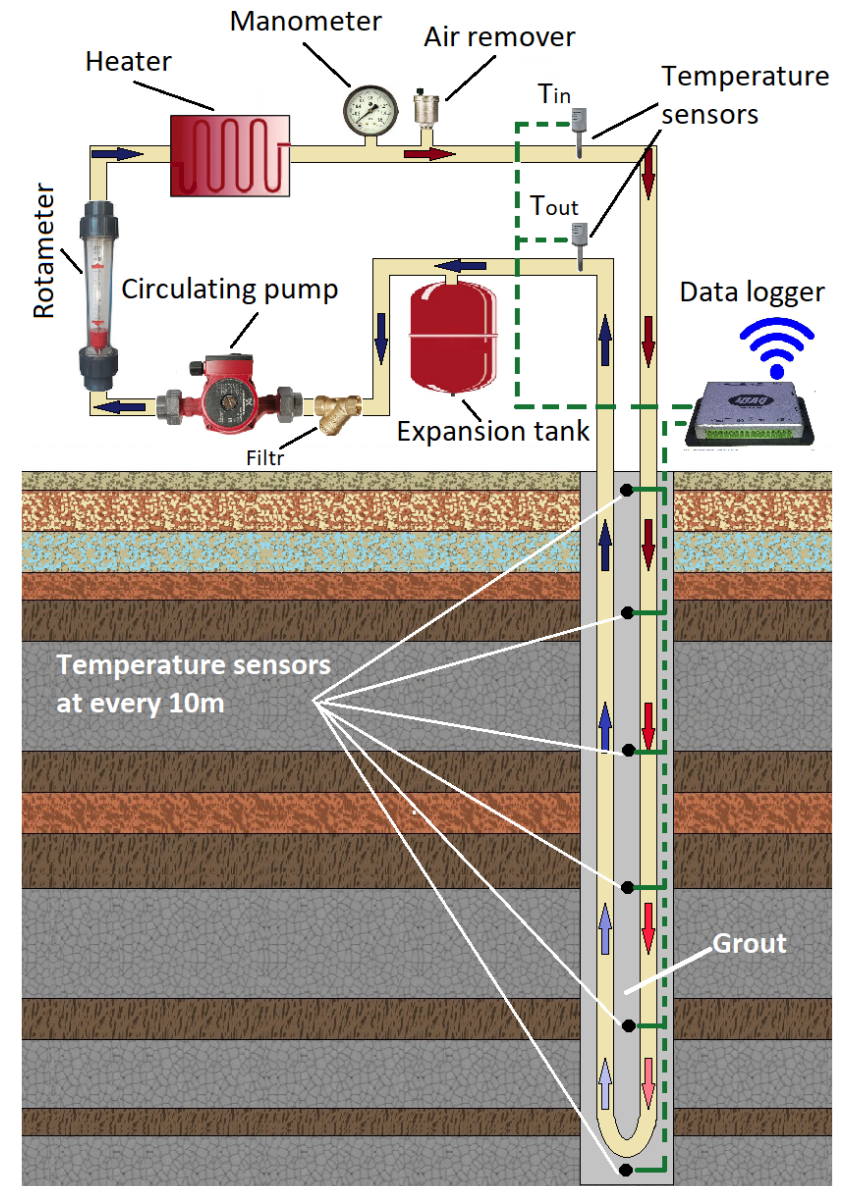


Ground source heat pump based heating system: a case study in Kazakhstan

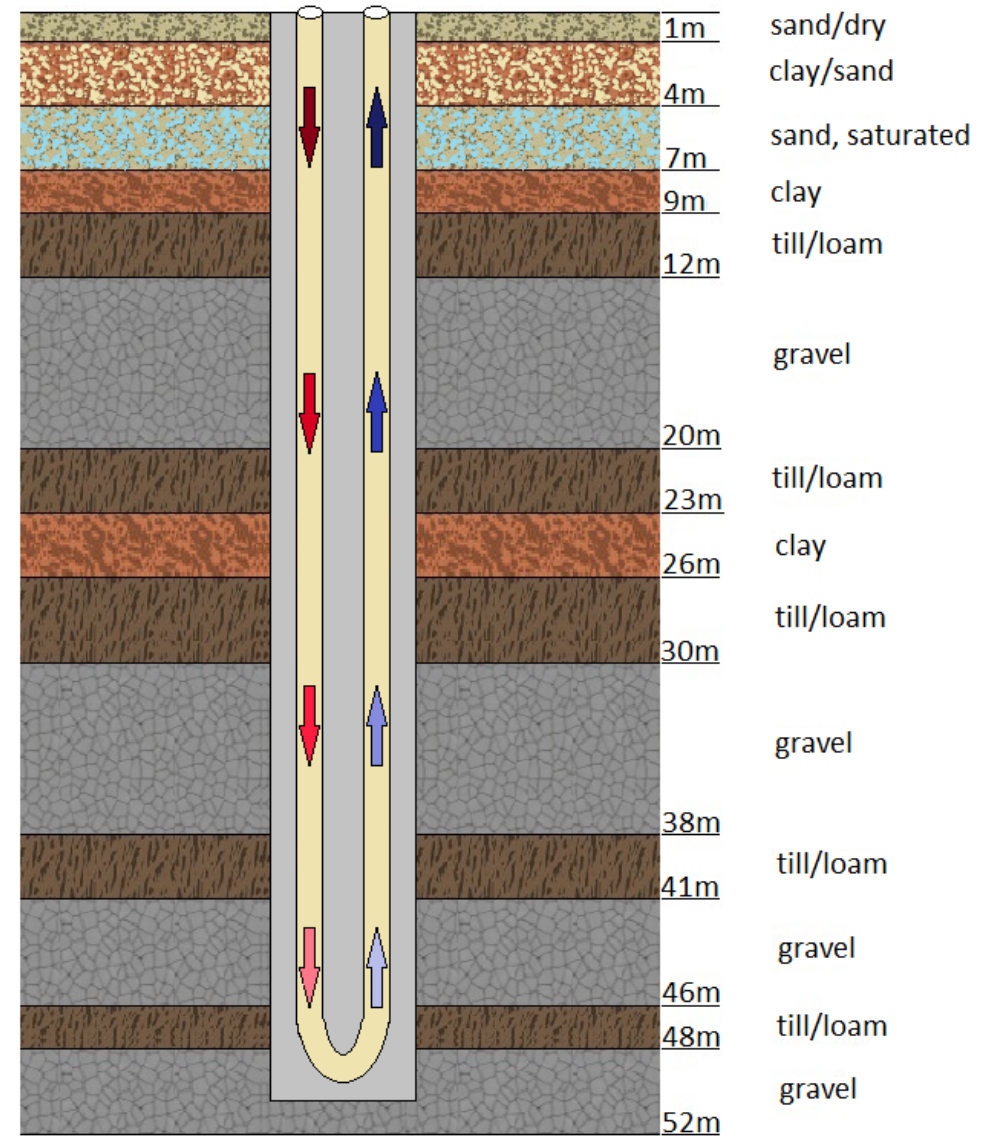
Thermal response test

- To measure the thermal conductivity of the soil.
- To measure the thermal resistance between the soil and heat transfer fluid circulating in borehole heat exchanger.

Thermal response test



Geologic structure defined during the drilling



Stratigraphic map of the area of Koksai Mosque

STRATIGRAPHIC COLUMN

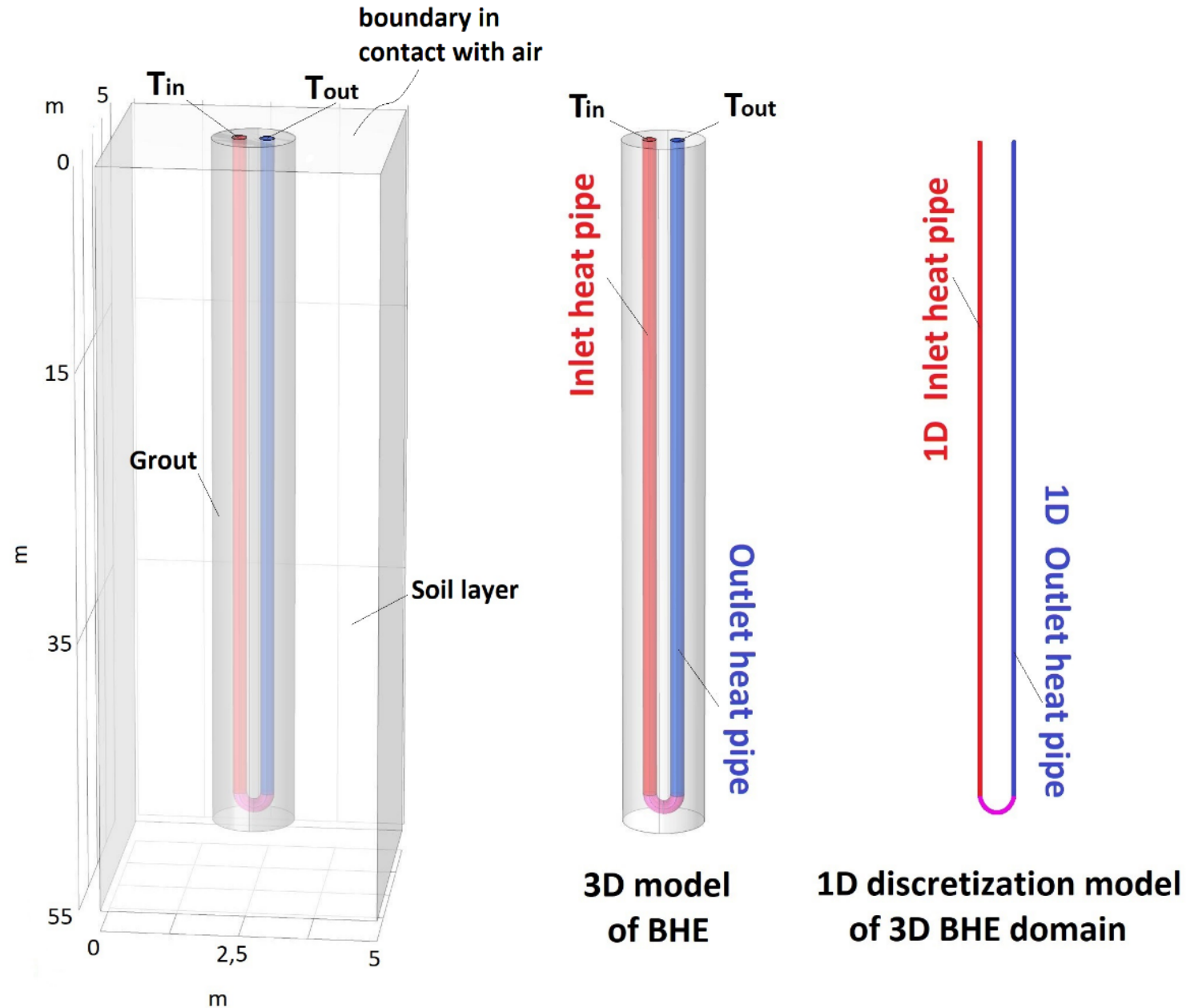
GROUP SUBGROUP SYSTEM	Department	TIER	INDEX	Formation thickness, m	CHARACTERISTICS OF ROCKS
QUATER- NARY			Q_{III-IV}	180	boulders, pebble, gravel, sand, sandy loam and till/loam
			Q_{II}	200	boulder-pebbles, sand, loess loam, gravel
			Q_I	30-230	boulder-pebbles, sand, loess loam
			N_2^{2-3}/I	440-900	Middle-Upper Pliocene. Ili retinue. Pale clays, silts, sands, gravelstones, sand-pebbles
NEOGENE	PLIO- CENE		N_1	400-1080	Red-brown mudstones with interlayers of green-gray, rubble
PA- LEO- GENE			Pg	720	Silts, red-brown mudstones with green-gray interlayers, rubble
CARBONIFEROUS	LOWER	NA- MUR	$C_{IV2+3-n}$	900-1200	Liparitic and dacitic porphyries, tuff lavas, tuffs, porphyrites, interbeds of tuff sandstones
		VISEAN			
		TOUR- NAI- SIAN	$C_{I1}-v_1kt$	820-1200	Katmen suite. Andesitic, andesite-basaltic porphyrites, their tuffs, dacitic porphyries and their tuffs, conglomerates, sandstones with <i>Caenodendron primaevum</i> Z a l., <i>Lepidodendron</i> cf. <i>obovatum</i> Sternb., <i>Asterocalamites serobiculatus</i> (Schloth.) Zeil.
DEVONIAN	UP- PER		$D_3^{?tr}$	420-670	Torsu suite. Interbedding of siltstones, sandstones and conglomerates
	LOWER AND MIDDLE		D_{1+2}^{*K5}	400-490	Kastek retinue. Liparite porphyries, sandstones with <i>Taeniocrada decheniana</i> (Goepp) Kr. et W., <i>Protilepidodendron</i> sp.
			D_{1+2}^{sg2}	200-530	Suganda Formation, upper subformation. Andesitic, basaltic, less often diabase porphyrites, conglomerates with cem. <i>Drepanophycaceae</i>
			D_{1+2}^{sg1}	300-650	Suganda Formation. Lower undersuit. Liparitic, dacitic porphyries, andesitic porphyrites, conglomerates with sem. <i>Drepanophycaceae</i>
ORDOVICIAN	MEDIUM		O_2	до 1650	Tuffs, tuff breccias, basic and intermediate effusives, sandstones with <i>Basilicus</i> cf. <i>tyrannus</i> (Murchison) and <i>Isotelus romanovskiy</i> Web. and shales with limestone interlayers with <i>Isoteloides homalnotoides</i> (Walcott), <i>Basilicus</i> sp.
	LOWER	AREN- IGSKY	O_{1ar}	250-1250	Sericite-chlorite schists with sandstone interlayers and limestone lenses in the upper part with <i>Taihungshania</i> sp., <i>Protopliomerops</i> sp. и <i>Megalaspis saltaensis</i> (Kausar)
CAMBRIAN	UP- PER		Cm_3-O_1	90-500	Shales, sandstones, tuff conglomerates with limestone lenses in the upper part with <i>Iphidella</i> aff. <i>pannula</i> Troed., <i>Acrocephalina armata</i> Troed., <i>Euloma</i> sp.
	LOWER AND MIDDLE				
			Cm_{1+2}^{*Kp2}	1700	Kapkatas Formation, middle subformation. Coarse, -medium, -fine-grained sandstones and shales with rare gravel interlayers
			Cm_{1+2}^{*Kp1}	300	Kapkatas Formation, lower subformation. Spilites, diabases, porphyrites interbedded with shales and siltstones

The map was compiled by the South Kazakhstan Geological Administration together with the Geology Administration of the Kirghiz SSR
Authors: N.M. Chabdarov, O. V. Bazhanov, Yu. V. Zhukov, R.M. Israeli
Editor V.F. Bespalov

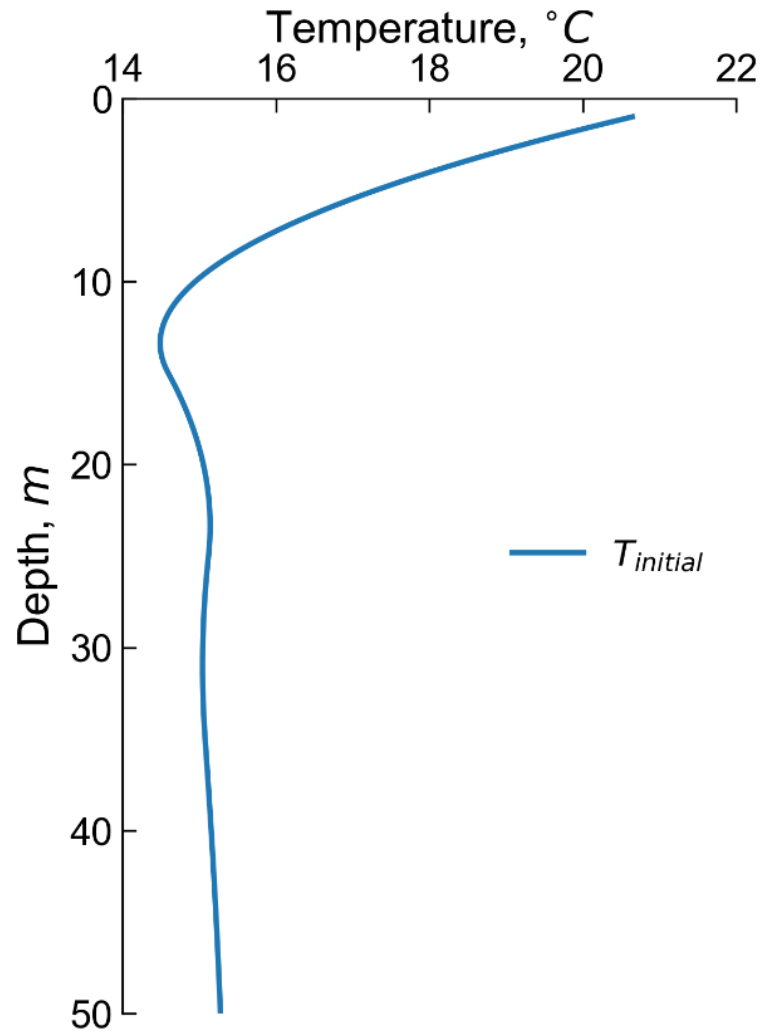
The map was approved by the Scientific and Technical Council of the South Kazakhstan Geological Administration on December 22, 1967.

The map was approved by the Scientific and Editorial Council of the Ministry of Geology of the Kazakh SSR on December 26, 1967.
Designed and printed at the Leningrad Mapping Factory of the Association "Aerogeology"
Design editors: cartographer I.S. Medvedovsky, geologist M.B. Leikin.
Technical editor V.M. Yakushev
Order 05222. Circulation 200 copies. Signed for print 20/XI in 1973

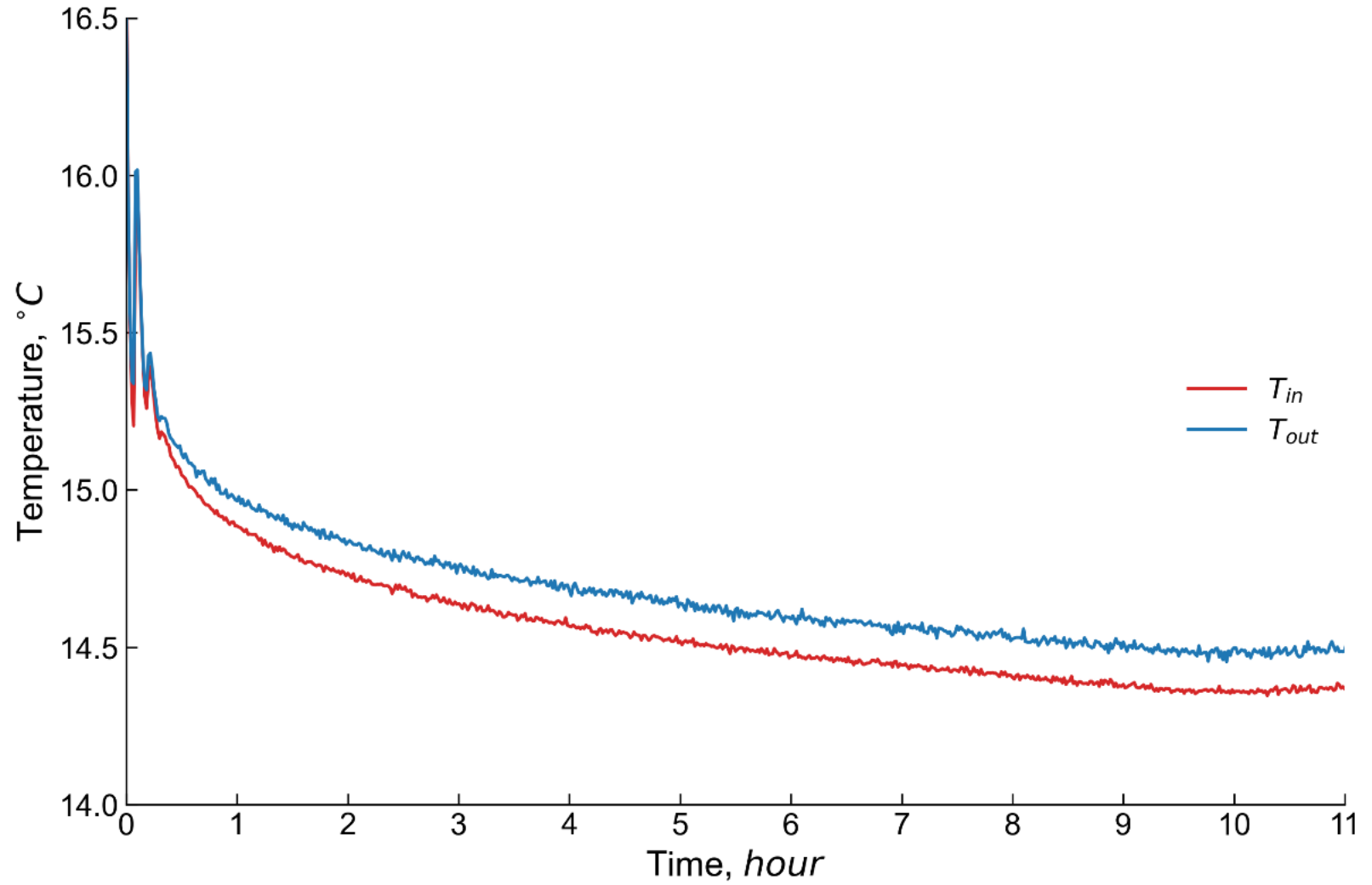
Computational domain of the borehole heat exchanger



Experimental results

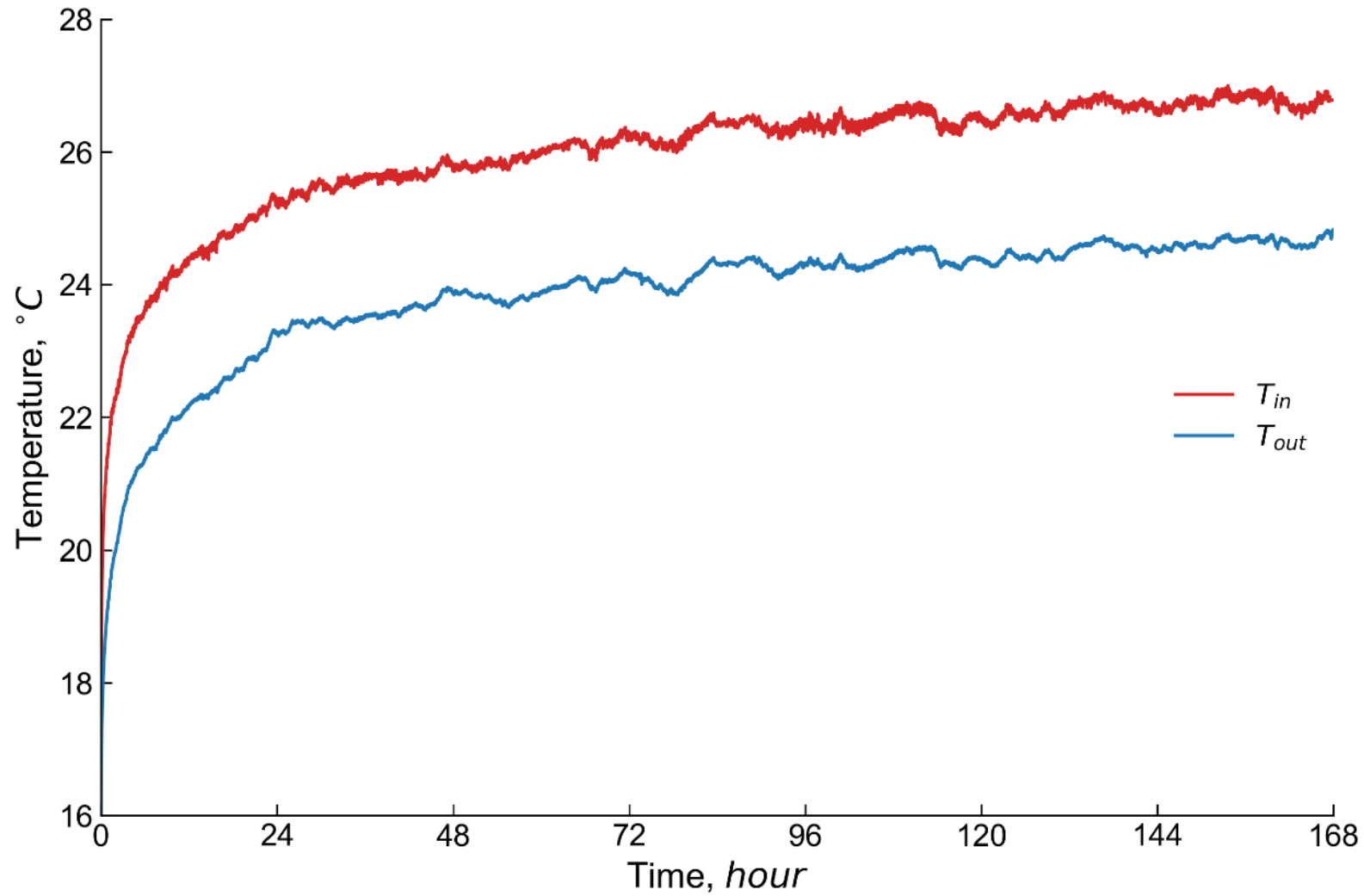


Undisturbed initial temperature of the ground



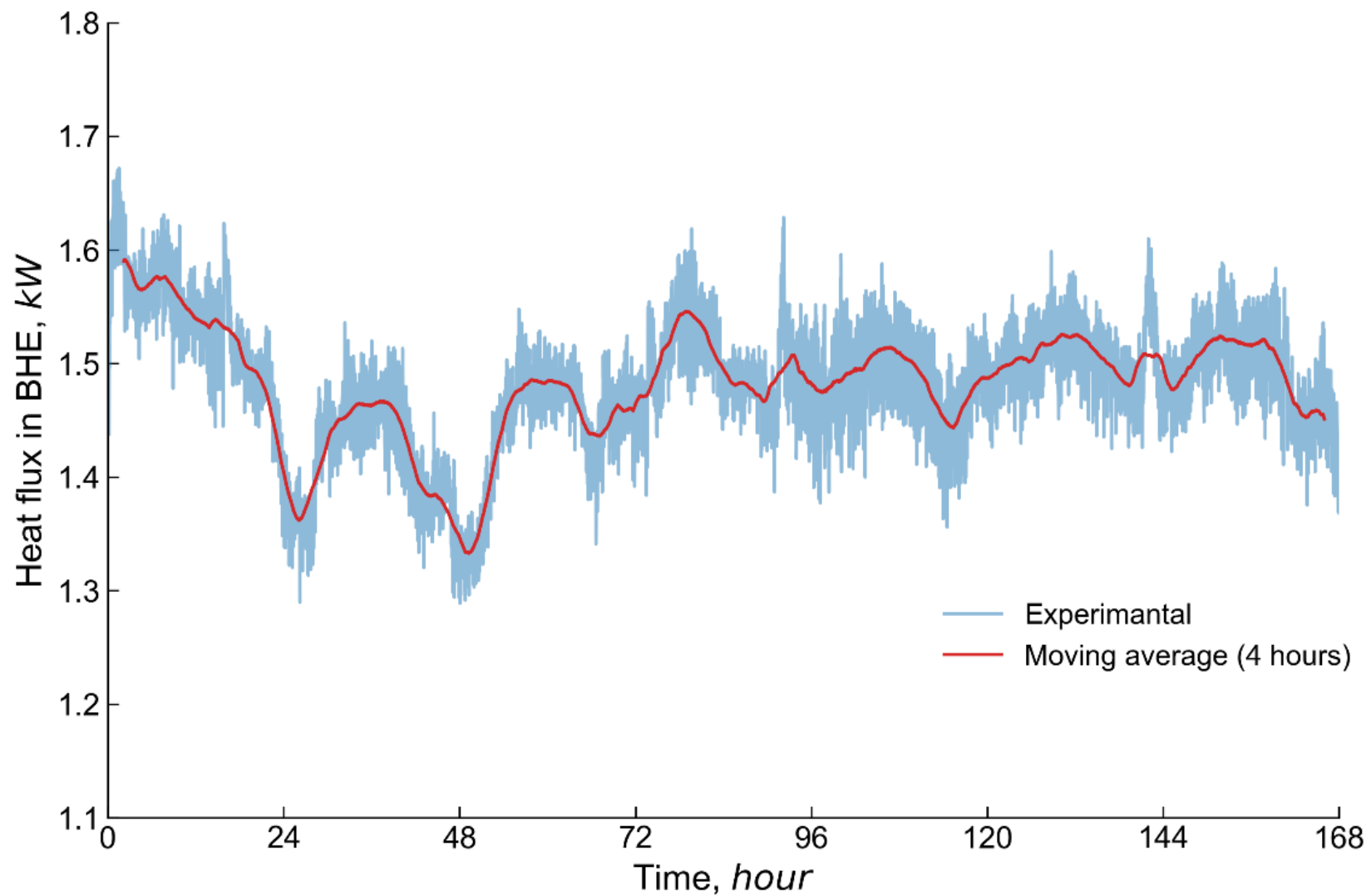
Undisturbed reference temperature of the ground

Experimental results



Temperature variation at the inlet and outlet part of BHE

Experimental results

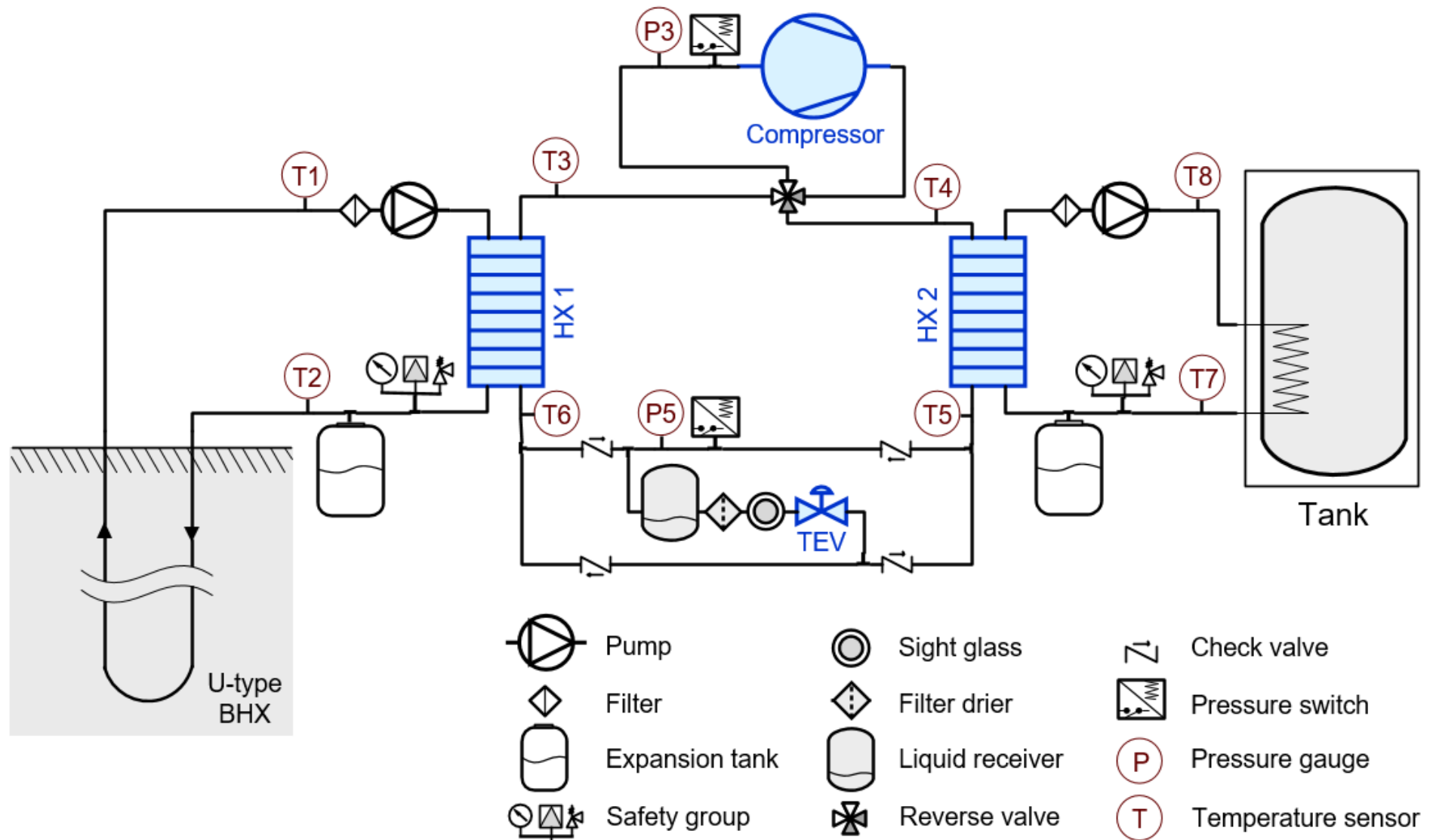


Energy performance of BHE

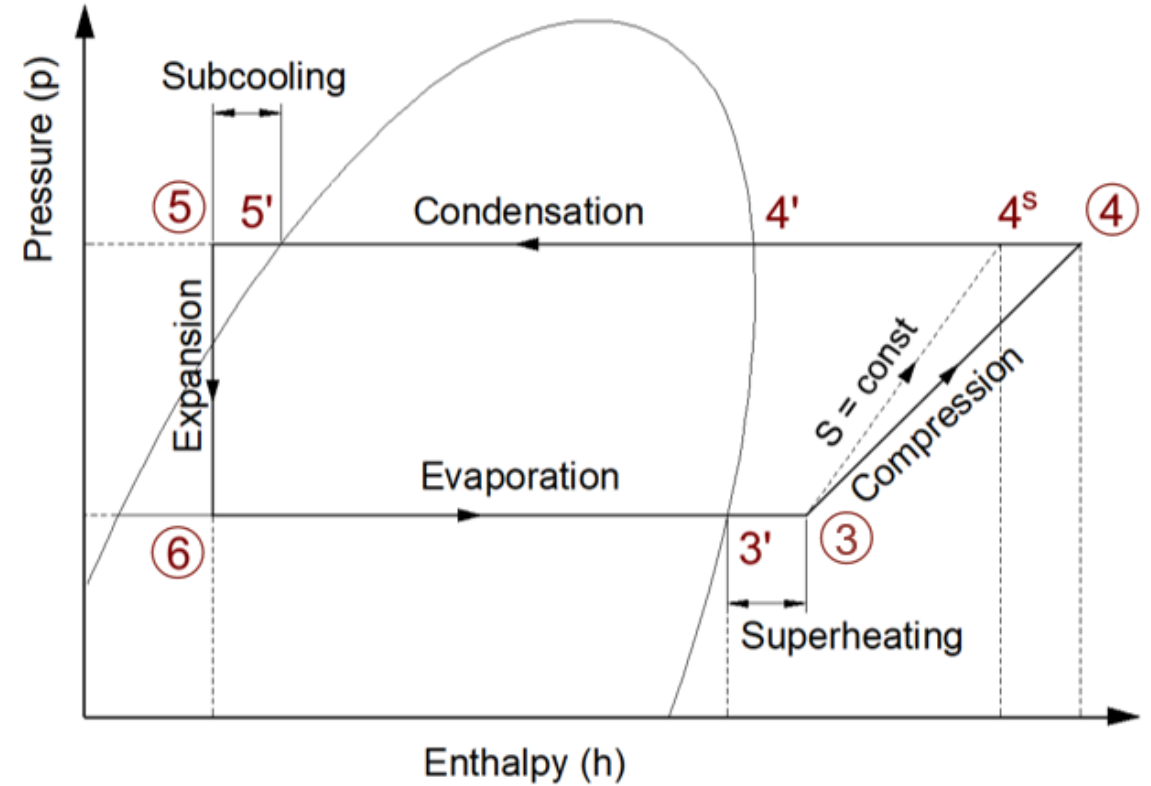
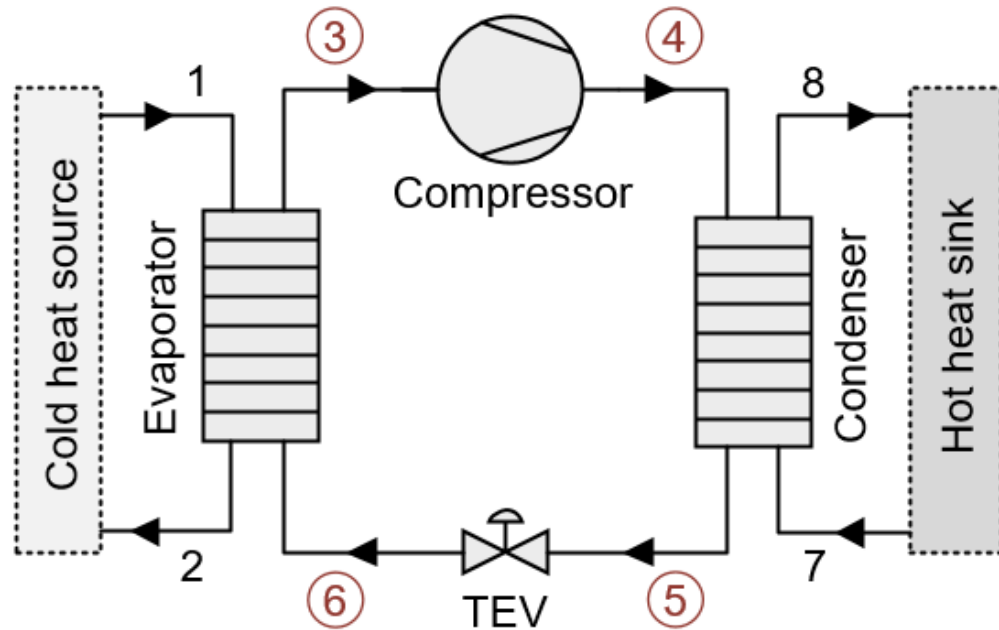
Experimental investigation of the heating system based on ground source heat pump

- Installation of the borehole heat exchanger.
- Installation of the heating system.
- Test the performance.

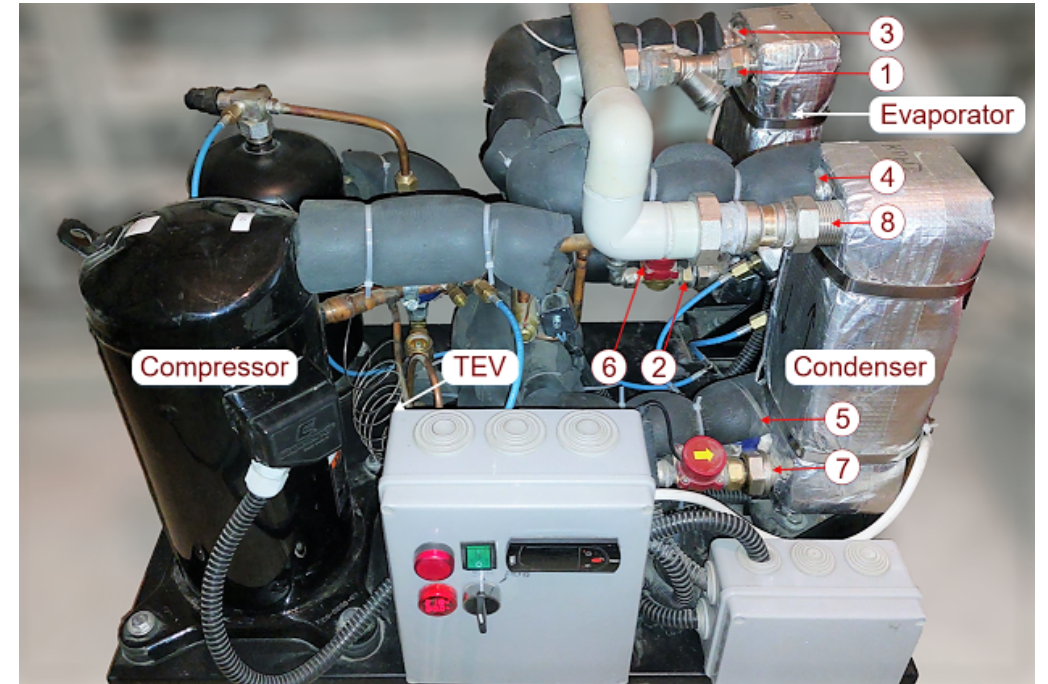
Schematic of the heating system



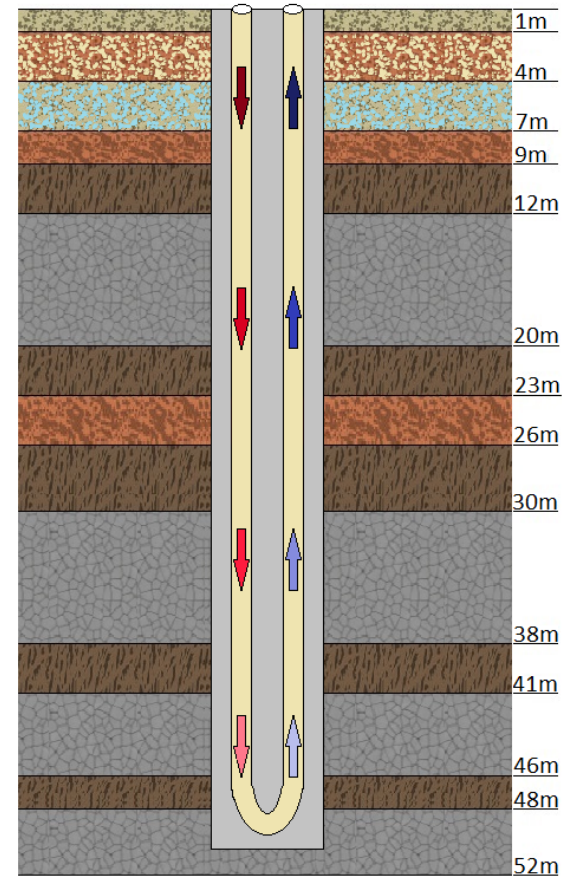
P - h diagram of the heat pump cycle



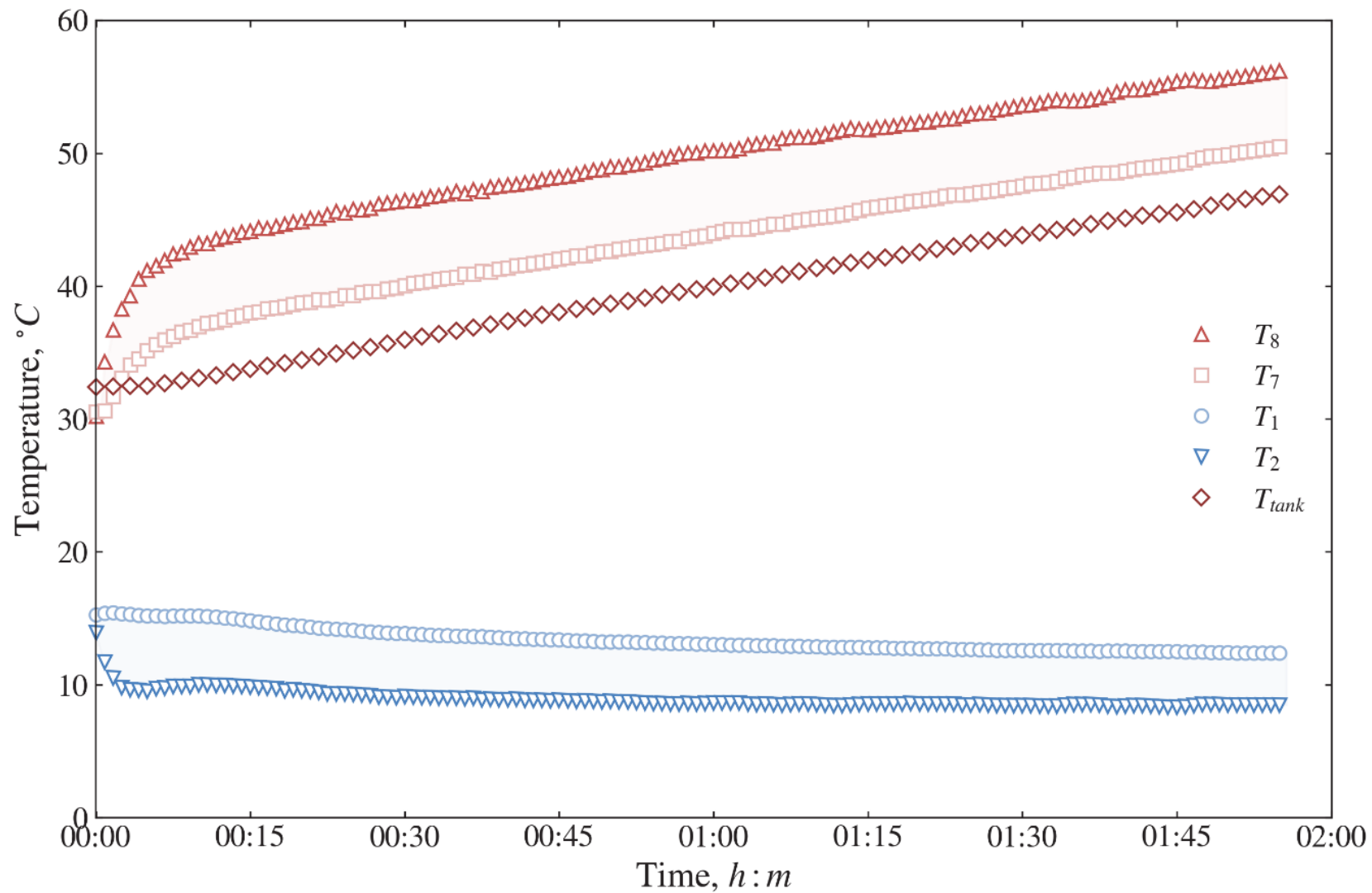
Photos of the system



Installation of borehole heat exchanger

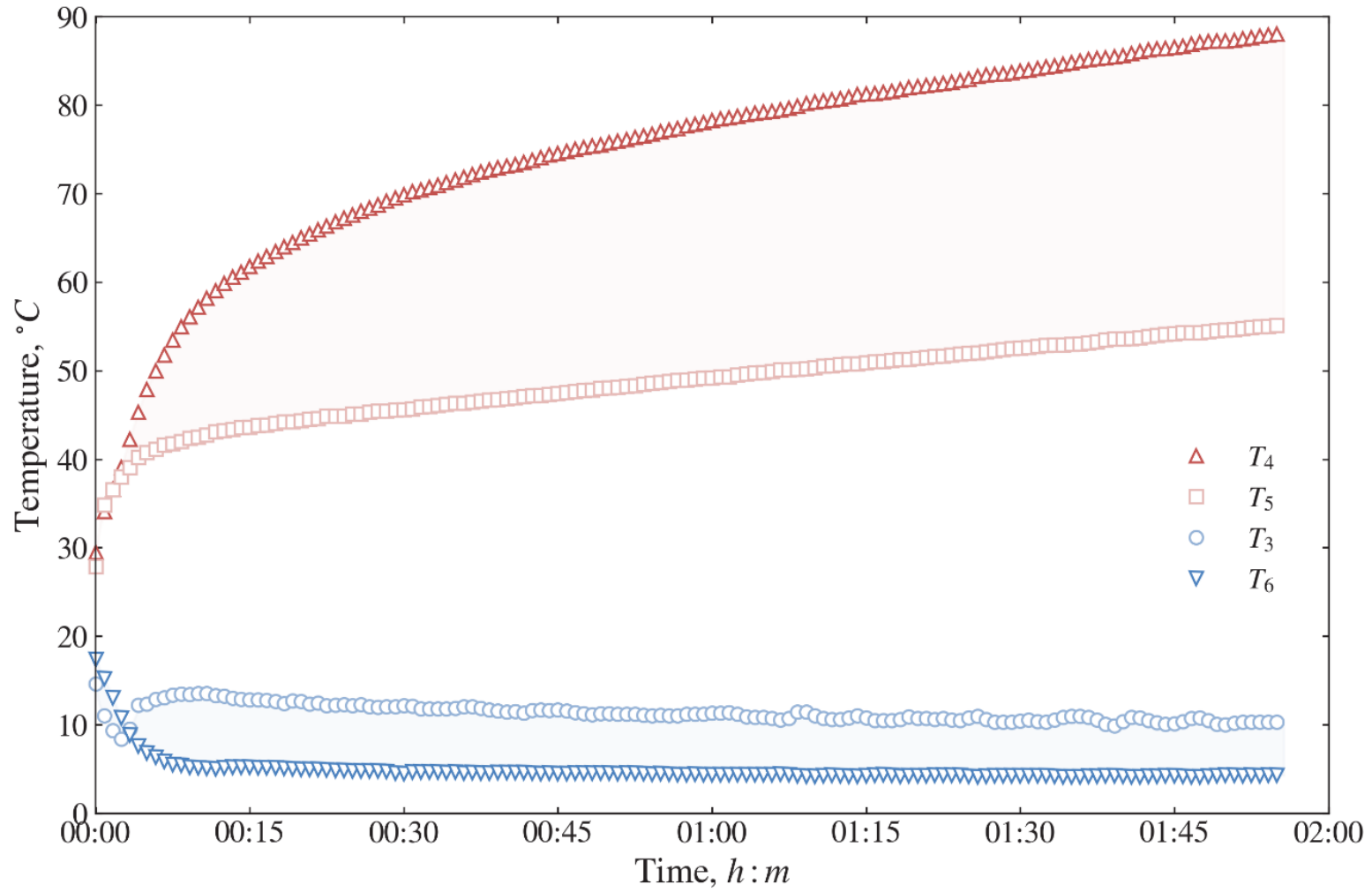


Experimental results



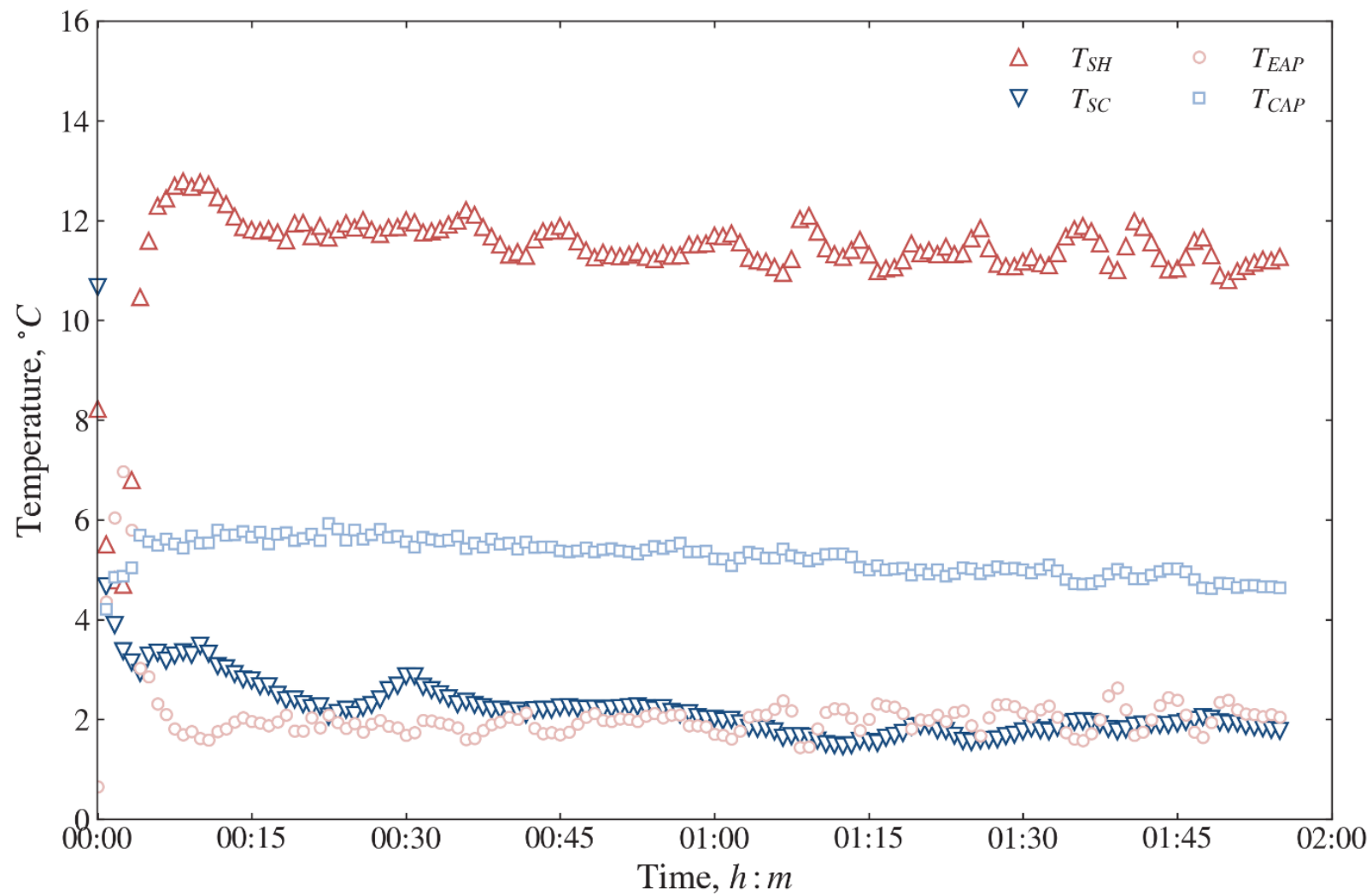
Temperature measurements for the heat transfer fluid

Experimental results



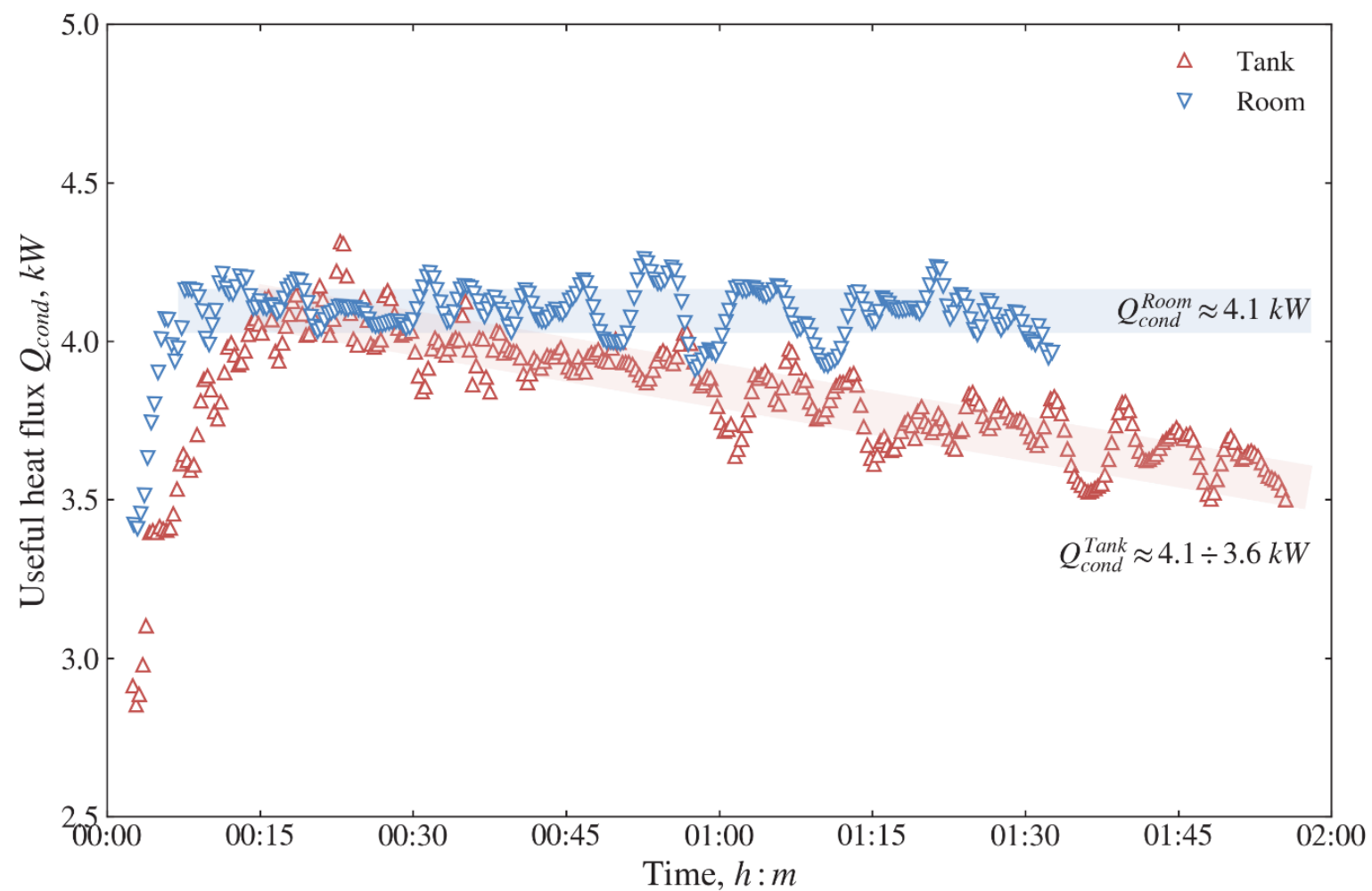
Temperature measurements for the refrigerant R134a

Experimental results



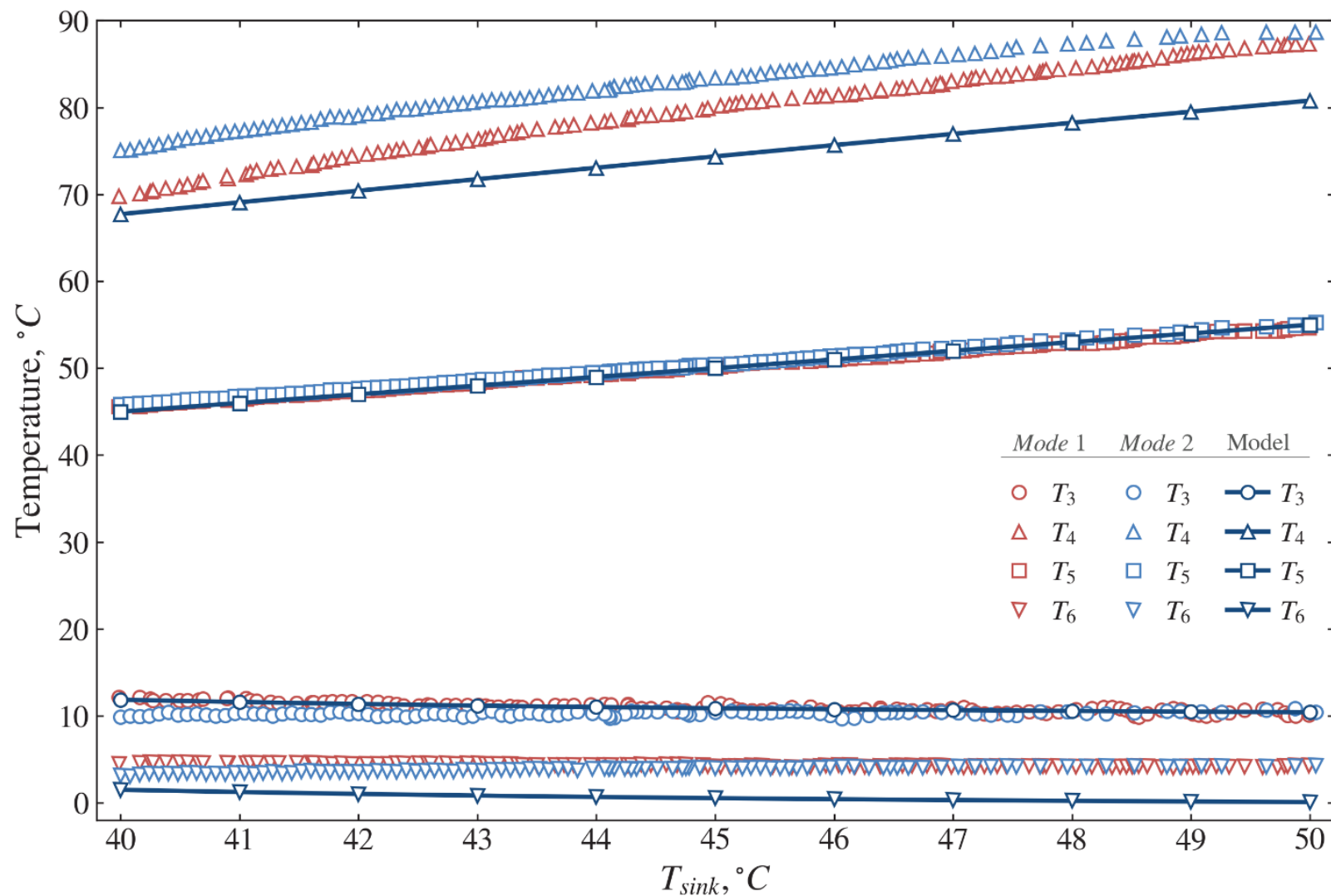
Temperature difference measurements.

Experimental results



Useful heat fluxes vs time

Experimental results



Temperatures of the cycle as a function of T_{sink}