SHALLOW GEOTHERMAL INNOVATION DAYS

Innovative Materials and Design for Shallow Geothermal

New compounds · new geometries · new evaluation models

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UPV Geothermal Test Site, Valencia · new equipment room

TU Delft · 14 October 2026 · Session 4 – Bringing Innovation to the Market

Three levers for a cheaper, better borehole



UPV Geothermal Test Site: more than a dozen instrumented BHEs

01 Materials

High-λ plastic pipes · enhanced grouts · PCM

02 Geometry

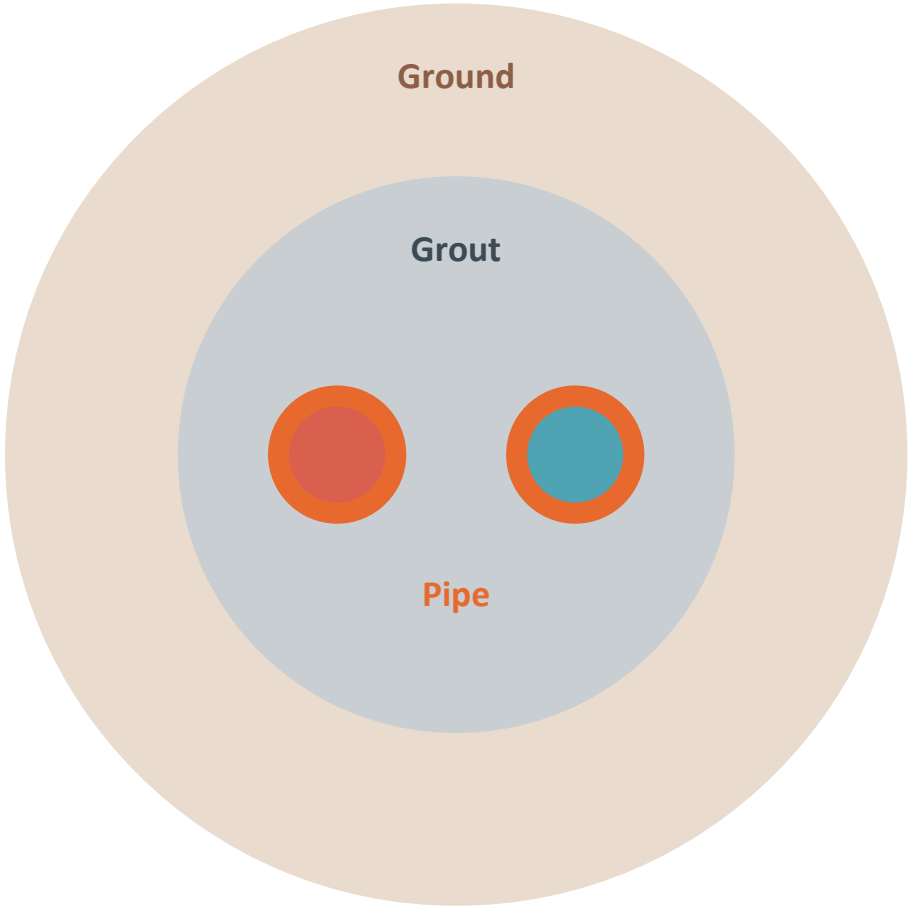
Trilobular ACT design · coaxial with self-closing tip

03 Models

C2RLS for multi-pipe BHEs · smarter TRT evaluation

Khattak, Badenes, Urchueguía & Sanner, Buildings 13 (2023) 2276

Every layer of the borehole is a thermal resistance



Pipe wall High-conductivity plastic compounds

Backfill Enhanced, pumpable cement-based grouts

Storage PCM-enhanced backfill for latent heat

2017–21
H2020 project

11
partners, 7 countries

UPV
coordinator

−25%
system cost target

System level: +13 % BHE exergy extraction in Stockholm, no gain in Valencia. The benefit depends on climate.

Mateo Pla et al., Renewable Energy 245 (2025) 122694

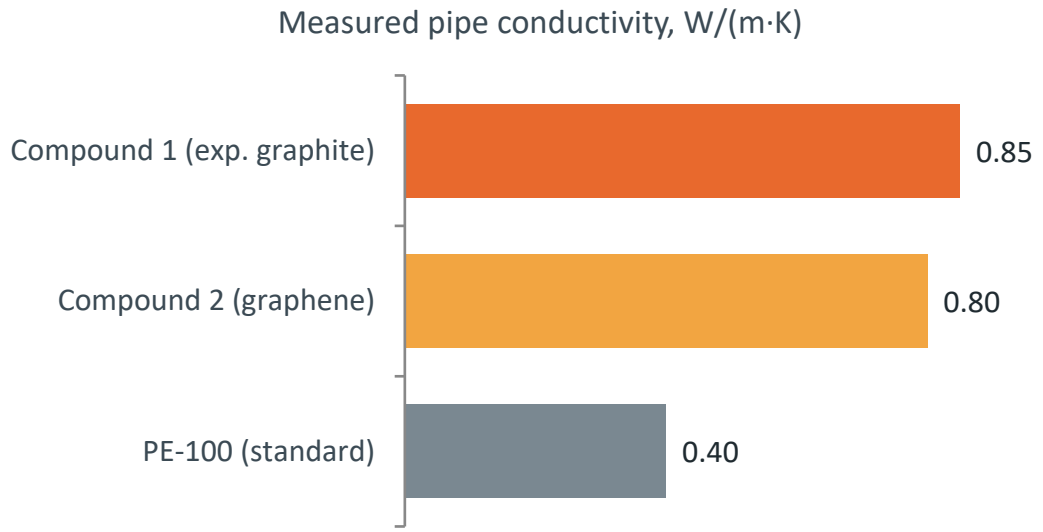
High-conductivity plastic pipes



Graphite / graphene-filled PE pipes, industrially extruded (CAUDAL)

×2–3

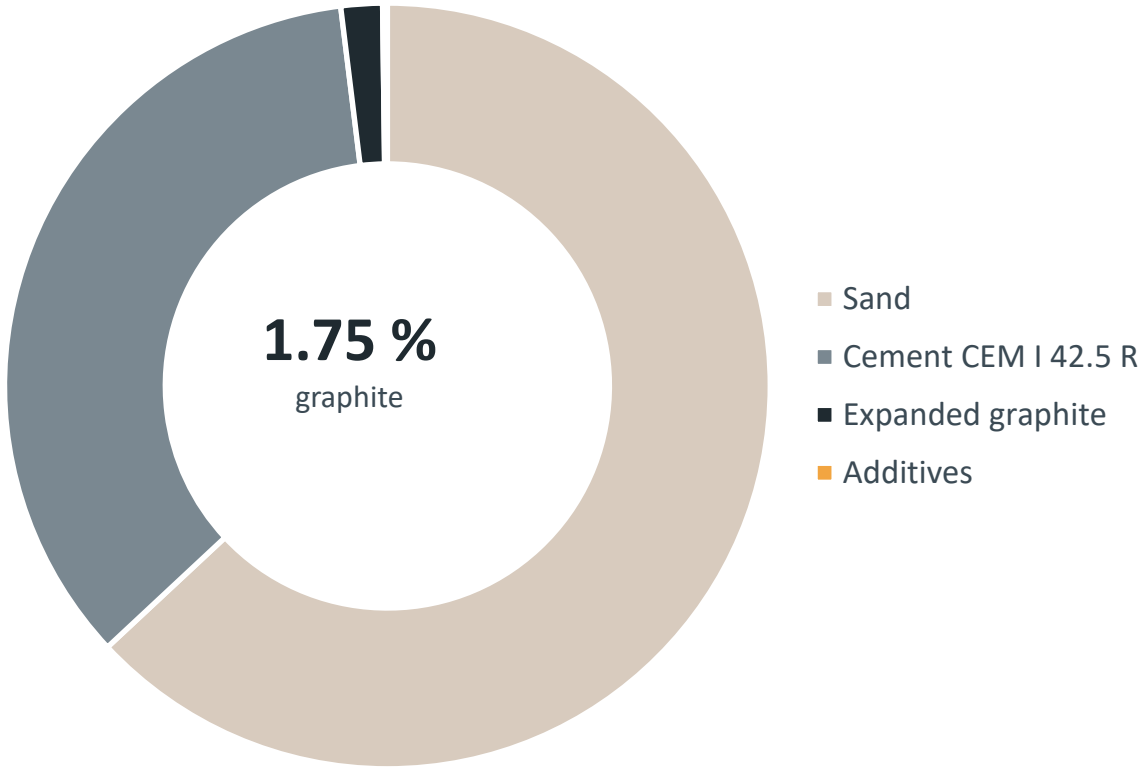
the conductivity of PE-100: ×2 on industrial pipe, up to ×3 in lab compounds; butt-weldable with PE-100



Urchueguía et al., Renewable Energy 222 (2024) 119816 · Mateo Pla et al., Renewable Energy 245 (2025) 122694

Enhanced cement-based grouts

GEOCOND grout F1a – dry mix composition



2.2

W/(m·K) on field samples (2.67 in the laboratory)

−15 %

comparable Rb* with the new grout alone; −27 % with new grout + new pipe (TRT + C2RLS)

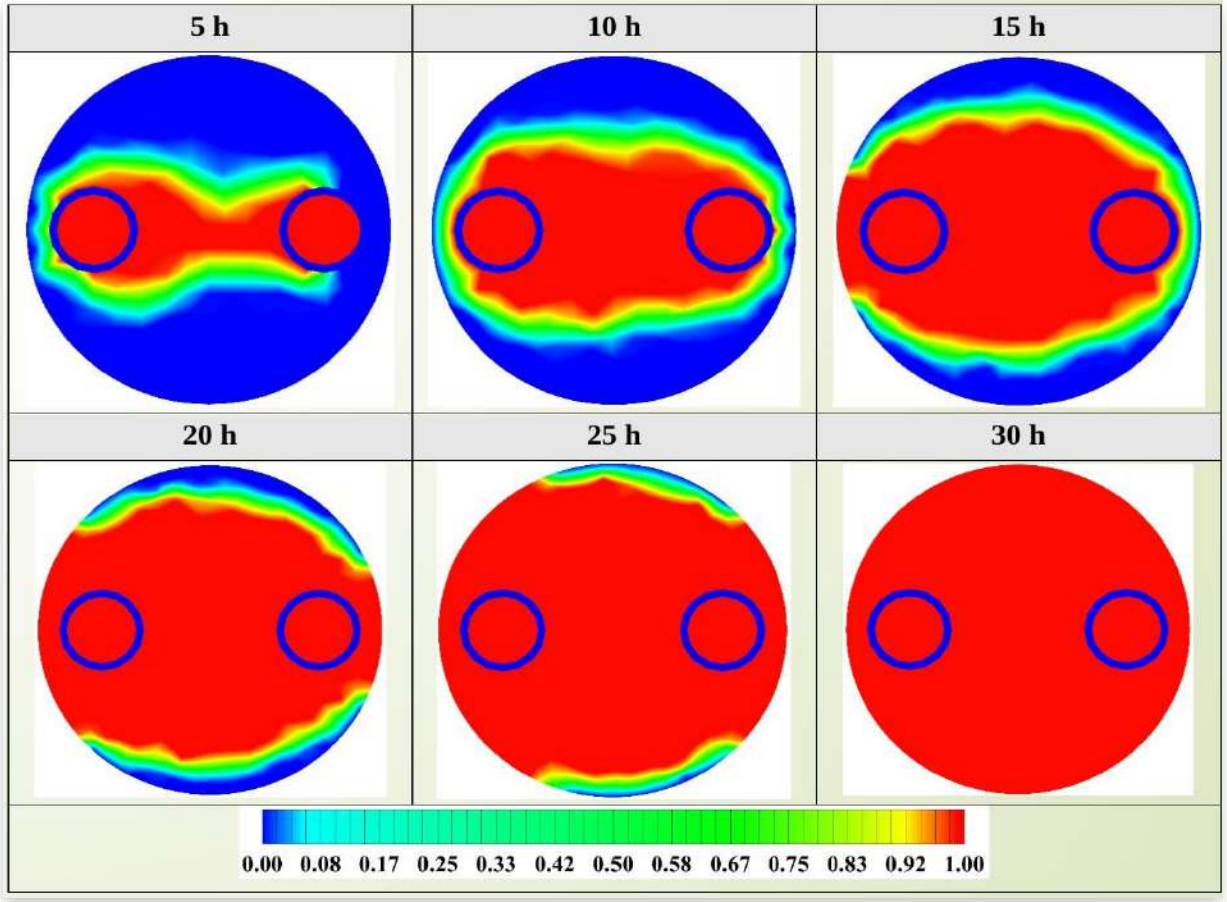
Pumpable with standard equipment · new pipe + grout: CAPEX reduction potential > 20 % in common BHEs

Žirgulis et al., Journal of Energy Storage 74 (2023) 109302

PCMs: heat storage inside the borehole

1. PCM (microencapsulated or shape-stabilised) mixed into the grout
2. PCM melts around the pipes during heat injection
3. Latent storage damps fluid temperature peaks

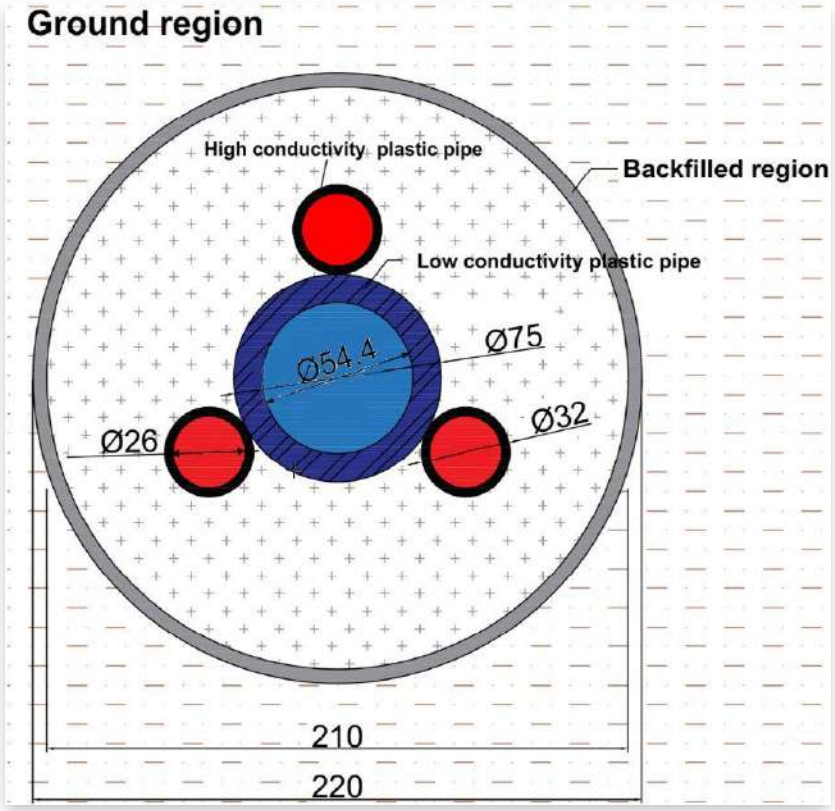
Lab cycling (RISE, 25 × 24 h): shape-stabilised PCM keeps a stable delay; the microencapsulated PCM effect fades



3D CFD, BHE 6: PCM liquid fraction after 5–30 h of heat injection (blue solid → red melted)

Urchueguía et al., Renewable Energy 222 (2024) 119816

Adapted Conductivity Trilobular (ACT) design



Cross-section (mm)



Trilobular foot, produced with CAUDAL

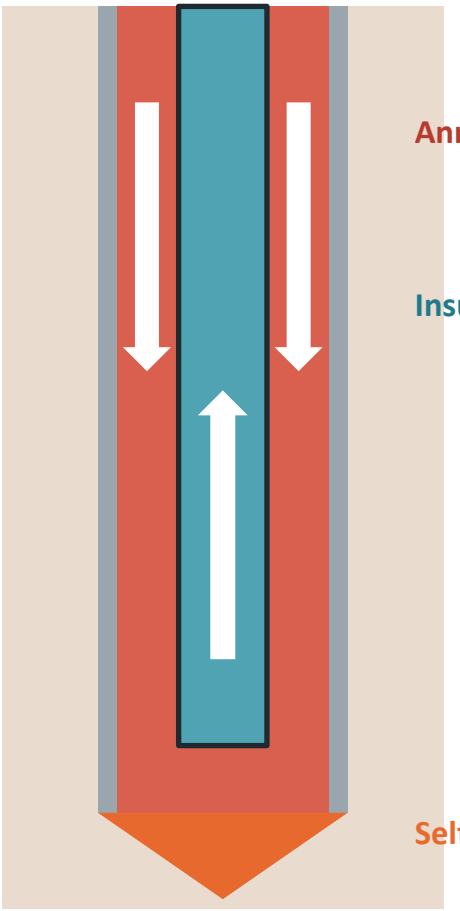


Installed at UPV

3 × high-λ pipes down · insulated return up (λ < 0.1) · same drilling & grouting as a single-U

European patent application EP22382743.7

Coaxial BHE with self-closing tip



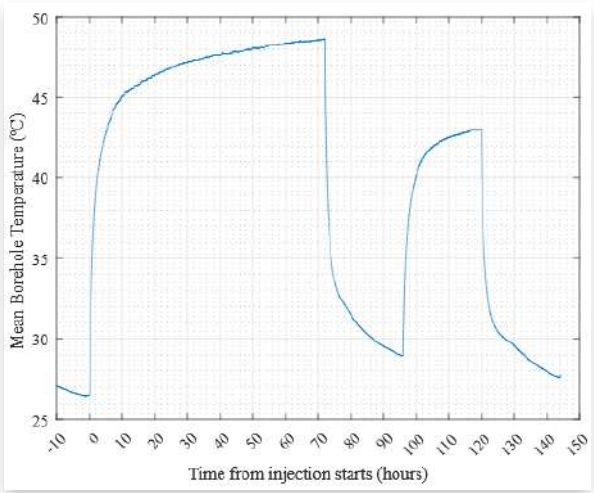
Annulus: heat exchange

Insulated return

Self-closing tip



Metallic coaxial (CHEAP-GSHPs) at the UPV test field



Plastic coaxial TRT (GEO4CIVHIC)

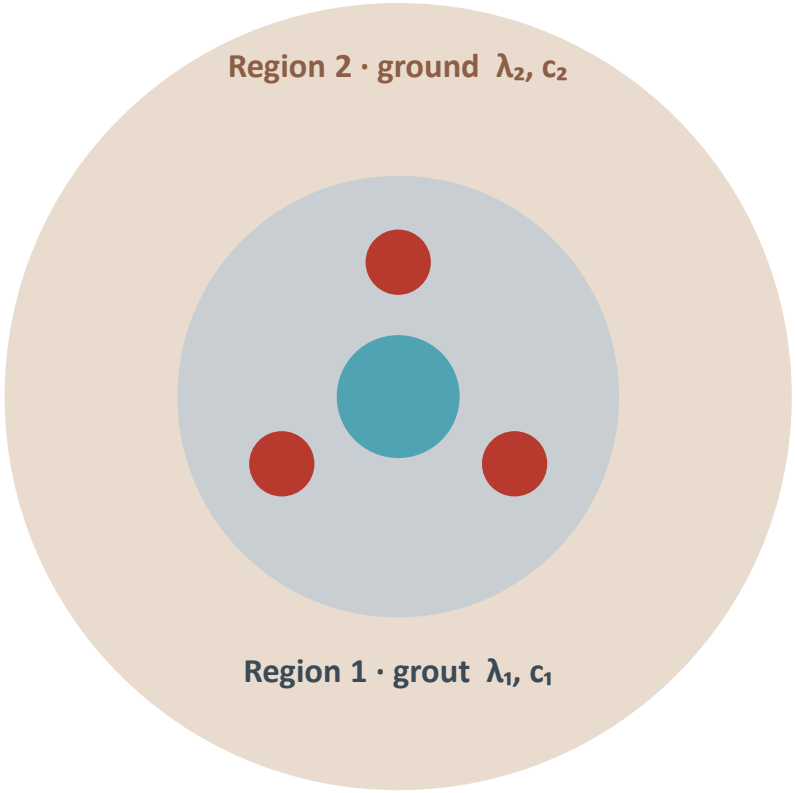
2015–19
H2020 · 18 partners

−20–30%
installation cost target

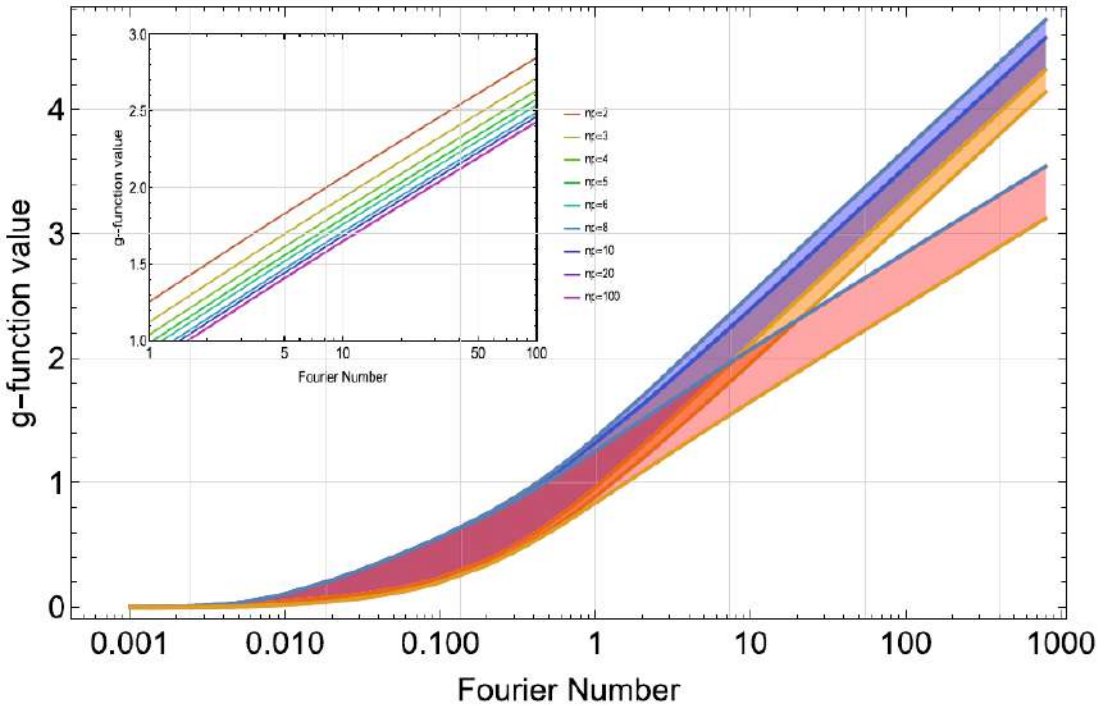
40–50 m
fast driven / vibro install

Urchueguía et al., Applied Thermal Engineering 231 (2023) 120910 · Renewable Energy 222 (2024) 119816

C2RLS: a two-region model for multi-pipe BHEs



n pipe sources + pipe resistance Rp

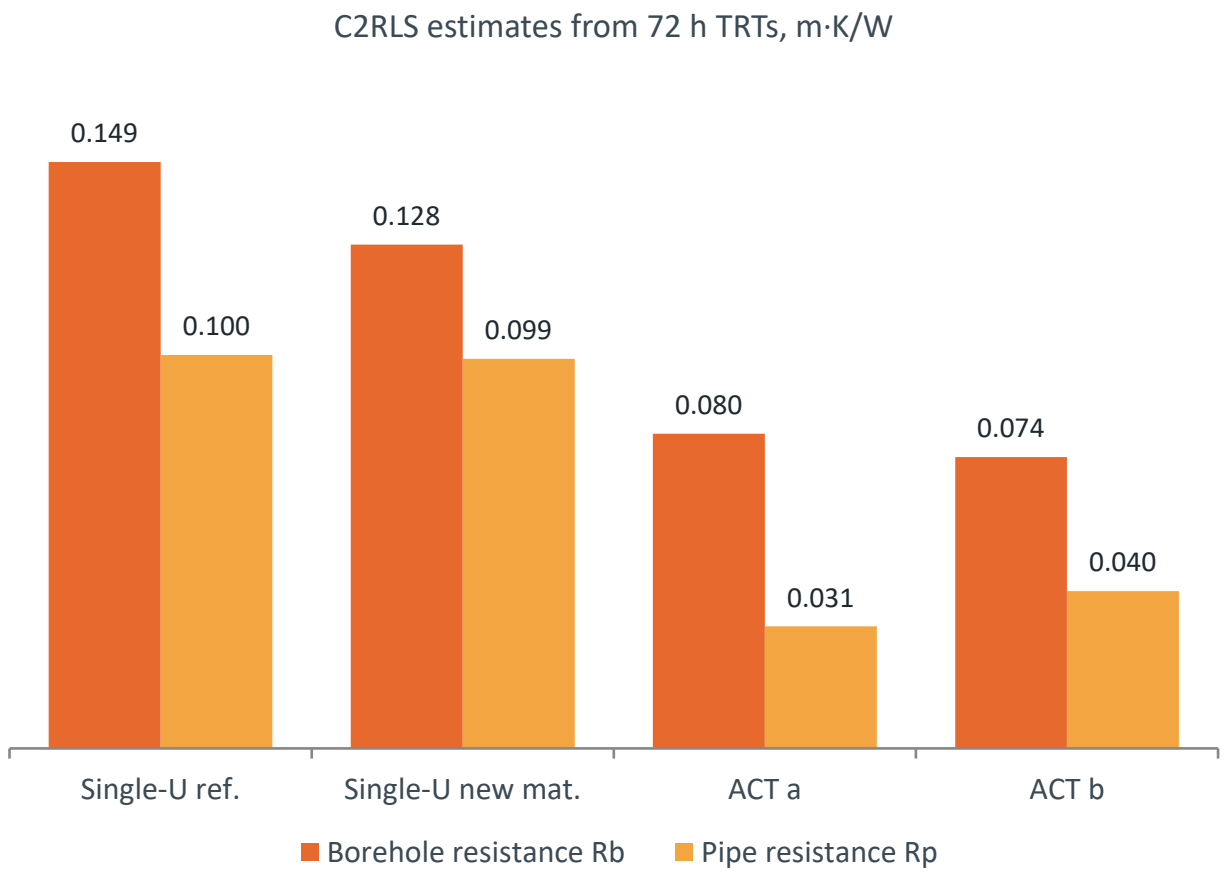


One surrogate g-function family: single-U (np = 2) → ACT → coaxial limit (np = 100)

Grout and ground separated · superposition for variable power · fast surrogate

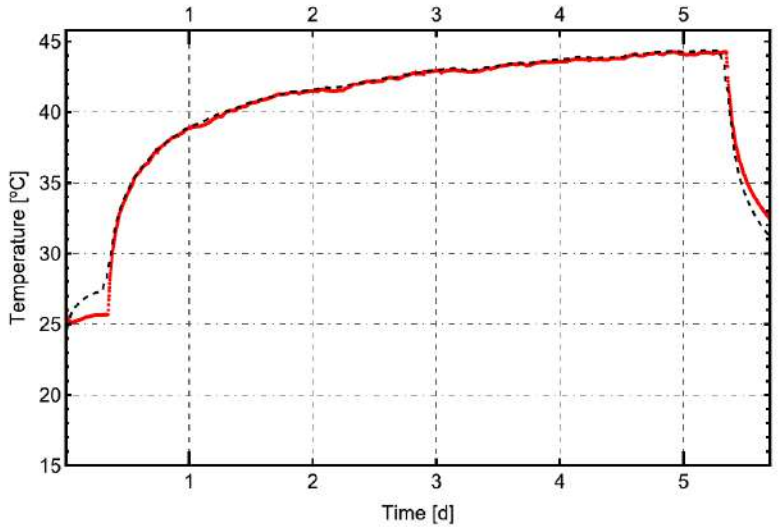
Urchueguía et al., Renewable Energy 222 (2024) 119816 · Mateo Pla et al., Renewable Energy 245 (2025) 122694

Applied to TRTs: ACT halves borehole resistance



−50 %

Rb: 0.149 → 0.074 m·K/W (single-U reference → ACT)



ACT 5-day test: measured (red) vs. C2RLS fit (dashed)

BRINGING INNOVATION TO THE MARKET

From test site to market

Materials

High-TRL compounds and grouts, made on industrial lines

Geometry

ACT installs like a single-U · patent pending · seeking industrial partners

Models

C2RLS on a standard TRT credits better materials in design



Our test site is open for joint testing

High-precision TRT laboratory · new equipment room · 12+ instrumented BHEs

NEXT STEPS

What's next?

Scale the technologies to higher TRLs

Pipes, grouts and the ACT geometry: from 10–12 m prototypes to standard-length BHEs

We are here

TRL 3–5

Lab + UPV test site: done

Next step →

TRL 6–7

Standard-length units, industrial production, pilot sites

TRL 8–9

Market roll-out

Consortium in place

Companies holding the ACT patent have joined forces to seek funding

No funding route yet

Innovation programmes with a strong role for national agencies are complex to combine

A bottleneck that probably also holds back other promising shallow geothermal innovations

Ideas and partners welcome

Thank you

Questions welcome, and see you at the site visit this afternoon

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ICTvsCC research group · ITACA · UPV

Further reading

- Urchueguía et al. Adapted composite two-region line source methods… Applied Thermal Engineering 231 (2023) 120910
- Žirgulis et al. Temperature evolution around four laboratory-scale BHEs grouted with PCM… Journal of Energy Storage 74 (2023) 109302
- Khattak, Badenes, Urchueguía & Sanner. Thermodynamic performance analysis of high thermal conductivity materials in BHEs… Buildings 13 (2023) 2276
- Urchueguía et al. New trilobular geometry using advanced materials… Renewable Energy 222 (2024) 119816
- Mateo Pla et al. Use of advanced pipe and grout materials in an experimental single-U BHE… Renewable Energy 245 (2025) 122694