Challenges and Opportunities of Sustainable Geoenergy Solutions:

A case study of geothermal energy and storage

Geosolutions
Leeds

UNIVERSITY OF LEEDS

Sandra Piazolo
Geosolutions@Leeds
School of Earth, Environment and Sustainability
University of Leeds, UK
www: geosolutions.leeds.ac.uk
s.piazolo@leeds.ac.uk

Big Thank you to the Leeds Uni team:
David Barns (social), James Van Alstine (regulatory), Fleur Loveridge (geo-engineer), Emma Bramham (geophysics), Simon Rees (engineer), Nick Shaw (geology), Frin Bale (finances), Fred Pessu (Petroleum engineer- scaling expert)
& Geosolutions Leeds support team
& Industrial, Governance partners

Overview

Setting the scene

Geoscience and the Energ

General challenges and B

Geothermal – Short overvi

Take home message

"Go beyond the technical report"

- Extract more info with less data

-> innovate

- Identify barriers - jointly create solutions

- Engage early, communicate, influence

Case Study

othermal - Overview

@ Leeds – A brief history

and How to meet them

Looking forward

Lessons Learnt

Skills and Action needed

Overview

Setting the scene

Geoscience and the Energy Transition

General challenges and Barriers

Geothermal – Short overview

Case Study

Shallow Geothermal - Overview

Geothermal @ Leeds – A brief history

Challenges and How to meet them

Looking forward

Lessons Learnt

Skills and Action needed

Key technologies of the energy transition

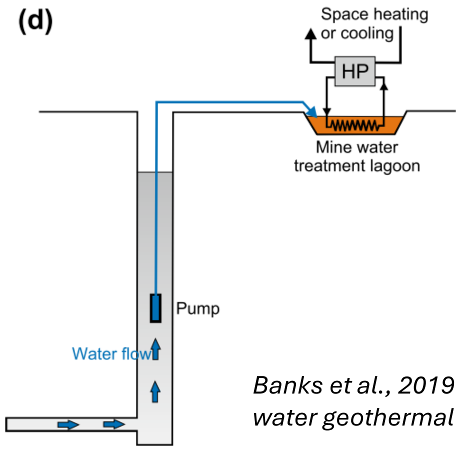
Geology Knowledge essential

Geology Knowledge supportive

Heat

- Geothermal including mine water
- Ground-source heat pumps and heat exchangers
- Solar and district heating/ground storage
- Hydrogen

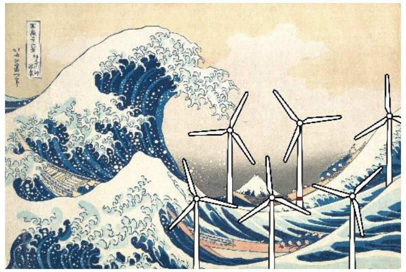
(d)



Banks et al., 2019 Mine water geothermal

Power

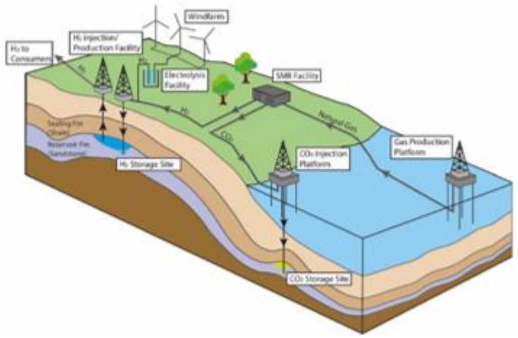
- Offshore wind
- Tidal/wave
- Solar
- Nuclear
- Geothermal
- Bio-energy with Carbon Capture and Storage (BECCS)
- Natural gas with CCS



Energy storage

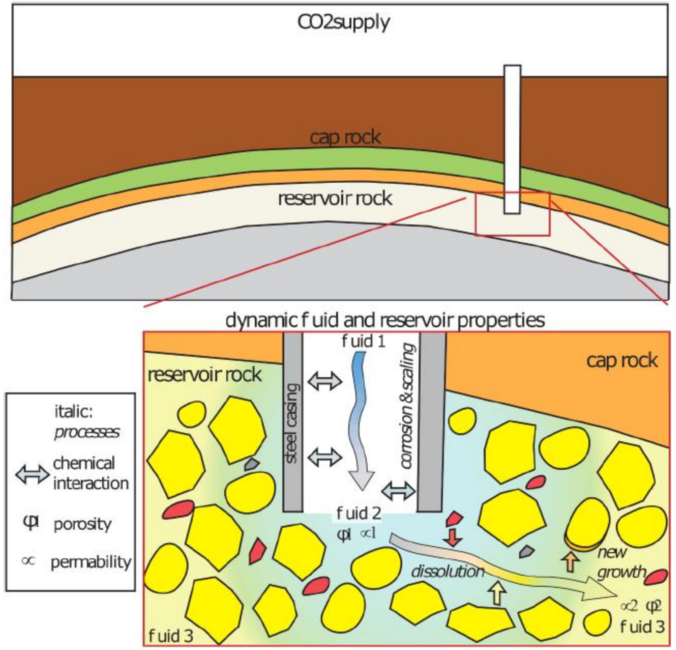
- Hydrogen
- Compressed air energy storage in caverns (CAESC) or aquifers (CAESA)
- Gravity storage
- Heat storage
- Nuclear waste

Heinemann et al., 2019
Hydrogen production and storage



Carbon sequestration

- CCS
- Direct Air Capture
- Enhanced weathering
- Afforestation



Pessu et al. 2025

Key technologies of the energy transition

Geology Knowledge essential

Geology Knowledge supportive

Heat

- Geothermal including mine water
- Ground-source heat pumps and heat exchangers
- Solar and district heating/grou… storag…
- Hydrog…

Power

- Offshore wind
- Tidal/wave
- Solar
- Nuclear
- Geot…

Energy storage

- Hydrogen
- Compress…

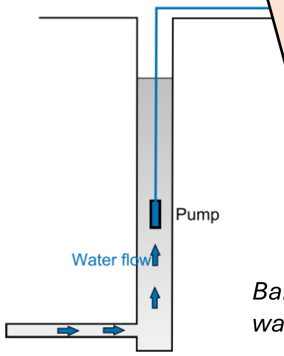
Carbon …stration

- … Air Capture
- …ced …ring
- …ation

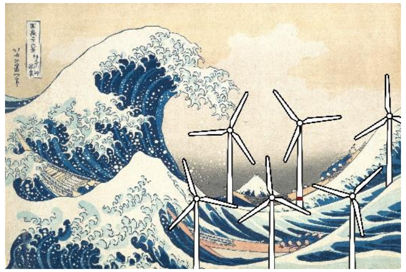
Key geoscience capabilities needed

- Subsurface fluids/ Reactions
- Fluid flow modelling
- Geochemistry
- Sedimentology/stratigraphy
- Geophysics & structural geology
- Engineering/Material properties

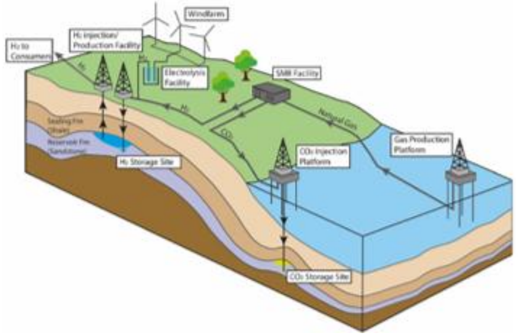
(d)

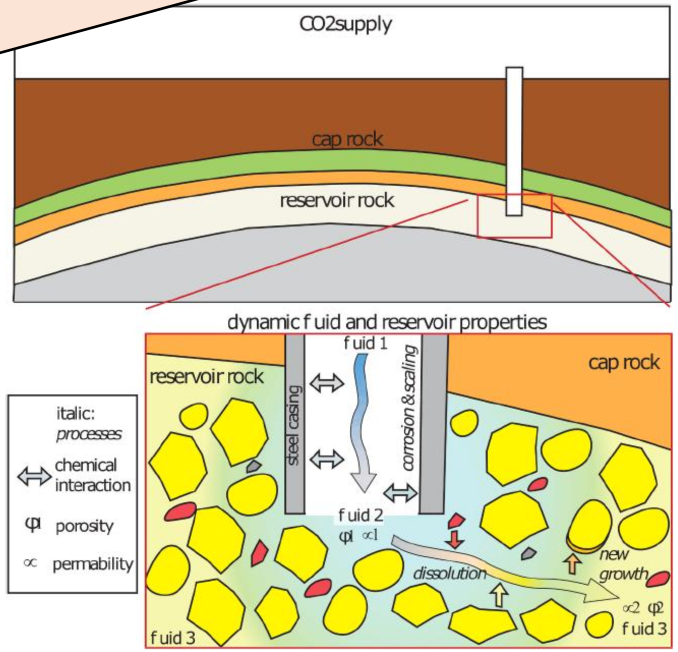


Banks et al., 2019 Mine water geothermal



Heinemann et al., 2019
Hydrogen production and storage

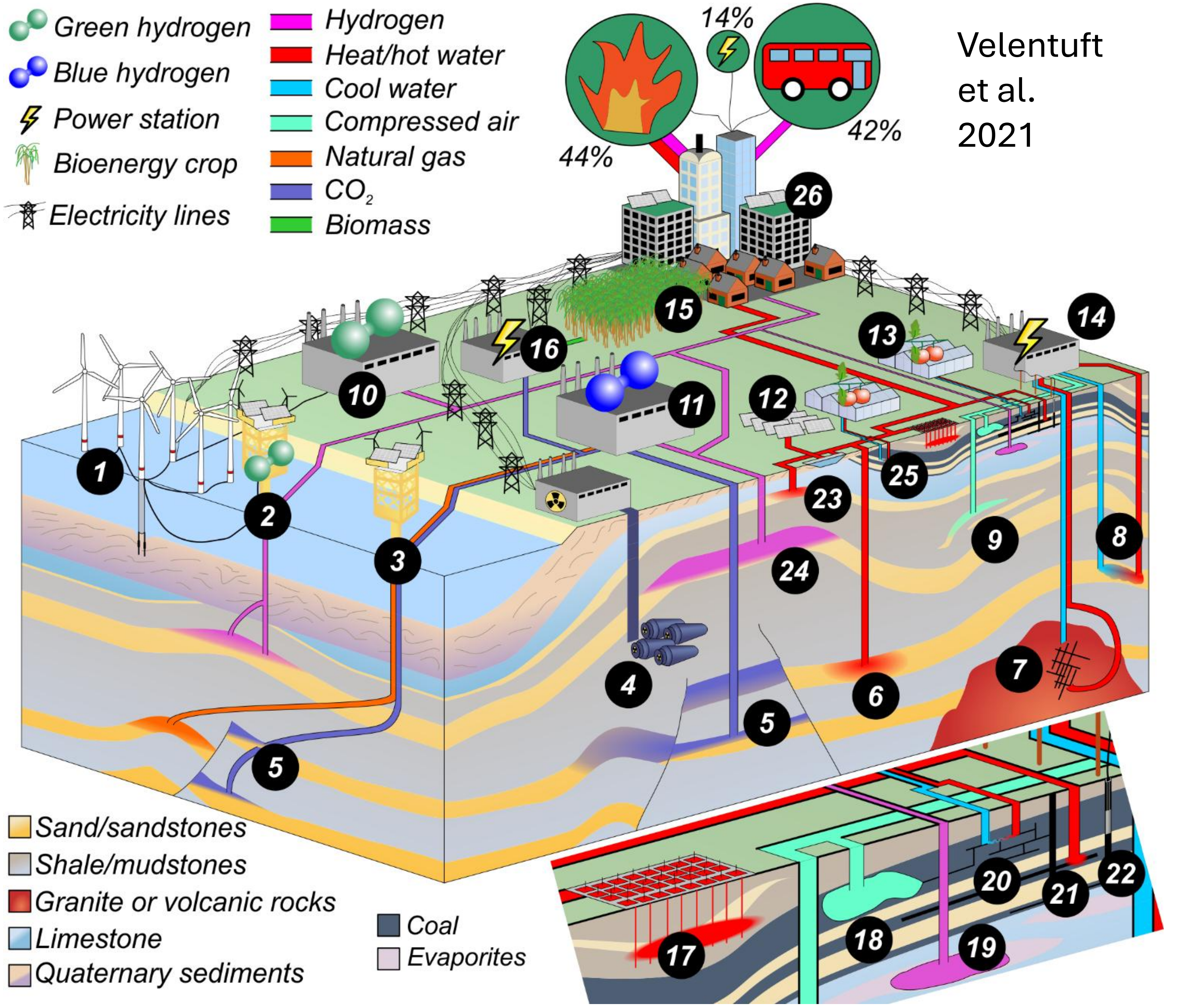




Pessu et al. 2025

Complimentary / competitive use of the subsurface for the Energy Transition

1 Offshore wind
2 Offshore green hydrogen production & storage
3 Natural gas production with Carbon Capture & Storage
4 Nuclear waste Geological Disposal Facility
5 Carbon Capture & Storage (CCS) site
6 High-Temp Aquifer Thermal Energy Storage (HT-ATES)
7 Enhanced/Engineered Geothermal (EGS)
8 Aquifer Geothermal
9 Compressed Air Energy Storage in Aquifers (CAESA)
10 Green hydrogen
11 Blue hydrogen with CCS
12 Solar & Pit Thermal Energy Storage (PTES)
13 Geothermally-heated greenhouse food



Velentuft et al. 2021

14 Geothermal electricity generation
15 Biomass farm
16 Bioenergy with CCS (BECCS)
17 Borehole Thermal Energy Storage (BTES)
18 Compressed Air Energy Storage in Caverns (CAESC)
19 Hydrogen storage in caverns
20 Minewater Geothermal
21 Minewater Thermal Energy Storage (MTES)
22 Suspended-weight gravitational storage
23 Aquifer Thermal Energy Storage (ATES)
24 Onshore hydrogen storage in aquifers
25 Shallow aquifer Geothermal
26 End-user energy demand

Complimentary / competitive use of the subsurface for the Energy Transition

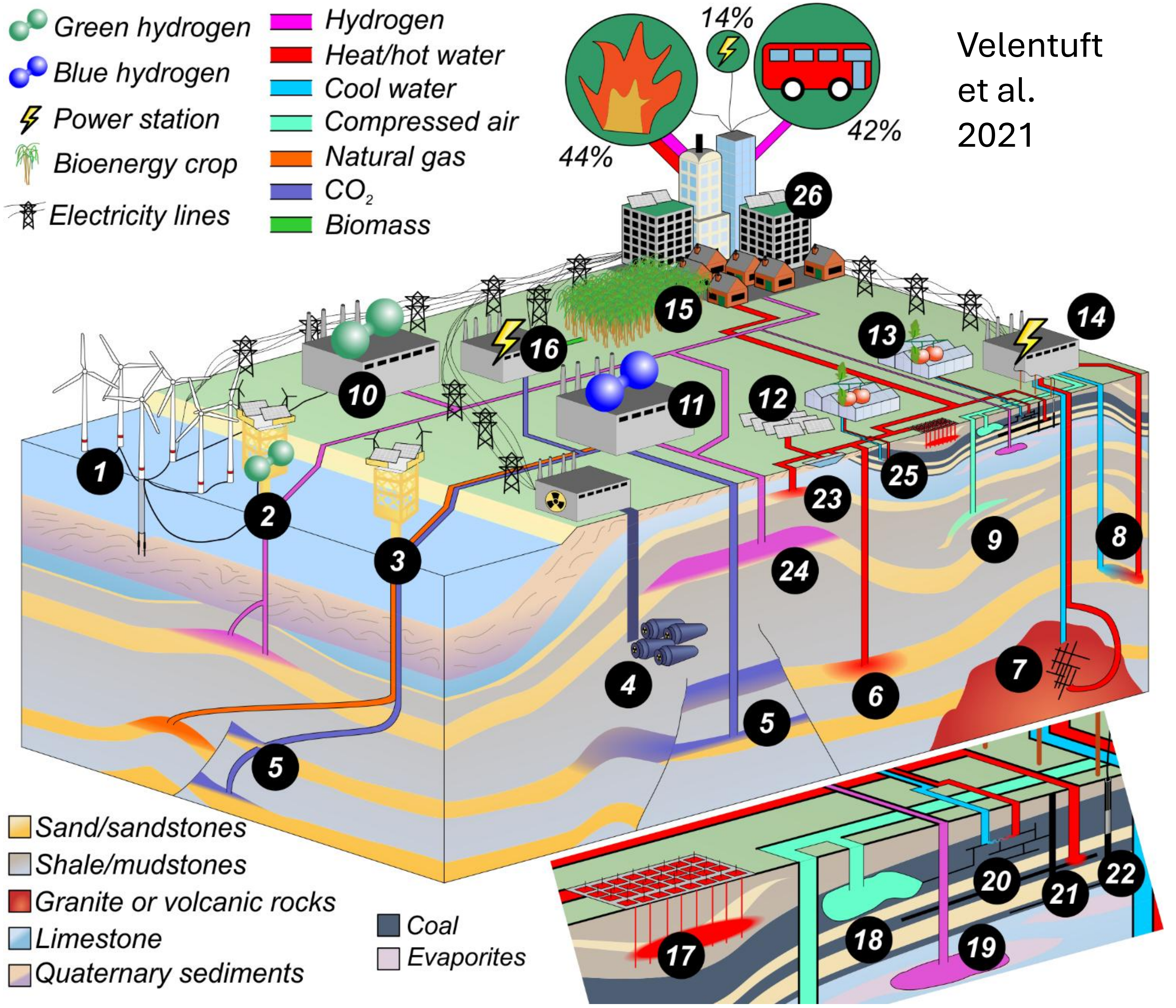
Smörgåsbord of opportunities
- Highly interlinked

Potential for subsurface use competition:
e.g. geothermal for heating versus food production

Which one is best?

To help decision makers

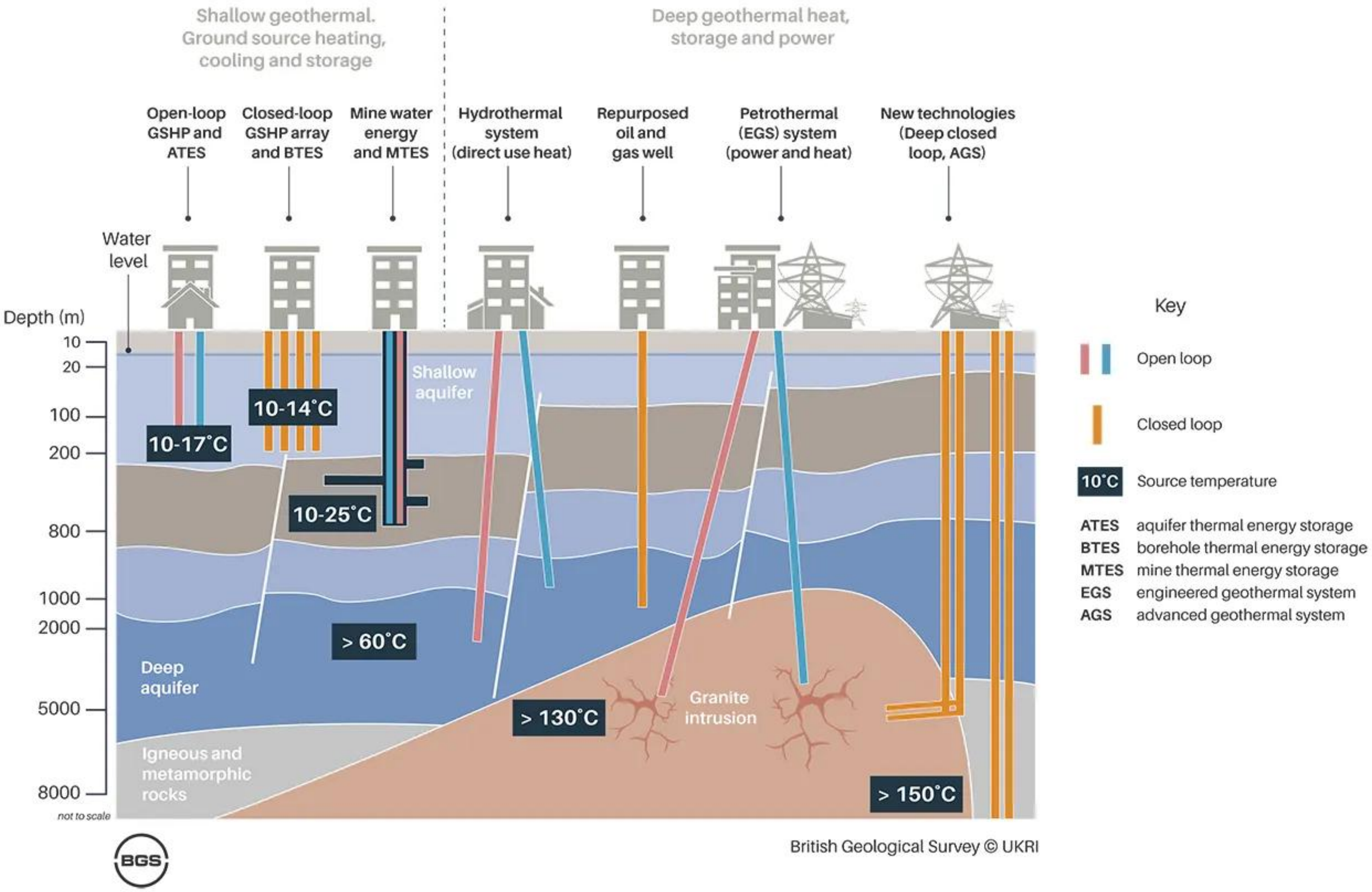
Need fo group of experts
- without bias
- different disciplines



Velentuft et al. 2021

14 Geothermal electricity generation
15 Biomass farm
16 Bioenergy with CCS (BECCS)
17 Borehole Thermal Energy Storage (BTES)
18 Compressed Air Energy Storage in Caverns (CAESC)
19 Hydrogen storage in caverns
20 Minewater Geothermal
21 Minewater Thermal Energy Storage (MTES)
22 Suspended-weight gravitational storage
23 Aquifer Thermal Energy Storage (ATES)
24 Onshore hydrogen storage in aquifers
25 Shallow aquifer Geothermal
26 End-user energy demand

Lets have a look - Geothermal - Overview



Case study:
Shallow Geothermal

- Arguably the most promising geothermal energy solutions due to relatively low initial investment needed

Geothermal heat and energy extraction

General design - Extraction systems

Injection-production wells

General design - Storage systems

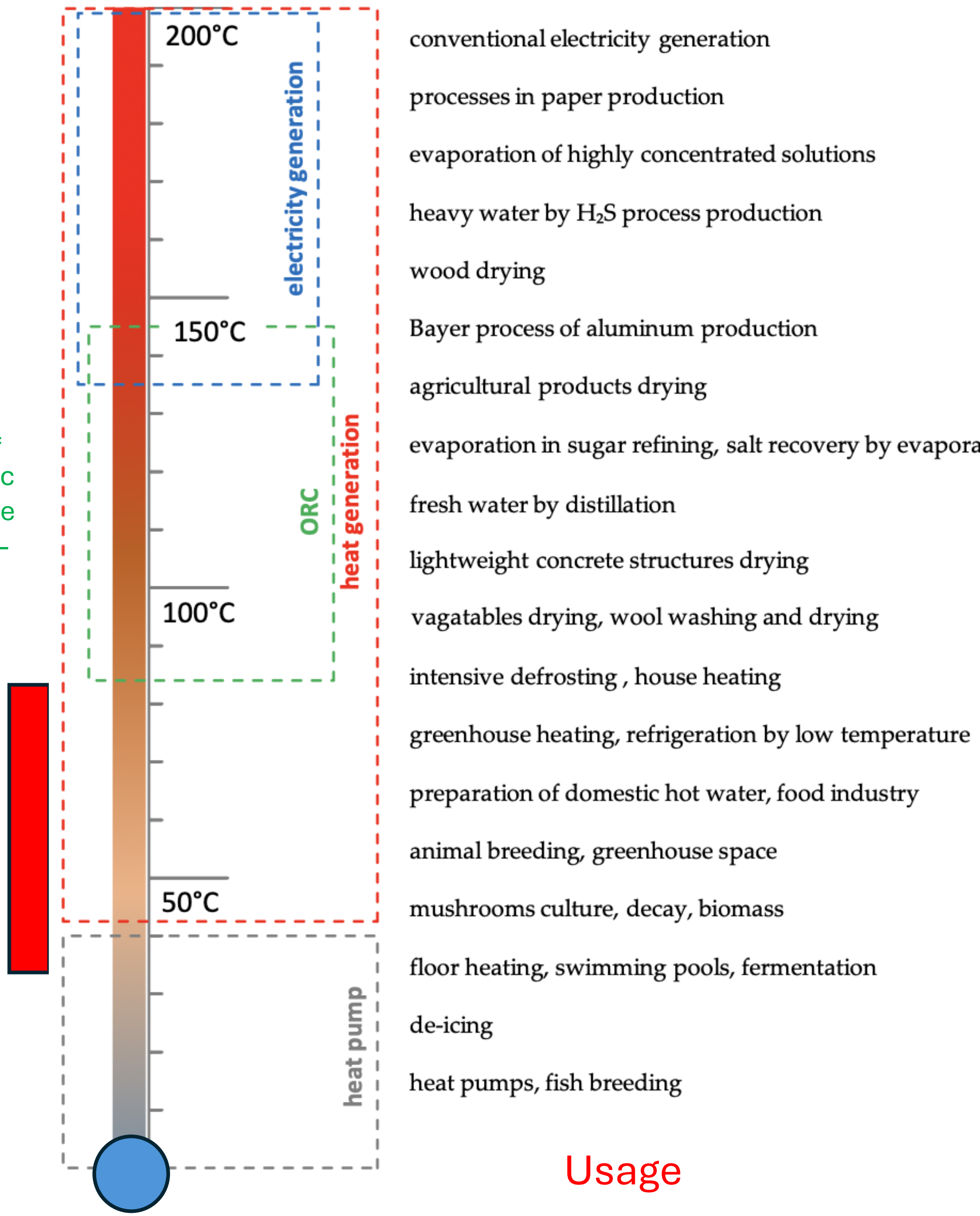
Cold-warm wells

Controls:

- Thermal conductivity
- Permeability:
  - Primary
  - Secondary
- Groundwater flow rate
- Fluid chemistry

Heating
- Domestic
- Commercial
- Food production

ORC = organic rankine cycle – waste heat



Geothermal heat and energy extraction

System designs:

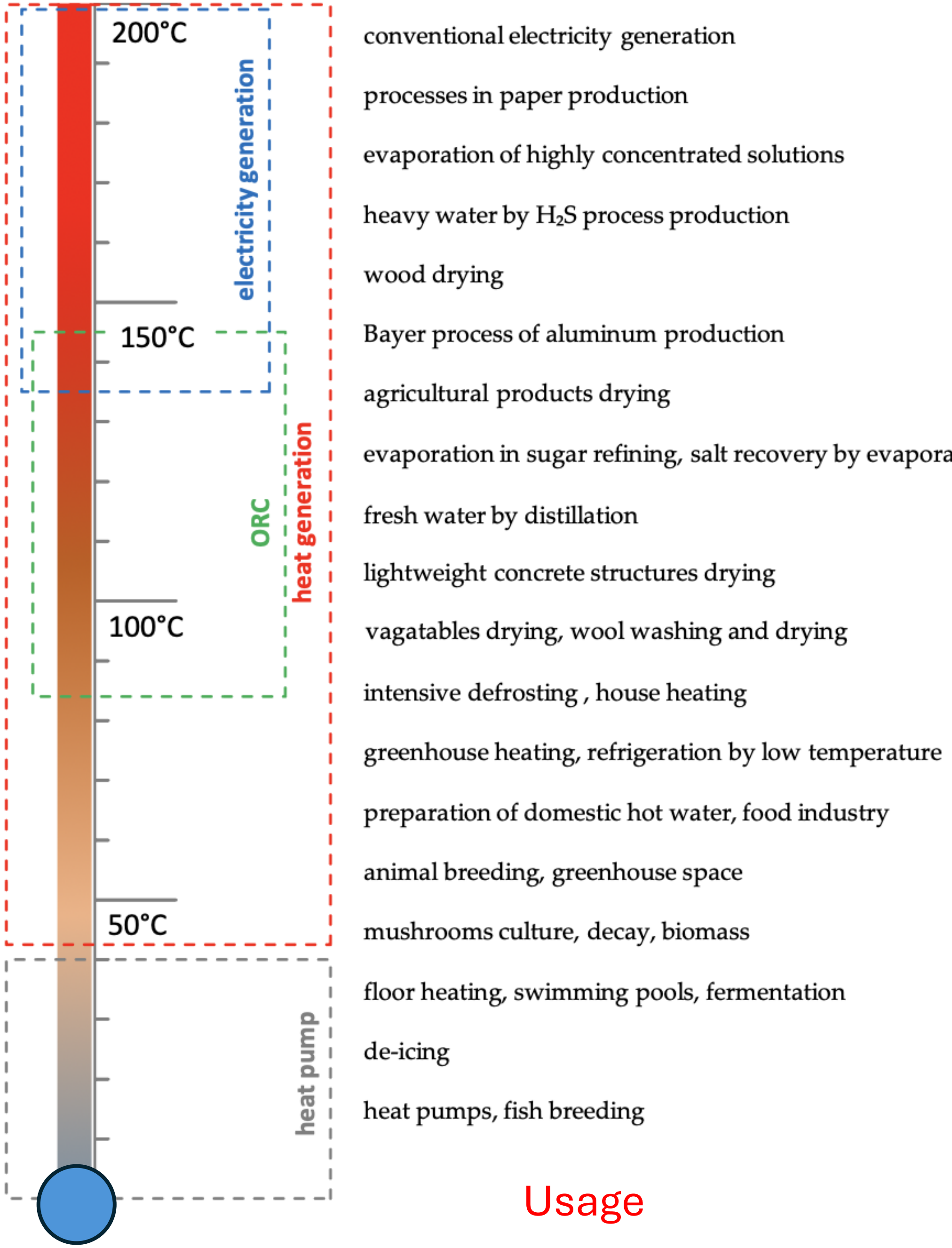
Conduction dominate:
- Low permeability: Limited flow
- Heat exchange in borehole
- Close loop: No direct contact to the rock or sediment

Convection dominate:
- High permeability (>10 mD): e.g., faults and fractures
- High thermal conductivity (30 ℃/km)
- Open loop: Direct contact to rock and sediment

Utilisation:

Direct heat:
- Low-enthalpy: <100 ℃ **<- Most economically competitive**
- Medium-enthalpy: 100-150 ℃

Energy generation:
- High-enthalpy: > 150 ℃



Usage

Overview

Setting the scene

Geoscience and the Energy Transition

General challenges and Barriers

Geothermal – Short overview

Case Study

Shallow Geothermal - Overview

Geothermal @ Leeds – A brief history

Challenges and How to meet them

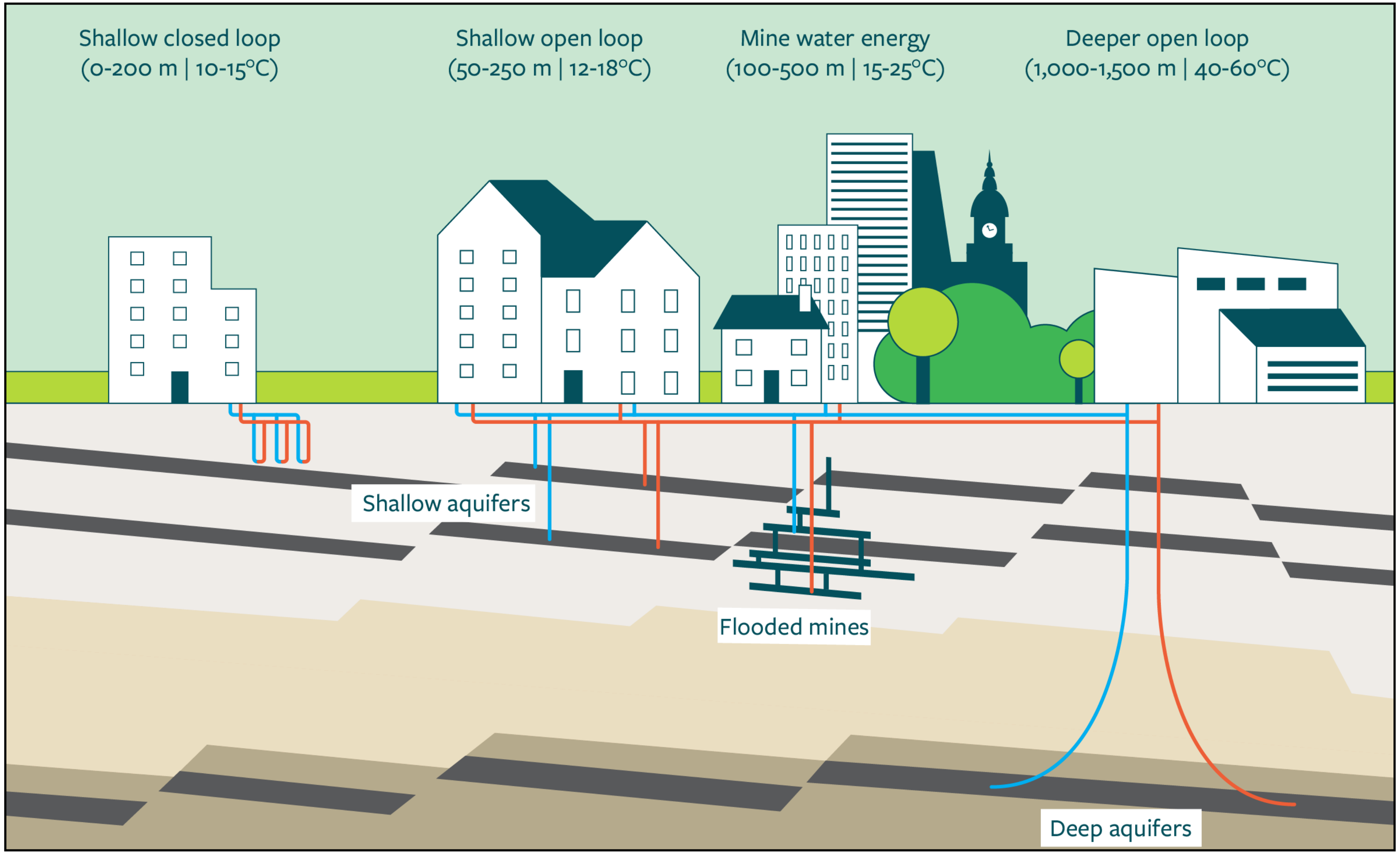
Looking forward

Lessons Learnt

Skills and Action needed

Shallow Geothermal - Overview

Important: Geothermal technologies for *heating & cooling*



Barns et al, 2025

Heating and cooling: Underground thermal energy storage: UTES

Fleuchaus et al. 2020. Kaminskaite et al. 2022.

Different systems

1. Tank thermal energy storage: TTES
2. Mine thermal energy storage: MTES
3. Pit thermal energy storage: PTES
4. Cavern thermal energy storage: CTES
5. Borehole thermal energy storage: BTES
6. Aquifer thermal energy storage:
   - Open-loop
   - HT-ATES: >50 ℃
   - LT-ATES: <50 ℃

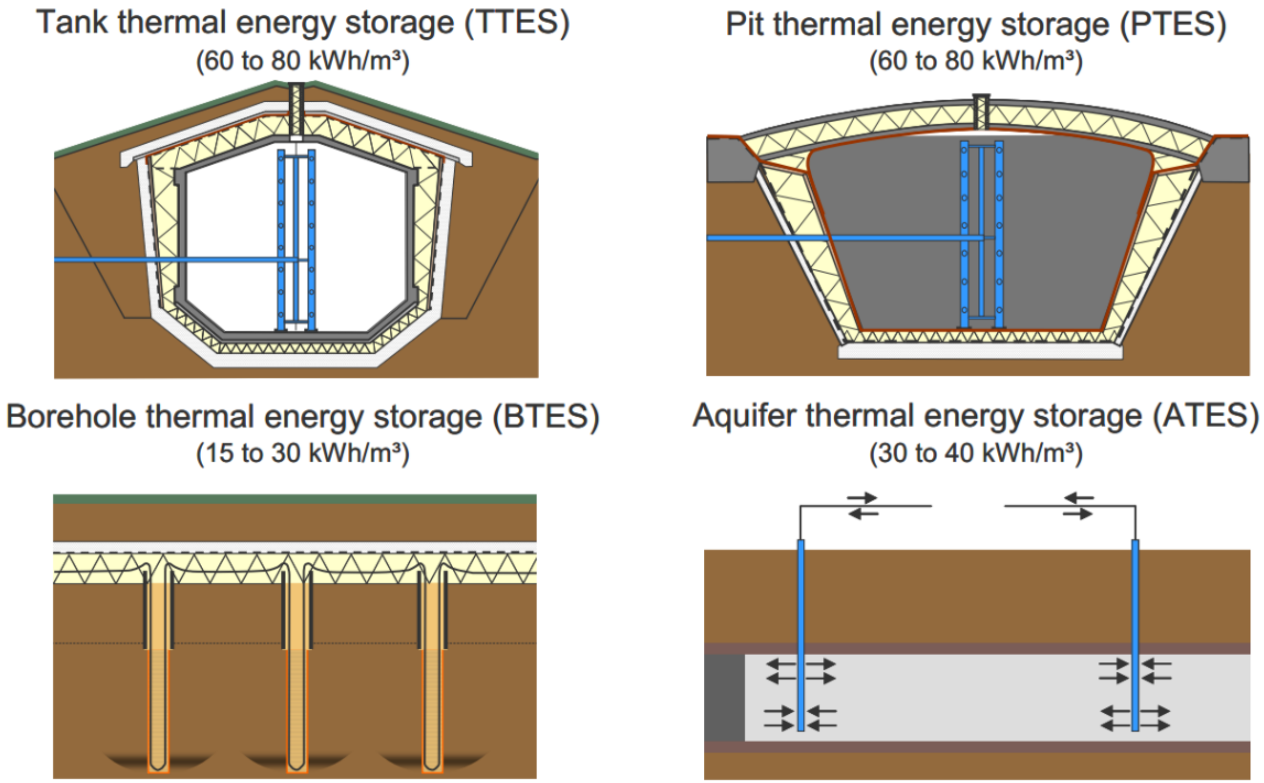


Diagram shows four types of common underground thermal energy storage [Delta Energy & Environment Ltd. 2016.].

Heating and cooling: Underground thermal energy storage: UTES

Fleuchaus et al. 2020. Kaminskaite et al. 2022.

Different systems

1. Tank thermal energy storage: TTES
2. Mine thermal energy storage: MTES
3. Pit thermal energy storage: PTES
4. Cavern thermal energy storage: CTES
5. Borehole thermal energy storage: BTES
6. Aquifer thermal energy storage:
   - Open-loop
   - HT-ATES: >50 ℃
   - LT-ATES: <50 ℃

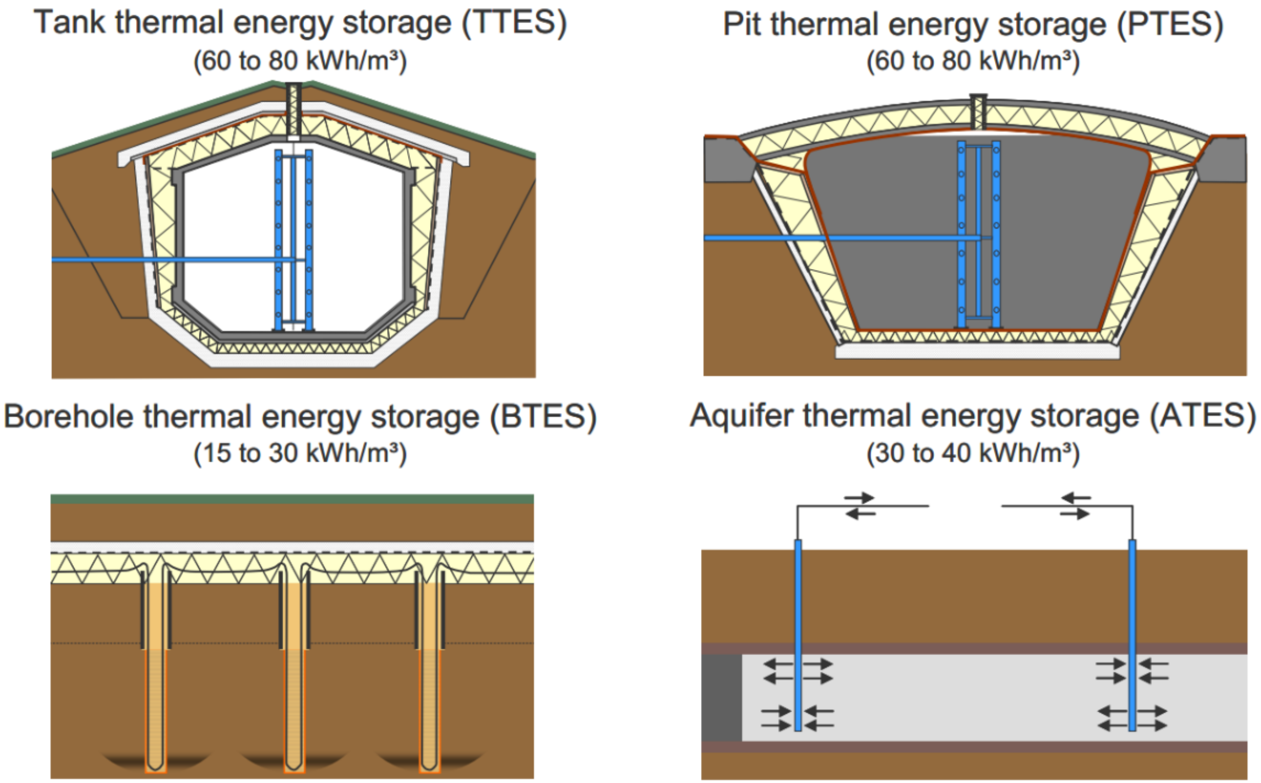


Diagram shows four types of common underground thermal energy storage [Delta Energy & Environment Ltd. 2016.].

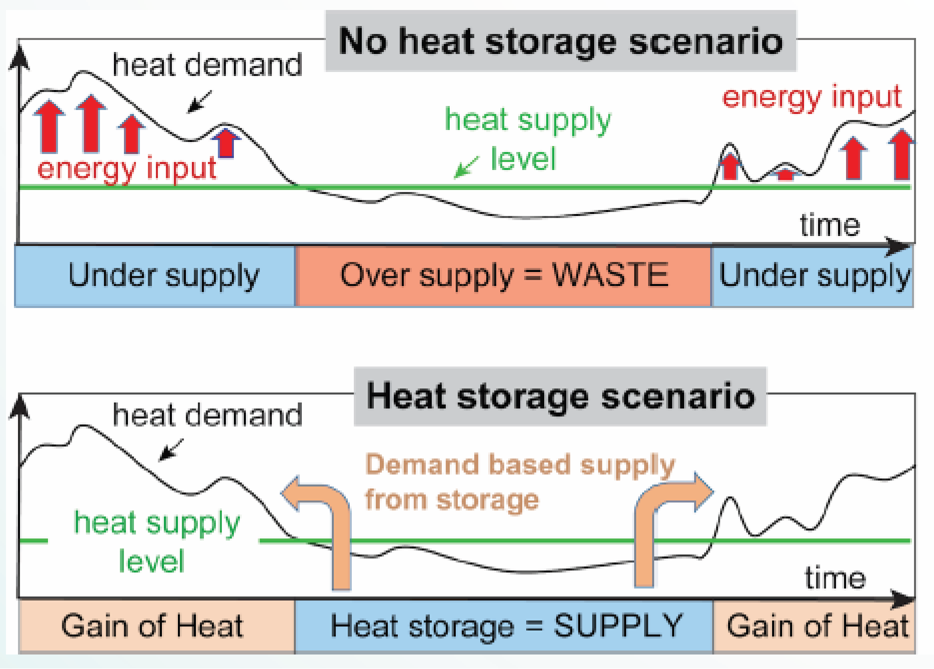
Aquifer thermal energy storage:

Characteristics/ Advantages

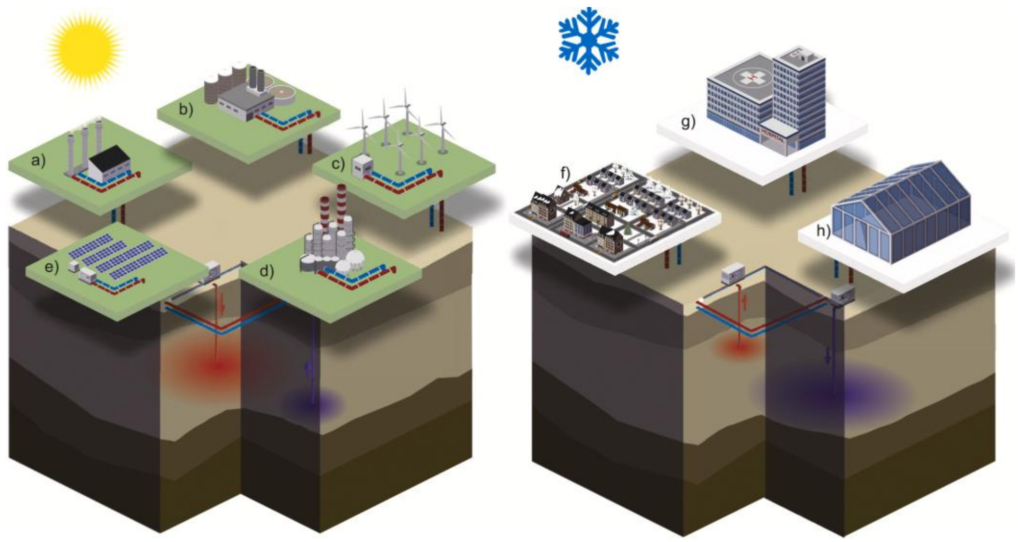
- Only open loop system in UTES
  : Direct contact between rock and fluid
- Bidirectional wells: Cold-Warm well
- Larger capacity than man-made reservoirs
- Seasonal thermal energy storage

Site-specific requirement

- Reservoir thickness
- Thermal conductivity
- Groundwater flow velocity



Schematic illustration of the concept of thermal storage in water throughout seasons (Rattle et al. 2020)



Operation of the aquifer thermal energy storage which recharges and discharge storing heat to serve the seasonal variable heat demand [Fleuchaus et al. 2020].

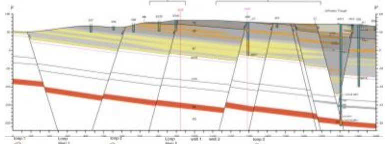
Shallow Geothermal @ Leeds

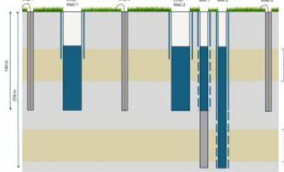
A brief History

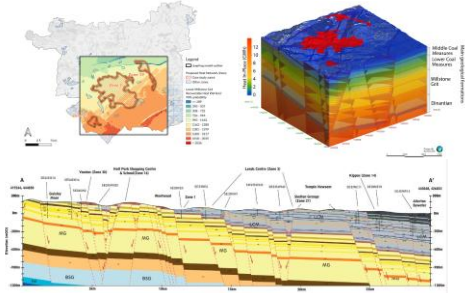
Geosolutions
Leeds

2019 UoL climate commitment, seven 'principles'

- Net zero campus
- Net zero city
- Decarbonisation of research and teaching

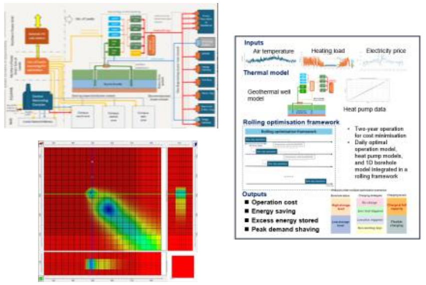






2024 Geothermal city projects

- Two policy projects around geothermal heat networks in the city
- Integrating geoscience, engineering, social science, governance and business models



2025 Geogrid project

- Linking the whole energy system: boreholes/heat pumps/grid/energy markets
- Geothermal as an alternative to increasing electrification for heating, cooling and energy storage

2023 – 2026 Geothermal campus project

On-campus drilling and associated research

2019 - 2022 | 2023 | 2024 | 2025 | 2026

2020 – 2022 Geosolutions Leeds established

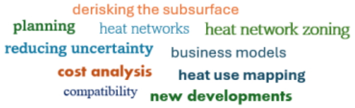
- An interdisciplinary virtual centre
- Pump priming funding from the university

IMPORTANT:
Paired projects, barriers and opportunities

Geosolutions
Leeds

January 2023 UoL/LCC Geothermal Workshop

How do we get geothermal on the map?



July 2024 Enabling Geothermal Heat Networks Workshop

Exploring viability and location for future geothermal heat networks

July 2025 Enabling a Geothermal Leeds: Stakeholder Session

Exploring viability and location for future geothermal heat networks

July 2026 SAFE Leeds – Exemplar City: Co-creation Workshop

Let's go!

Case Study

Shallow Geothermal - Overview

Geothermal @ Leeds – A brief history

Challenges and How to meet them

Sustainable Geoenergy Solutions: Geoassets in Yorkshire

3 months project

Imogen Rattle/ J. van Alstine/ S. Piazolo

Interviews

(Questions informed by paired project concentrating on geoscience / engineering potentials in Yorkshire)

‘Supporting conversations’

Supporting video conferences

Briefing note on development opportunities for mine shafts

Mapping out initial narratives…

Leeds Gateway 45	West York CA	Durham mine water heat
Council Principal Planner – policy Council lead for Sustainable Energy and Air Quality Council head of Sustainable Energy & Climate Change University G45 lead	WYCA lead for infrastructure & Investment Head of Humber LEP City of York chair of climate change scrutiny committee Head of Yorkshire Energy Institute	NE LEP Energy Sector Lead Durham council Regeneration Manager
Trade Union national policy officer Friends of the Earth head of policy		

Outcome:
Barriers to creating ***policy*** for utilizing geoassets

- Issue 1: Silos and levels
- Lack of national policy which incorporates geoassets
- Issue 2: Local authorities must mandate in local policy that developers connect to district heat schemes
- Developers challenge these policies

Identified barriers to adopting shallow geothermal solutions at local and regional level

Lack of consideration
-> "Don't know this is possible"
-> "Cannot quantify easily"

The energy beneath
–> Who owns it?

Lack of public acceptance and regulatory framework
-> is it safe?
-> no regulation in place/ too restrictive

Lack of investment
-> Needs investment before resource is known
-> Often complicated ownership
-> Too many unknowns
-> Profit margins are small

BUT:
What about geology?

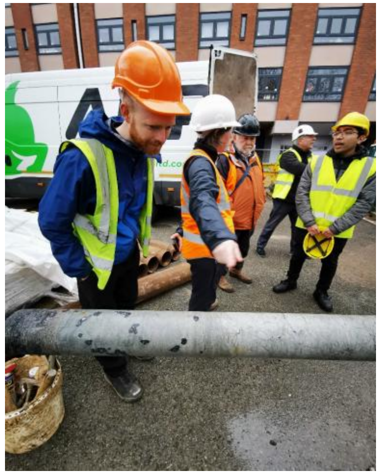
Key policy and governance uncertainties for implementation of heat networks

- **Geothermal data availability and access:** no centralised data system or common framework for data sharing
- **Heat network policy, regulation and planning:** uncertainty on how heat will be regulated and broader government strategy
- **Managing risk and uncertainty using fi** ncial mechanisms to mitigate risk and incentivise geothermal h
- **Mine water energy policy and re** ent either within England or the devolved governments that co hermal projects
- **Local policy and planning: heat h** horities lack policy power to adequately pressure developers to s in both England and the wider United Kingdom
- **Local policy and planning: carbon reduction targets:** local authorities need to be further empowered to allow for more stringent carbon reduction targets, ideally akin to those of Greater London Authorities
- **Education and outreach:** need greater public engagement and understanding of geothermal opportunities

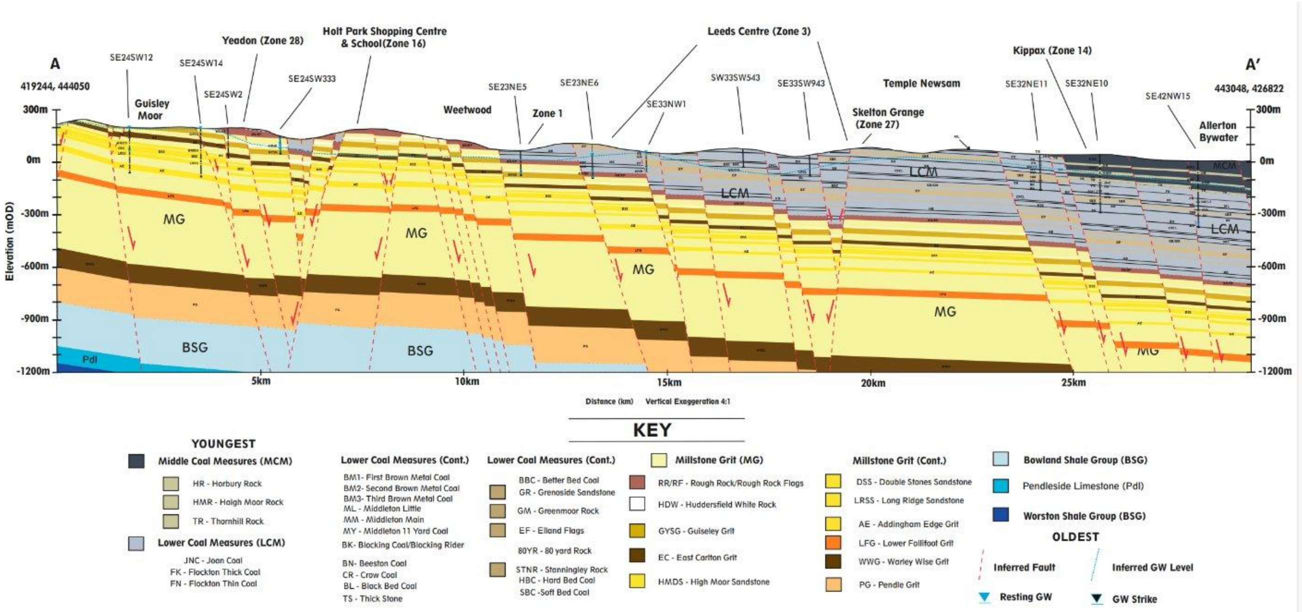
To go forward
Needs interdisciplinary effort across sectors to become viable/ a reality

Geosolutions
Leeds

Example Geothermal Campus



- Exploring shallow aquifers for heating and cooling through a 'live' geothermal project and living lab
- 2024: geothermal drilling underway, 8 sites
  - Information for scheme design
  - Gather data across wider campus
  - **Reduce risks for university and beyond**

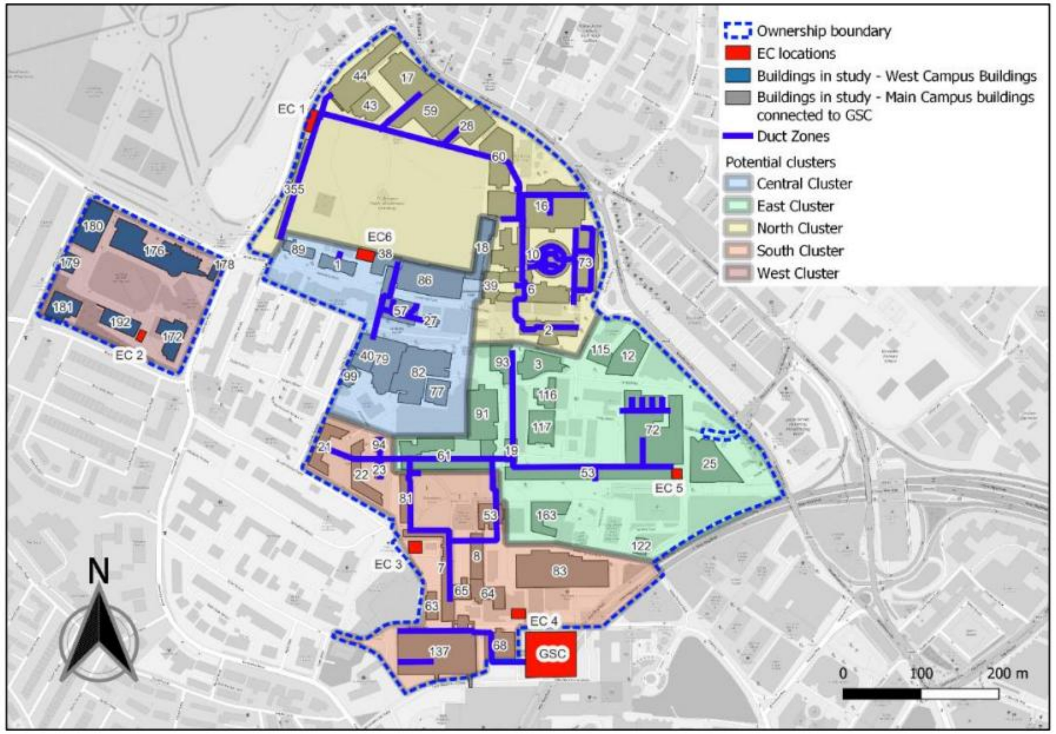


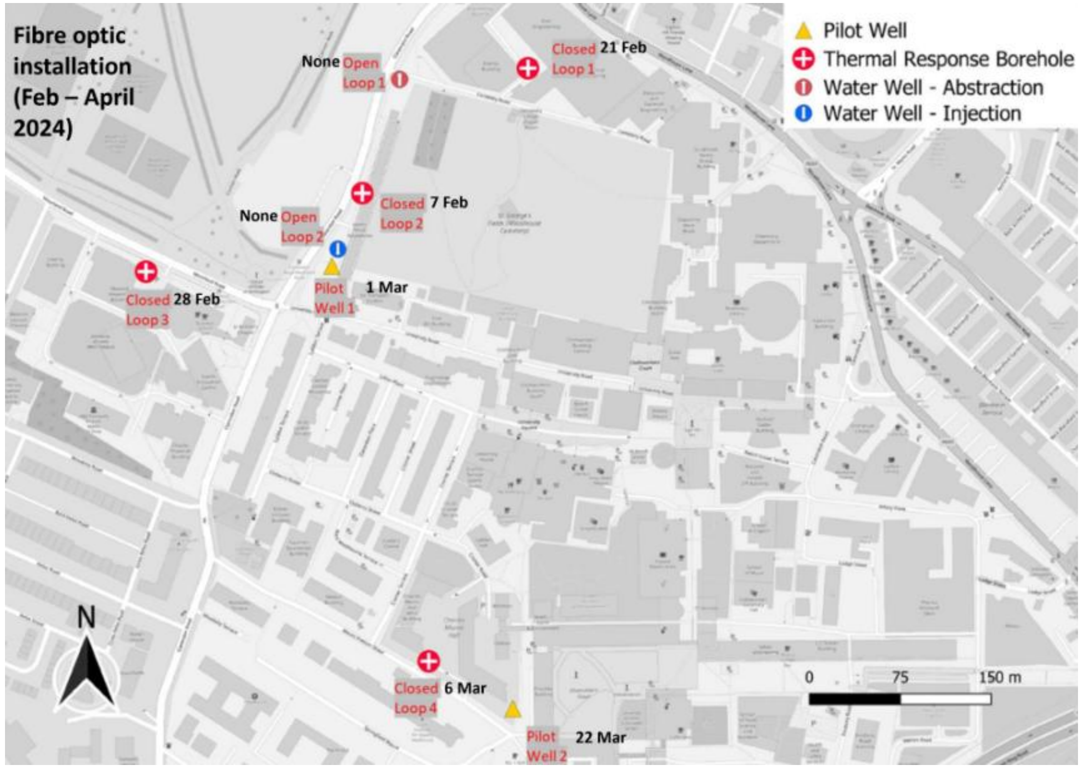
Gouiza et al. submitted

Geosolutions
Leeds

Communication is Key

Geothermal Campus – Co- design with estates/ Uni. council



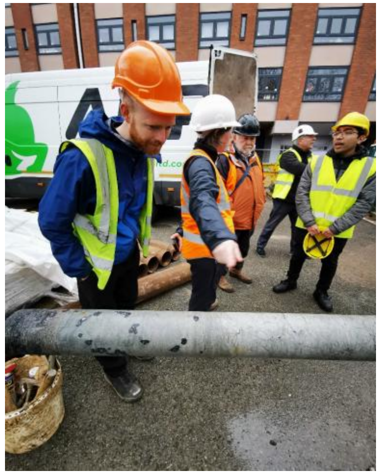


Lessons Learnt

Importance of trust and personal relationships
e.g. estate manager: knows his limitations – asked for help
Consultancy – several ex-students – willing to listen, personal interest

Geosolutions
Leeds

Geothermal Campus – Vision developed/Co-design with estates and university council



- Exploring shallow aquifers for heating and cooling through a ‘live’ geothermal project and living lab
- 2024: geothermal drilling underway, 8 sites
  - Information for scheme design
  - Gather data across wider campus
  - Reduce risks for university and beyond
- A living lab for research and student education
  - Linked research activity & leverage other funding
  - Capture activity for taught courses & data for student research projects
- Impact
  - Net-zero carbon heating and cooling for the University of Leeds campus
  - Supporting commercial scale-up through subsurface intelligence and derisking investments

Barriers & Solutions

Based on Geothermal Campus Experience

Geological challenges

- Took about one year to get to legacy data - boreholes
- Geological model provided by contractor too simplistic (needed to ask several times for improvement)

Technological challenges

- First phase – only funding for heating not cooling
- Needed policy, economic change before technology could be developed

Continuous Communication is Key

Socio-economic challenges

- Convince estates of low risk
- Implementation of system to monitor potential disruptions (extra funding for DAS and DAT system in monitoring holes)

Policy-regulatory-governance challenges

- Since University property no direct challenge
- However still unclear who owns the heat
- Need of external contractor for derisk -> expensive/ needed for insurance purposes

(DAS/DAT – Distributed Acoustic Sensing/Temperature)

Barriers to adopting shallow geothermal solutions at local and regional level

Lack of consideration
-> “Don’t know this is possible”
-> “Cannot quantify easily”

Commercial Leeds City climate commission report: NO geothermal

Lack of public acceptance and regulatory framework
-> is it safe?
-> no regulation in place/ too restrictive

Lack of investment
-> Needs investment before resource is known
-> Often complicated ownership
-> Too many unknowns
-> Profit margins are small

Barriers to adopting shallow geothermal solutions at local and regional level

Need to be smarter:
Built on Oil/Gas workflow
+
- Utilize Legacy data
- Work like a surgeon (lowest interference with highest return)
- Quantify uncertainty
- Communicate in different ways and different outlets

Lack of consideration
-> "Don't know this is possible"
-> "Cannot quantify easily"

Commercial Leeds City climate commission report: NO geothermal

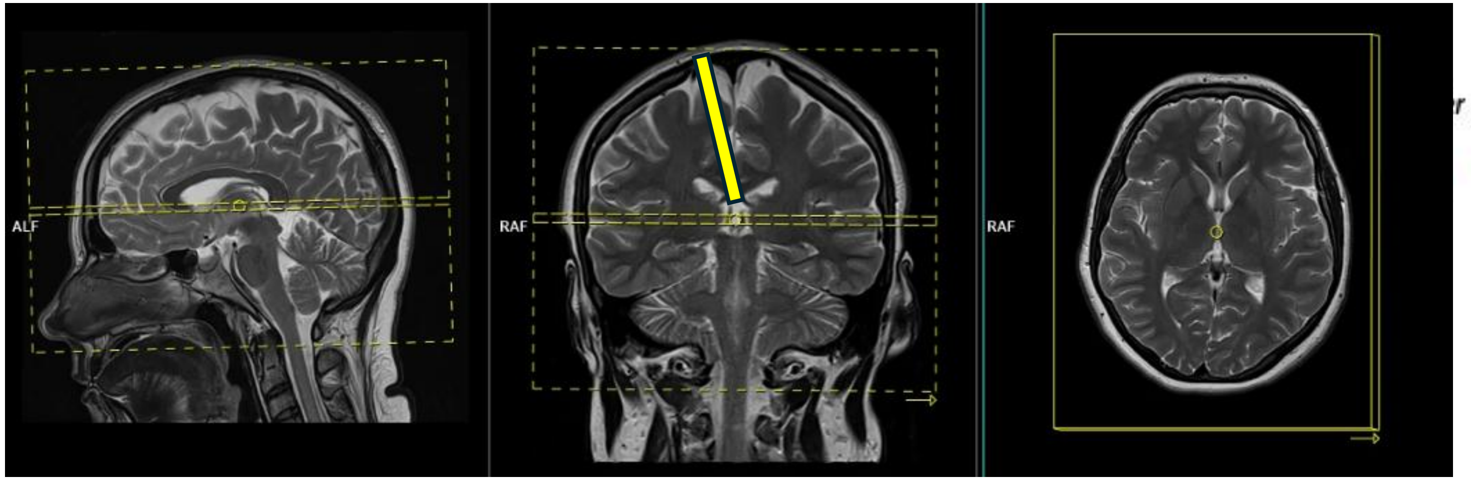
Lack of public acceptance and regulatory framework
-> is it safe?
-> no regulation in place/ too restrictive

RISK

Geological challenges
- ***Know more with less investment***
- ***Monitoring is Key***

RISK

Lack of investment
-> Needs investment before resource is known
-> Often complicated ownership
-> Too many unknowns
-> Profit margins are small



Piazolo et al. READY proposal, 2020

Barriers to adopting shallow geothermal solutions at local and regional level

Communication is Key

Geoscience on a shoe string

Need to be smarter:
Built on Oil/Gas workflow

+

- Utilize Legacy data
- Work like a surgeon (lowest interference with highest return)
- Quantify uncertainty
- Communicate in different ways and different outlets

Lack of consideration

Social-economic

s is possible”

fy easily”

Commercial Leeds City climate commission report: NO geothermal

Lack of public acceptance and regulatory framework

Social-Policy

in place/ too restrictive

Geological challenges

- ***Know more with less investment***
- ***Monitoring is Key***

Lack of investment

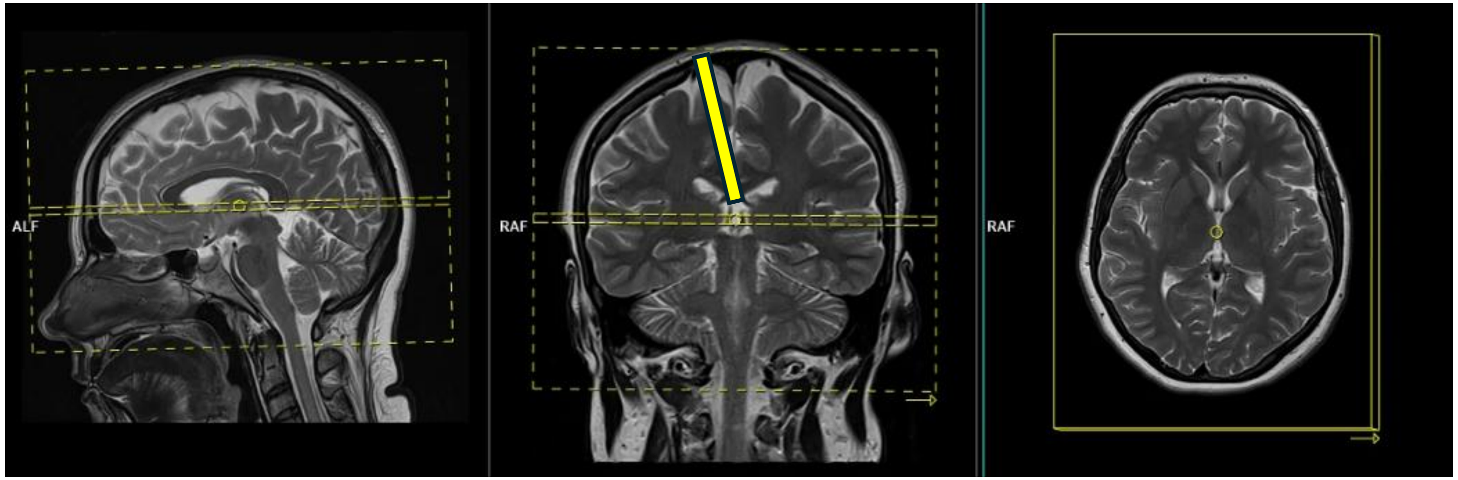
-> Needs investment before resource is known

Economic

licated ownership

knowns

-> Profit margins are small

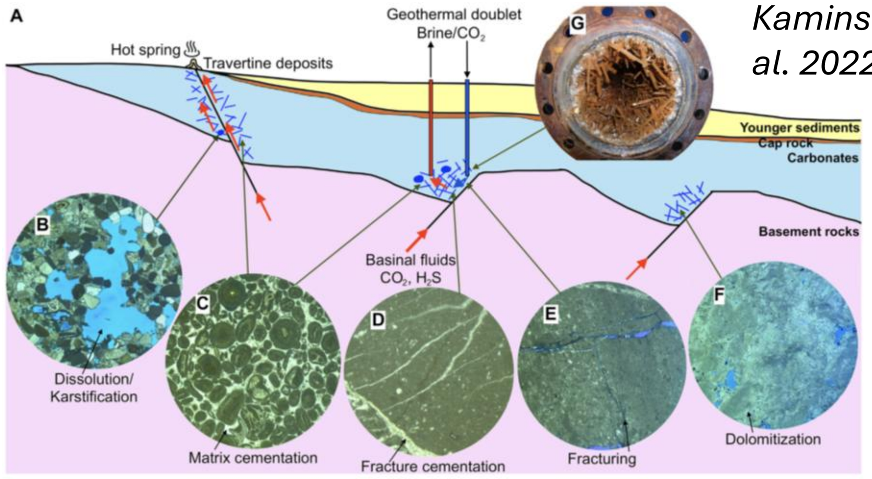


Geological challenges

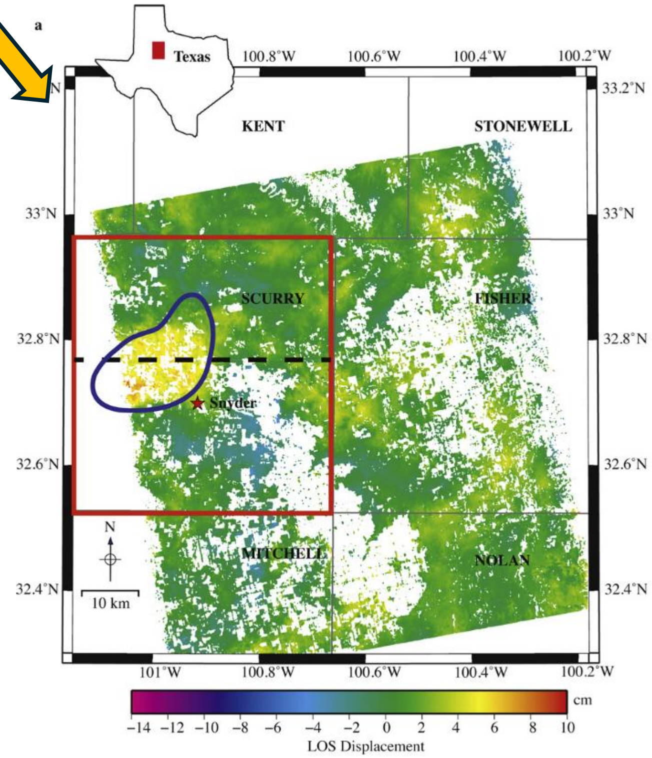
- Data sharing
- Geophysical "Grey area" characterisation
- Thermo-Hydro-Bio-Mechanical-Chemical (THBMC) effects of fluid-rock interactions
- Multiphase fluid flow - prediction
- Derisking – real time monitoring (chemical and physical) – InSAR (e.g. SatSense @ Uni Leeds/ DAS/DAT) – cheap!
- Assessing potential induced seismicity
- Quantification of Uncertainty
  -> Stochastic/probabilistic approaches/ ML
  -> challenge: communication

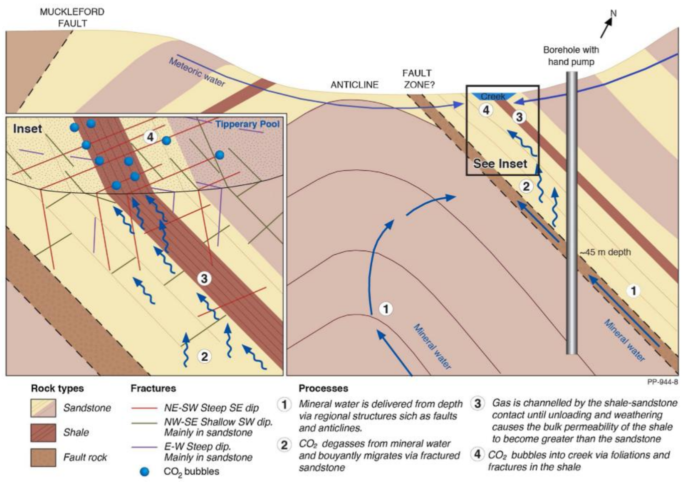
Geoscience on a shoe string

Intermediate depths below typical groundwater/engineering understanding (~100 m) and HC reservoir depths (>2000 m) is poorly characterised in terms of structure, poro-perm and geophysical characteristics.
-> New techniques needed



Kaminskaite et al. 2022



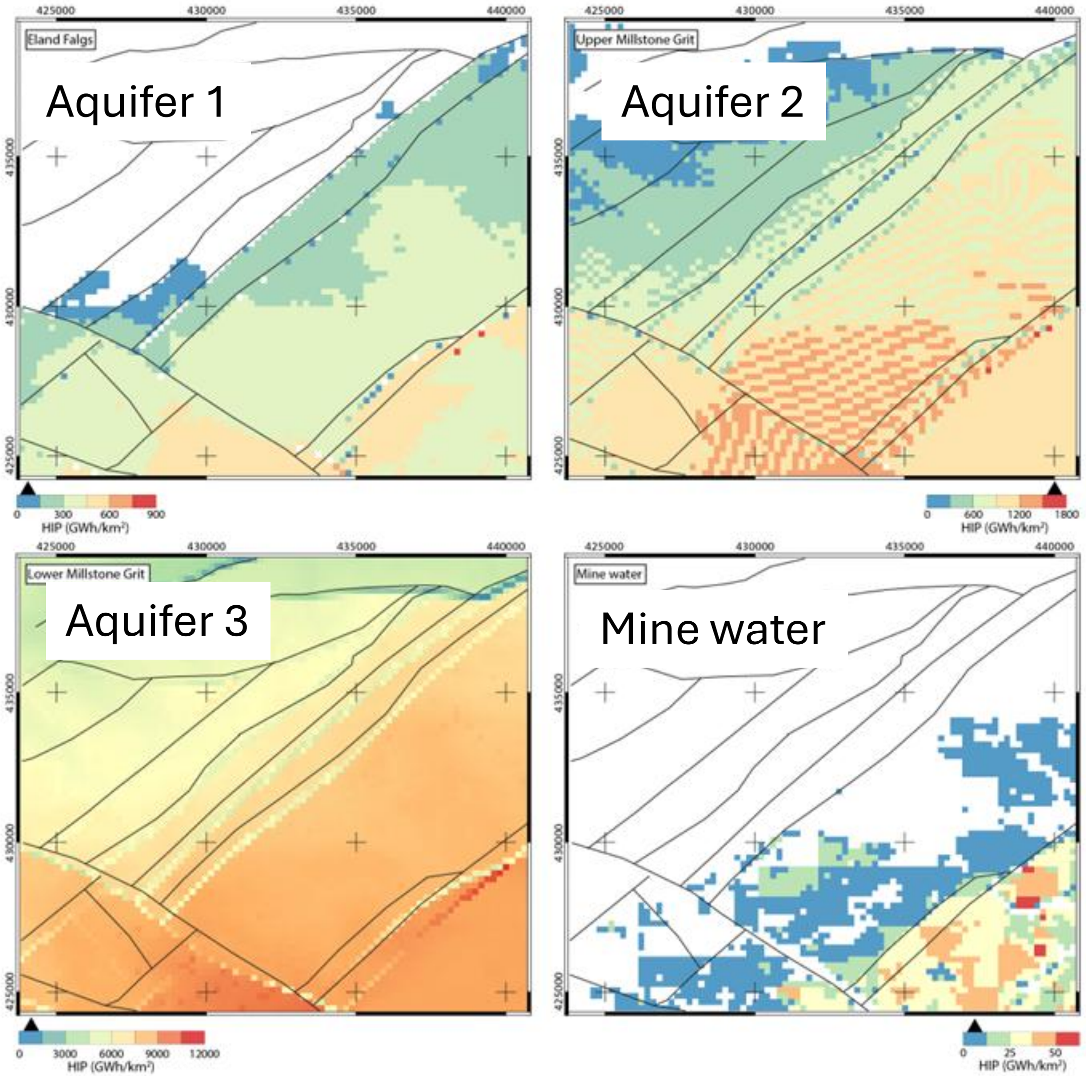


Roberts et al., 2019

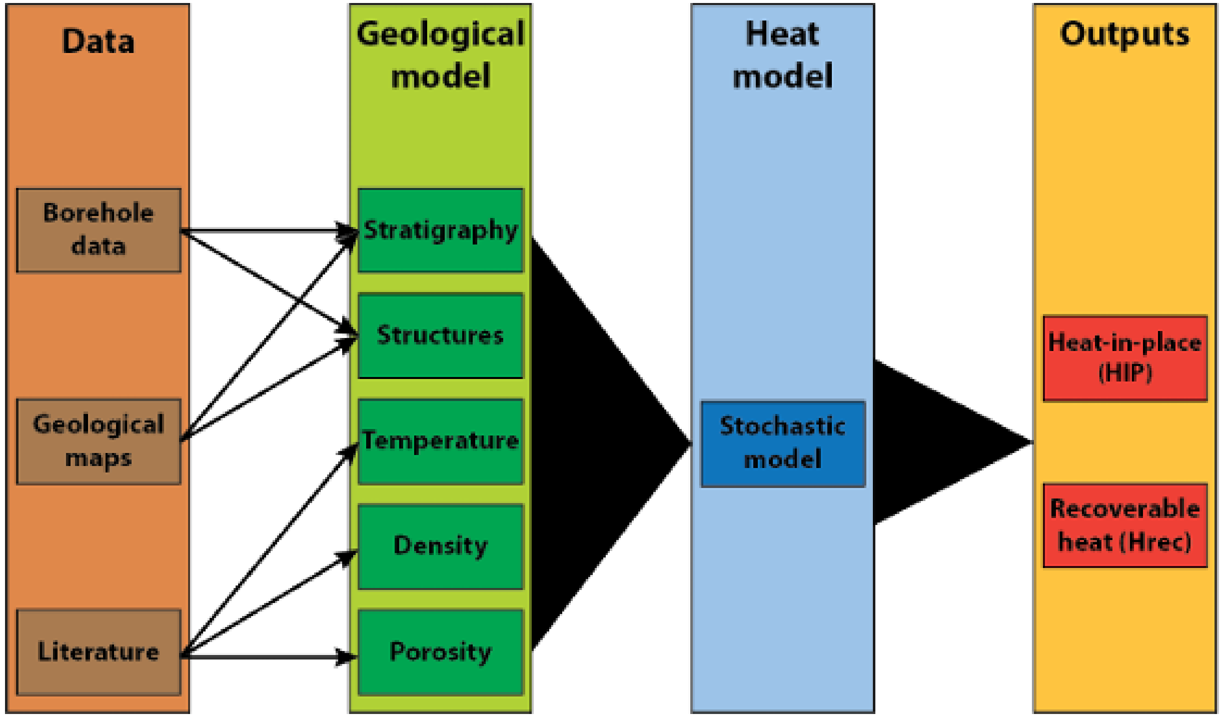
Example Leeds City Multi-level geothermal potential

Scientific journal

Output: Heat potential (Gwh/km2)



I. Workflow



Gouiza et al., submitted

Example Leeds City Multi-level geothermal potential

Policy Brief

Policy Leeds

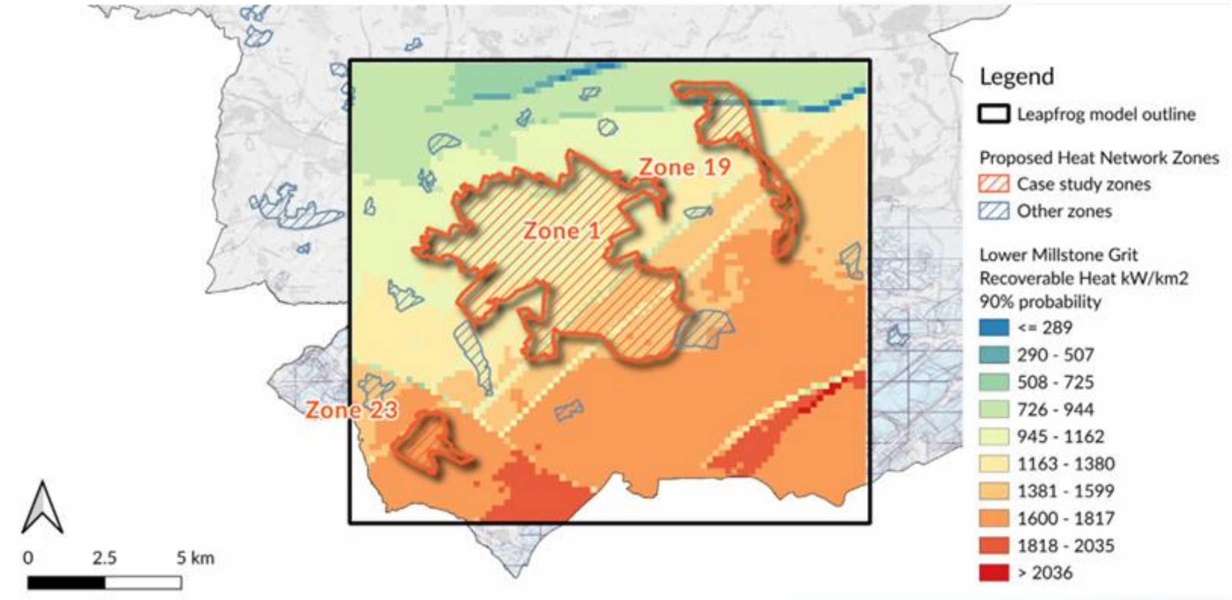
UNIVERSITY OF LEEDS

Affordable, secure and clean energy: The case for geothermal

Brief No. 14
5 May 2026

Policy Leeds
University of Leeds
leeds.ac.uk/policy-leeds

Figure 2. Mapping of geothermal heat under central Leeds. The map shows potential recoverable heat from one of the four aquifer layers modelled, the Lower Millstone Grit, with blue indicating regions of lower availability through to red indicating higher availability areas. The current designated heat network zone (Zone 1) and two additional case study zones (Zones 19 and 23) are shown.



Overview

- **Shallow geothermal is an untapped energy resource under many UK urban areas.**
- **Shallow geothermal could contribute to lowering energy bills and increasing energy security as part of the Clean Energy Mission.**
- **Research at Leeds finds reservoirs under the city centre could heat 350,000 homes**
- **Current energy planning frameworks do not account for geothermal resources and so overlook economically viable opportunities.**

Unlocking cost and security benefits

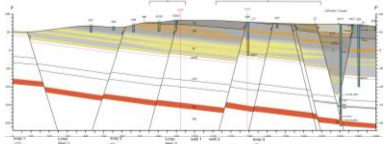
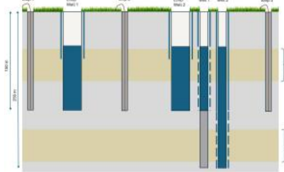
1. Make the subsurface visible in energy planning
2. Align heat, electricity and grid planning
3. Enable geothermal to capture flexibility value

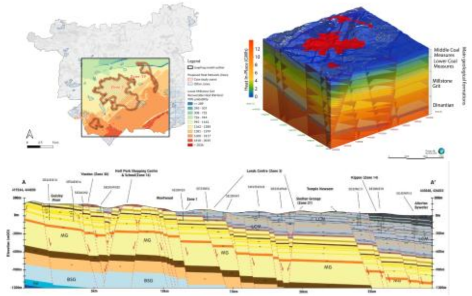
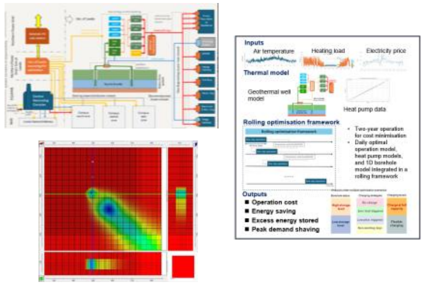
Note:
Policy Briefs
For politicians/MPs

Shallow geothermal @ Leeds

A brief History

Geosolutions
Leeds

2019 UoL climate commitment, seven 'principles'

- Net zero campus
- Net zero city
- Decarbonisation of research and teaching

2024 Geothermal city projects

- Two policy projects around geothermal heat networks in the city
- Integrating geoscience, engineering, social science, governance and business models

2025 Geogrid project

- Linking the whole energy system: boreholes/heat pumps/grid/energy markets
- Geothermal as an alternative to increasing electrification for heating, cooling and energy storage

2023 – 2026 Geothermal campus project

On-campus drilling and associated research

2019 - 2022 | 2023 | 2024 | 2025 | 2026

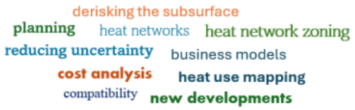
2020 – 2022 Geosolutions Leeds established

- An interdisciplinary virtual centre
- Pump priming funding from the university

IMPORTANT: Paired projects, barriers and opportunities

January 2023 UoL/LCC Geothermal Workshop

How do we get geothermal on the map?



July 2024 Enabling Geothermal Heat Networks Workshop

Exploring viability and location for future geothermal heat networks

July 2025 Enabling a Geothermal Leeds: Stakeholder Session

Exploring viability and location for future geothermal heat networks

July 2026 SAFE Leeds – Exemplar City: Co-creation Workshop

Let's go!

Lessons Learnt

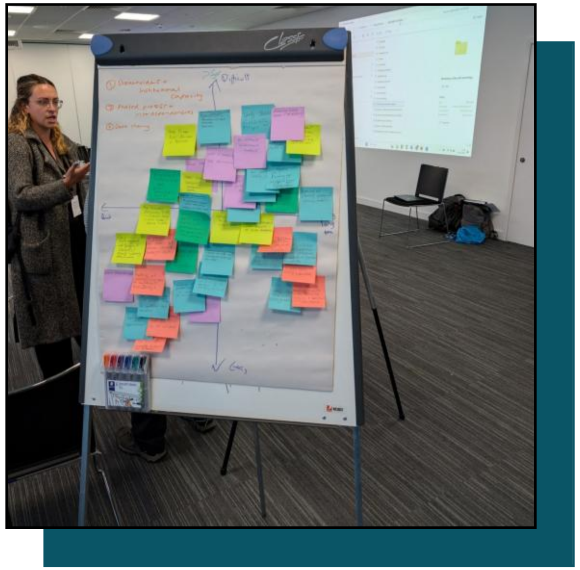
Importance of Early engagement with stake holders

Geosolutions
Leeds

Example Workshop Geothermal City

- Launch event, January 2023
- Agreement to further develop and take forward a city and regional (place-based) approach
- Highlighted areas of focus
- Non-technical factors
  - Heat use ⍰ heat networks ⍰ heat network zoning
  - New development ⍰ compatibility ⍰ Planning
- Derisking the subsurface ⍰ reducing uncertainty
  - Links back to Geothermal Campus

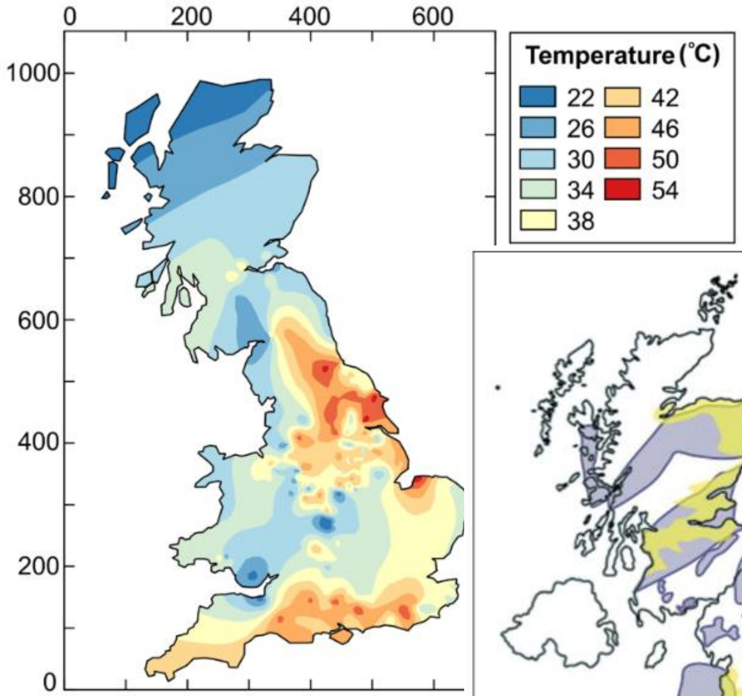
Bobo Ng from NE Local Enterprise Partnership telling the January 2023 workshop about developing minewater heat schemes



Start to work together on *Heat Network Zoning* – From national to regional to local!

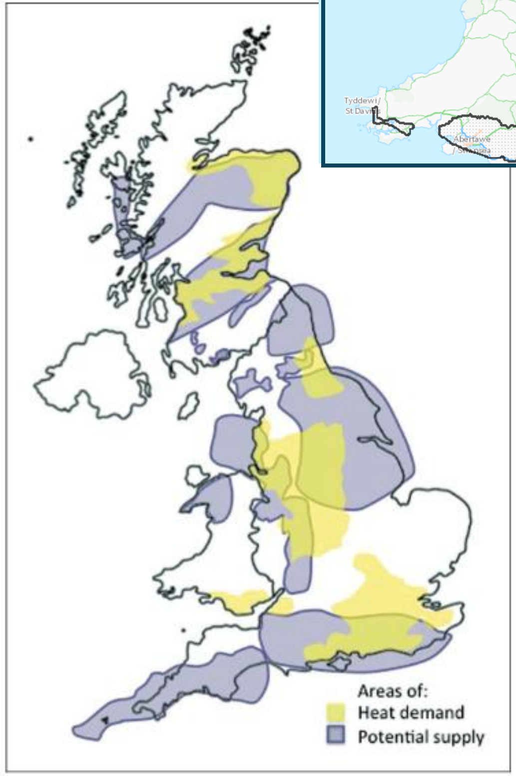
- Geographic zones across England where heat networks are expected to be the **'lowest cost solution for decarbonising heat'**.
- Spatial demand mapping using building data and optimisation algorithm to heat every building, with air source heat pump counterfactual
- Will directly influence policies in *Heat Network Zones e.g. financial support/incentives, regulatory details*

=> *IMPORTANT!!*

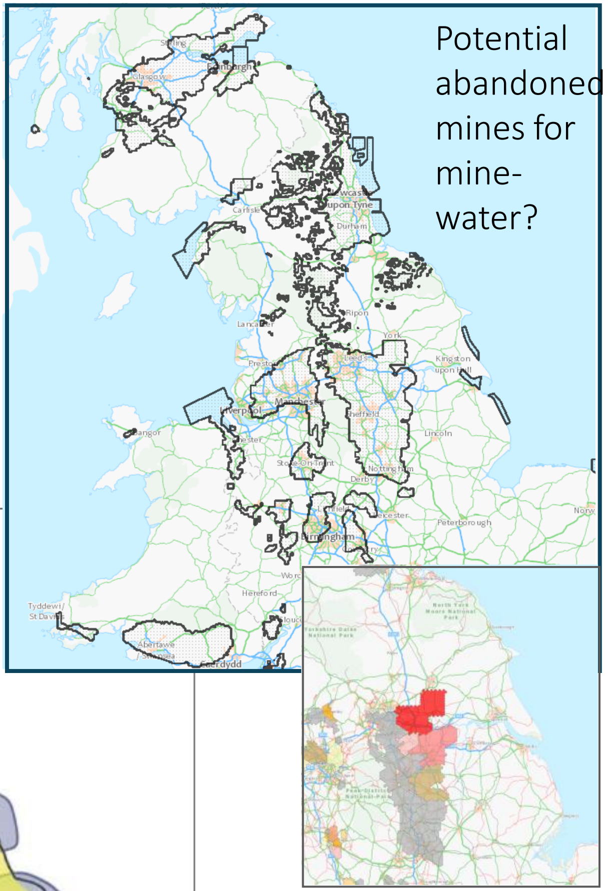


Regional temperature variation at 1 km depth across the UK

Watson et al., 2020



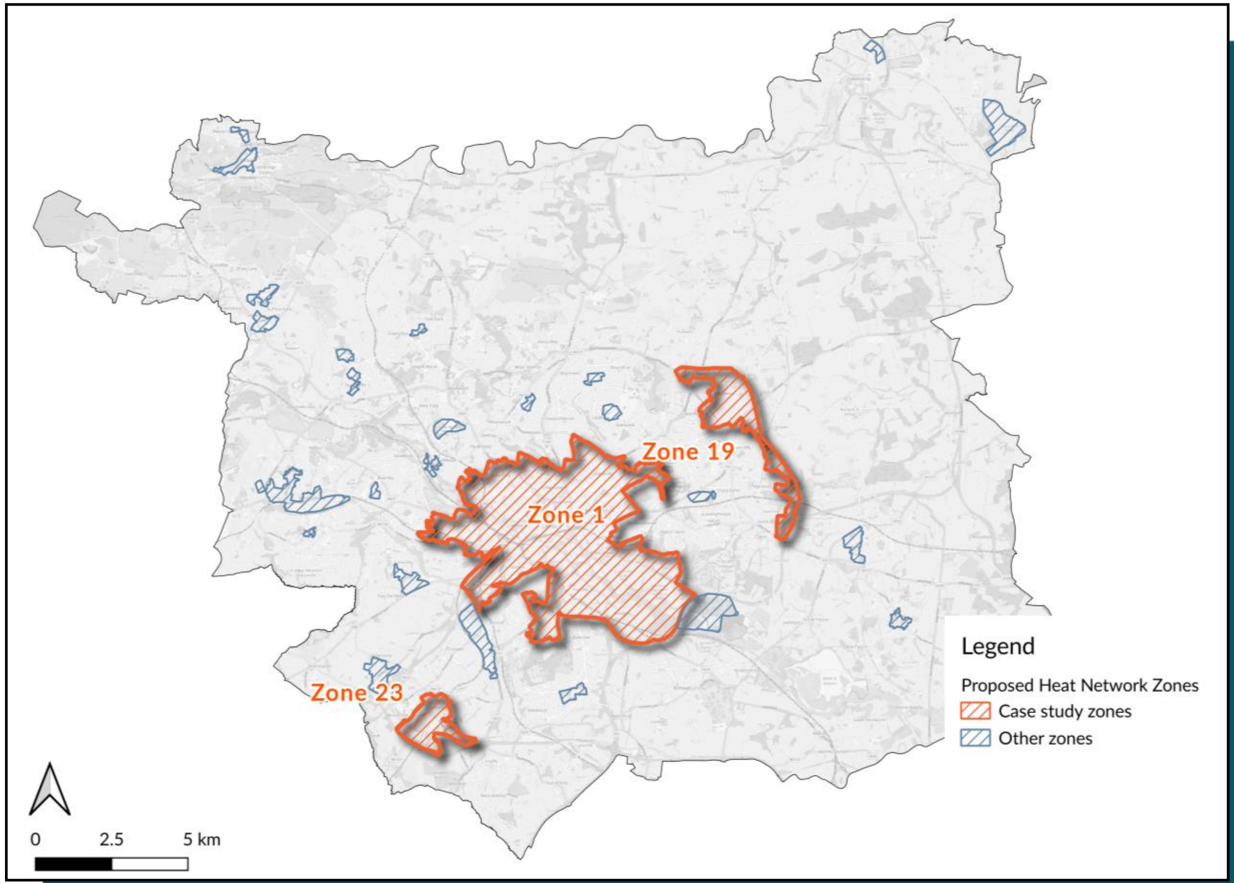
Estimated geothermal resources vs heat demand
Gluyas et al., 2018

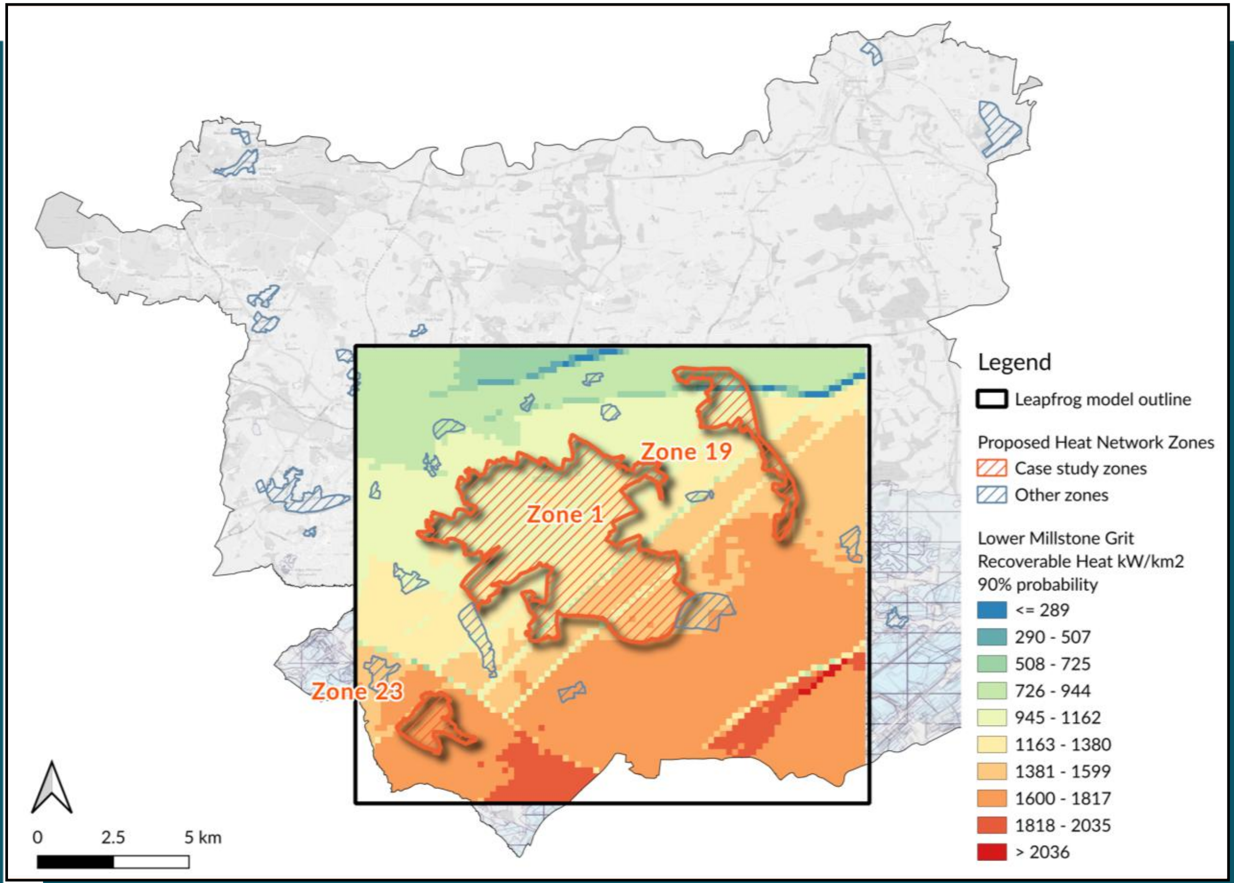


Source: Interactive map, The Coal Authority

Geosolutions
Leeds

Aligning above and below ground evidence





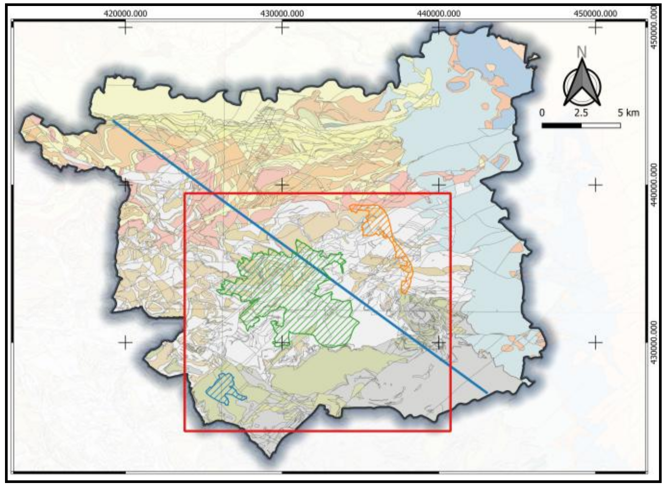
Subsurface modelling and analysis

Approach

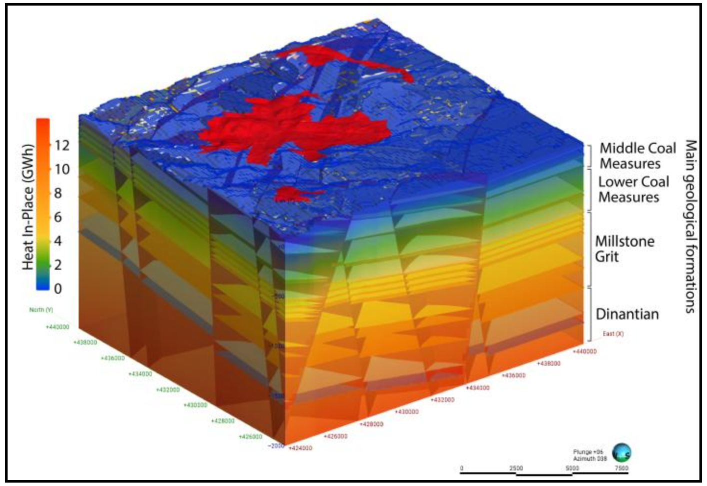
- First-order models of geology, heat-in-place, and recoverable heat
- Geothermal resources (total and specific to each aquifer) beneath case study zones

Findings

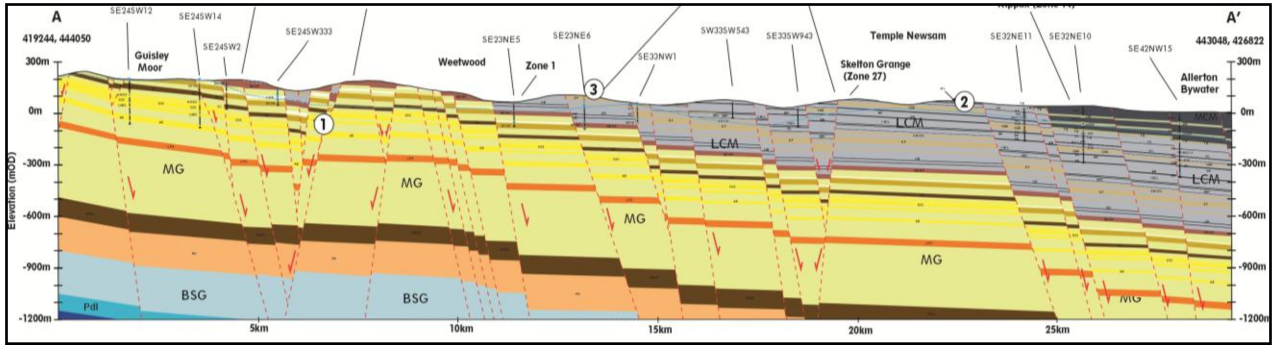
- Multiple shallow aquifers below Leeds, with different depth, temperature and energy characteristics.
- Across the city and within zones, energy availability changes (towards south-east)
- Highlights the complexity of geothermal inclusion as a heat source in the zoning model



Geological map of Leeds area (BGS)



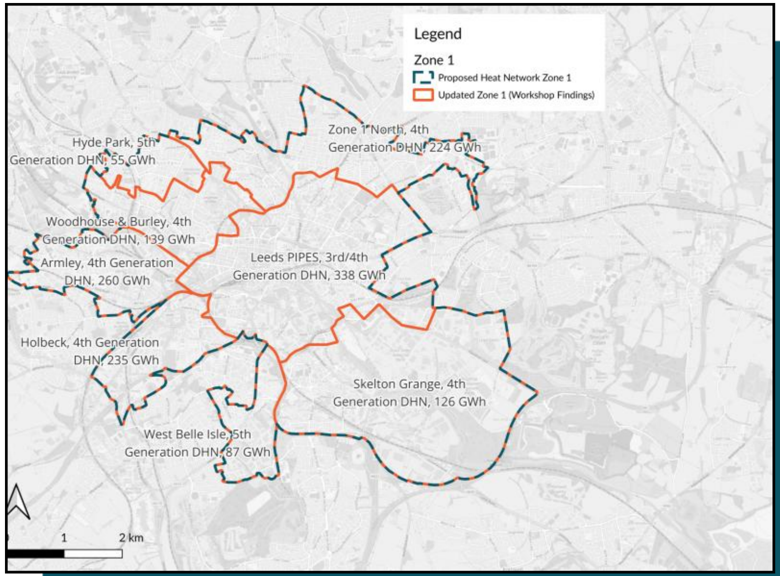
Heat-In-Place (HIP) down to 2000 m (below sea level), underneath Leeds, in GWh (Gouiza *et al.*, Geosolutions Leeds, 2024 (in prep))

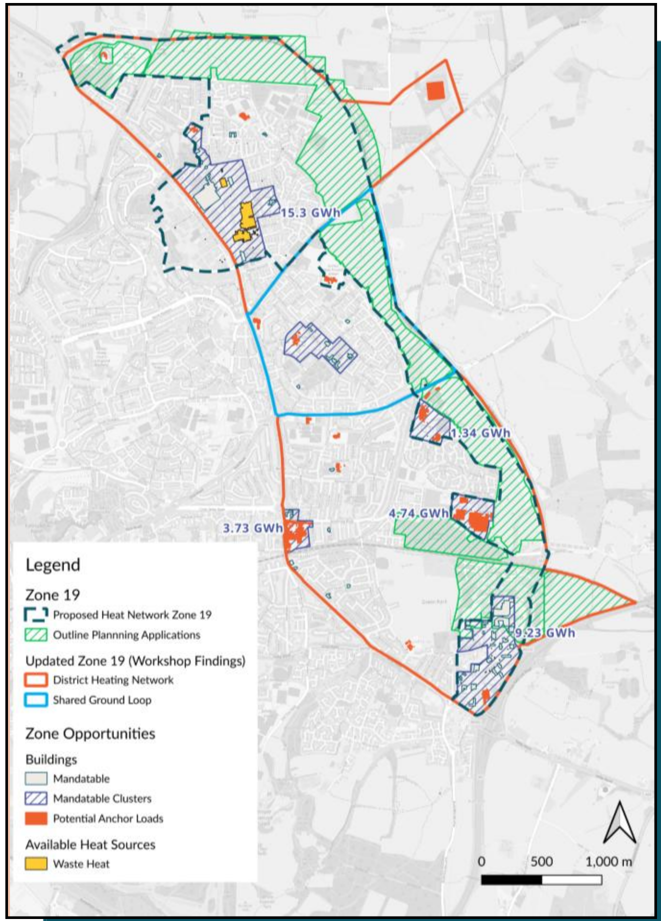


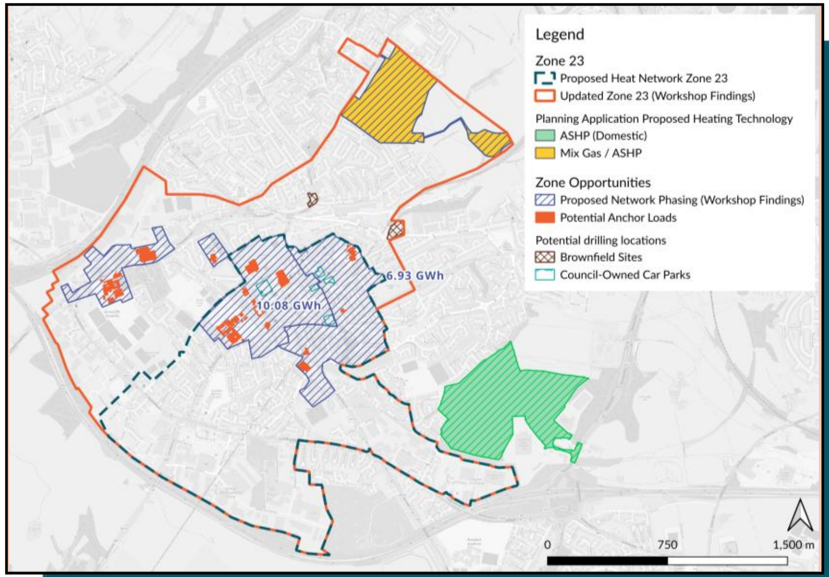
Geological cross-section over Leeds (Johnson, Geosolutions Leeds, 2024)

Geosolutions
Leeds

Proposed heat network zones - Leeds City







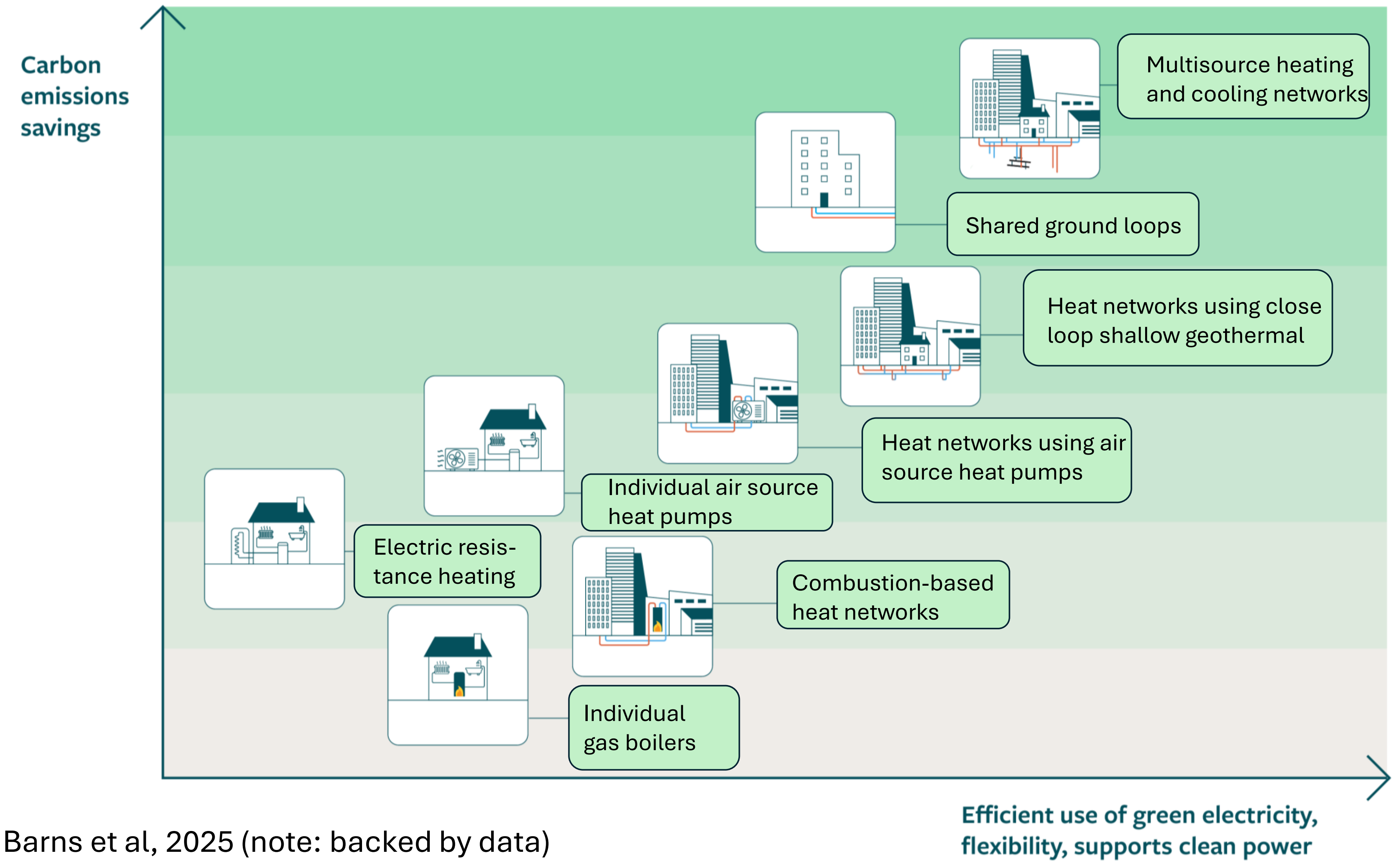
Barns et al. (2025, in prep)

Geosolutions
Leeds

Lessons Learnt

Outcome Example Optimal deployment in urban areas

Communication Tools



Barns et al, 2025 (note: backed by data)

Lessons Learnt

Importance of Early engagement with stake holders

Geological challenges

Technological challenges

Communication is Key

Socio-economic challenges

Policy-regulatory-governance challenges

How to communicate ? – How to co-create?

Example stakeholder/regulator engagement

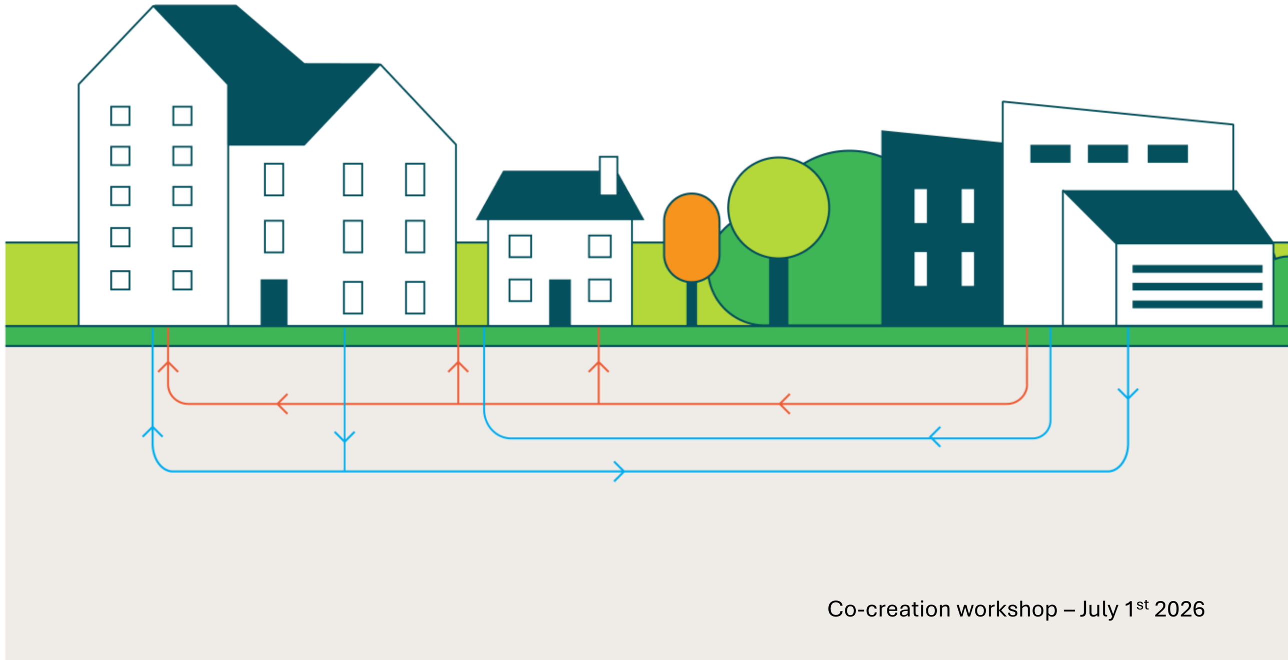
Geosolutions
Leeds

stakeholder/regulator engagement workshop City Leeds

Footwork before workshop

- Long term planning
- Identify key players
- Significant time – morning / afternoon
- Neutral venue
- Facilitator if possible
- Clear goalsetting
- Chatham house rules

When a meeting, or part thereof, is held under the **Chatham House Rule**, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed.



Comment by Leeds City Council worker:
“First time I meet and have time to discuss with other members of Leeds City Council / other divisions”

Aims for today

Session 1

- Vision

Session 2

- Deeper dive into the practicalities of implementing the vision

Session 3

- Making it happen

What would be your 10 word vision statement for Leeds City Council Energy Development in next 5 years?

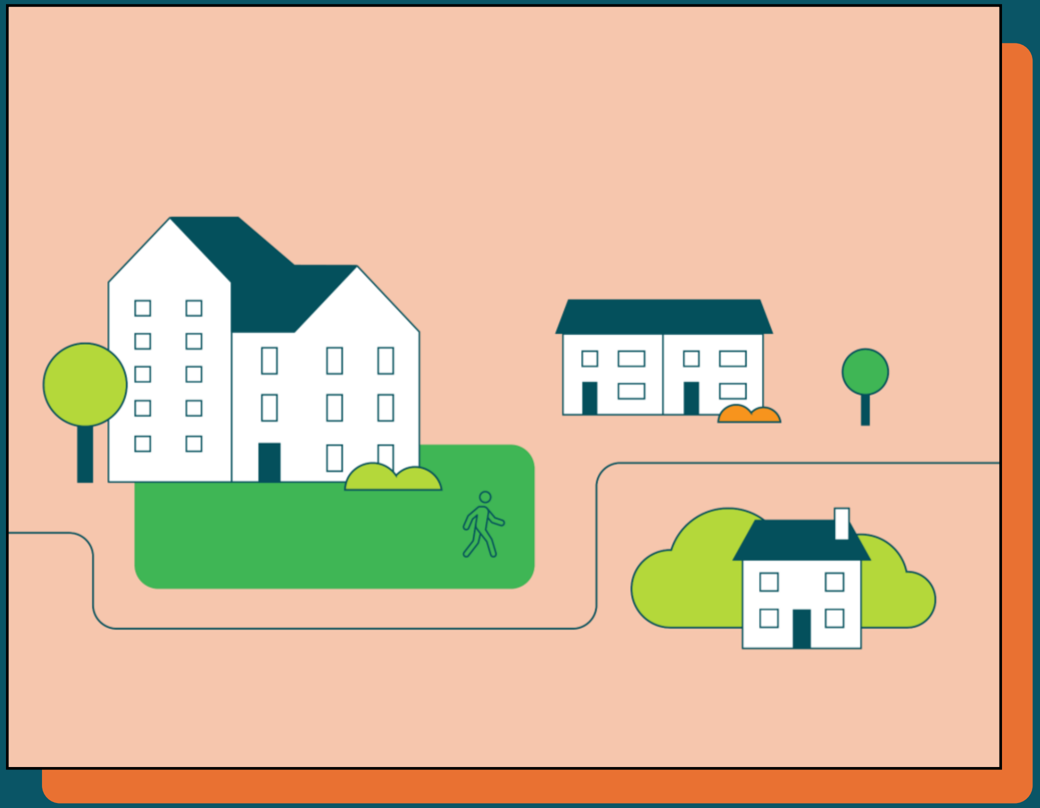
Just collect and show

The Slido app must be installed on every computer you're presenting from

slido

Session 2

Collaborative session 2: The mechanics



Geosolutions
Leeds

Session 2: Deeper dive into the practicalities of implementing the vision

Pre-defined break out groups

Group 1: Optimal use and regulation of the subsurface

- How could different aquifers be used for different purposes?
- How might a strategic approach to allocating the subsurface impact its use?
- How ‘should’ heat ownership be optimally regulated locally? (i.e. 2D, 3D, flow…)
- How does technology choice / approach (e.g. casing) interact with regulations around heat ownership
- How to manage the balance between open and closed loop systems, to avoid interaction?

Group 2: Aligning heat use, heat networks, & geothermal at city scale

- How can decisions about technology adoption above ground be made strategically at a local level?
- What about zones outside of the current pilot?
- How can we work with Planning to facilitate this in areas of new development?
- How might the regulation of heat networks change the sector?
- How will changes to building regulations impact the sector?

Group 3: Developing a local / city regulator

- What kind of entity / is this a new local institution?
- How would it be resourced?
- What area should this cover? The city, the region?
- How would this entity work with other relevant stakeholders?
  - LZCs, LAEPs, RESPs…
- How much flexibility would be appropriate… national to local?
- What is a minimum viable product?

Short reports back to wider group

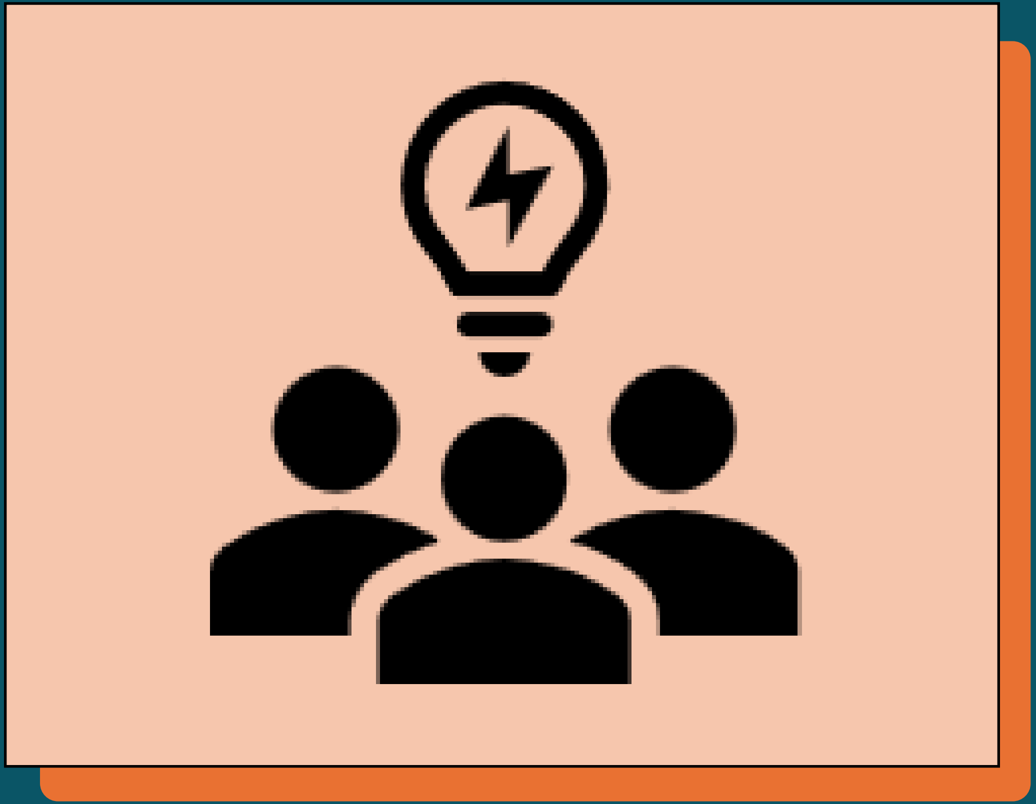
Lunch - Buffet

UNIVERSITY OF LEEDS

Session 3

Making it happen

Please move around as you like!



Geosolutions
Leeds

Session 3: Making it happen – the process

Group 1: Stakeholder mapping

- Who needs to be involved in the process?
- What role would they play?
- Who isn't here but needs to be?

Group 2: Journey mapping

- Where are we starting from?
- How do we get there?
- What are the key steps along the way?
- Are there parallel journeys?

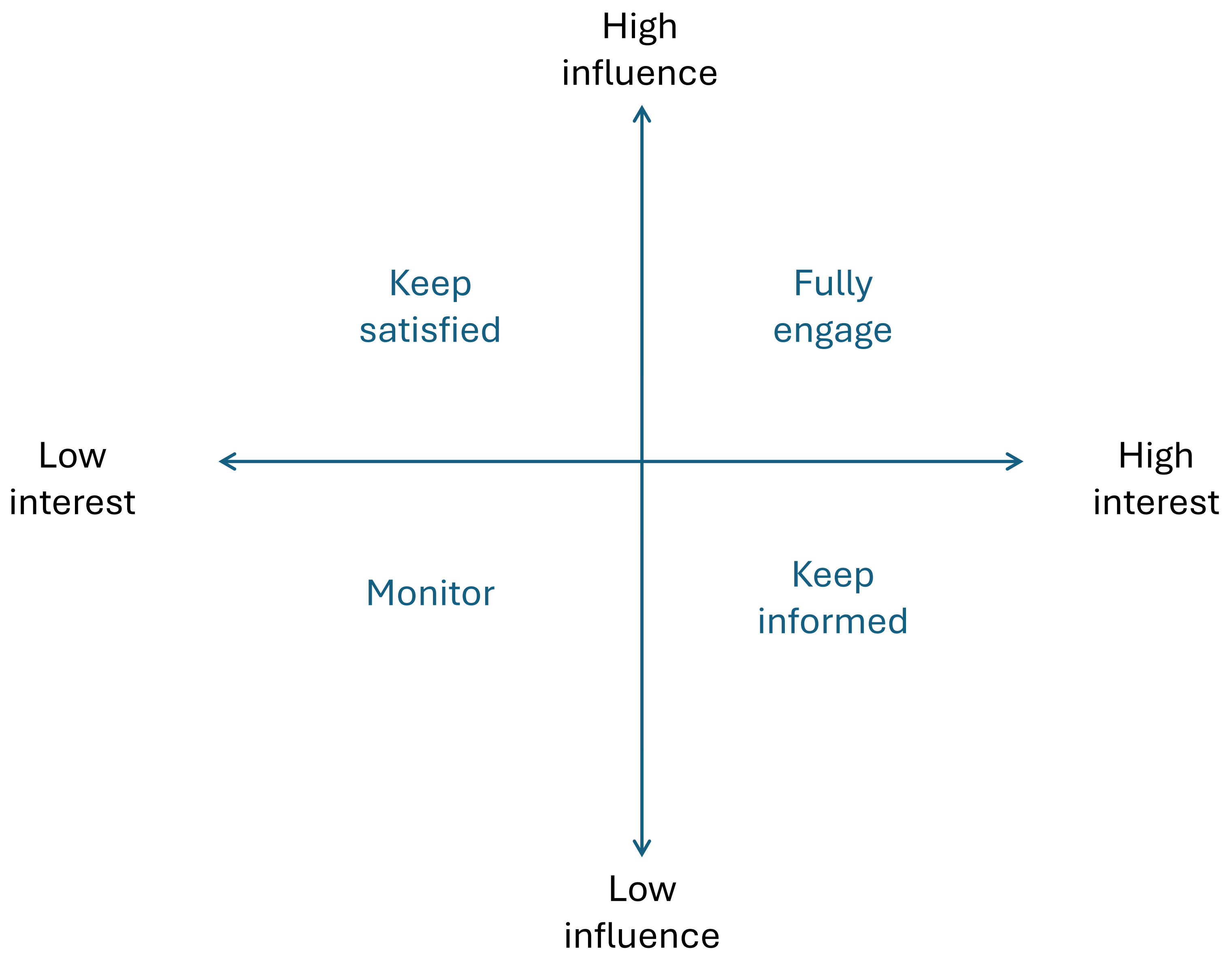
Group 3: Priority mapping

- What are the key priorities for the process?
- Impact/effort framework
- What is a minimum viable product?

Geosolutions
Leeds

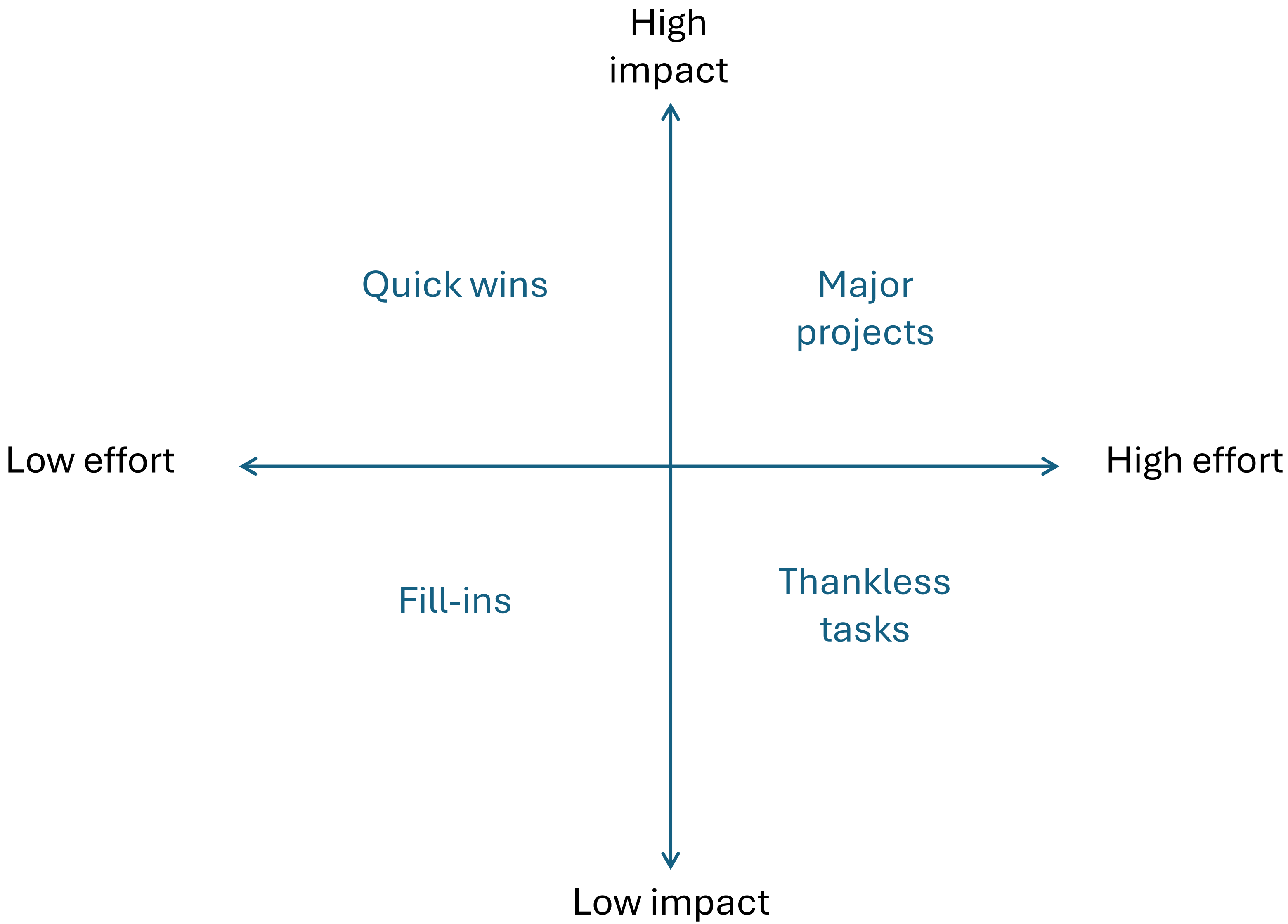
Stakeholder mapping

Add post-it notes



Geosolutions
Leeds

Priority mapping

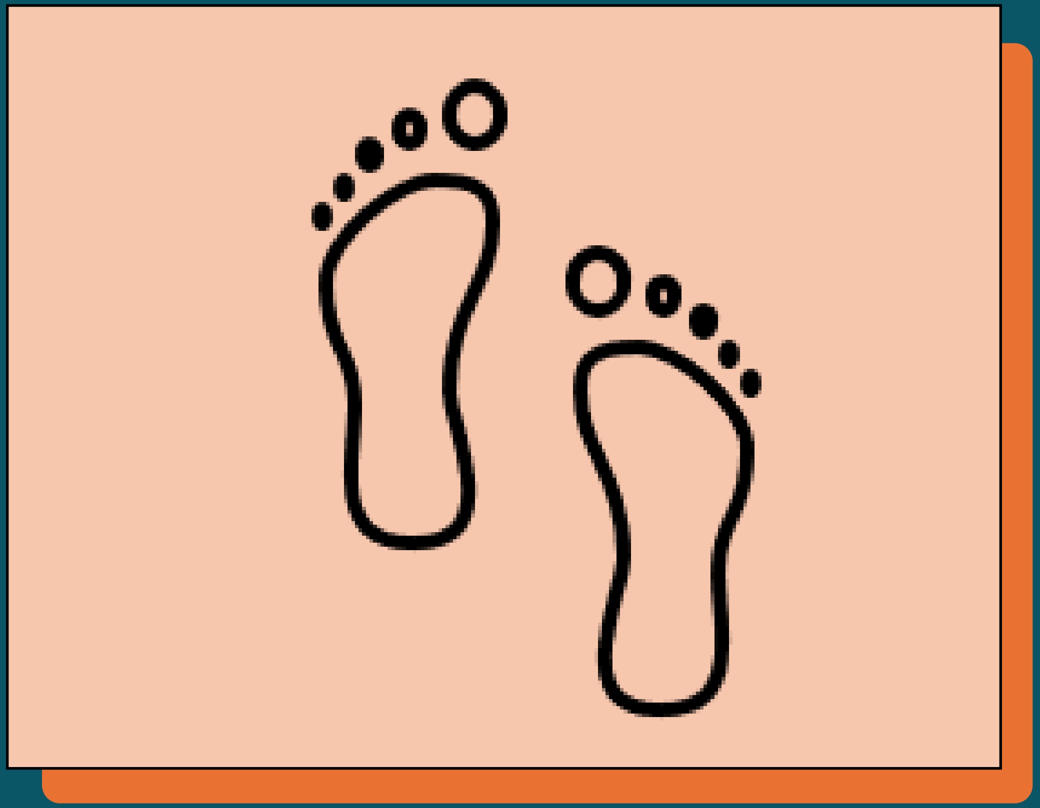


Add post-it notes

What do you think are the key challenges we should be focusing on?

Would you be up for joining us on this journey?

Wrap-up and next steps



Geosolutions
Leeds

Lessons Learnt – Leeds City – Action points examples

- A database of open access geodata £
- How to guides: technical, planning, investment etc £
- Proposals for governance or planning approaches £
- A programme of community participation £
- More detailed surface/subsurface/technology mapping £
- City wide training scheme £
- City wide geophysics £££
- Site specific drilling ££
- Demonstrator sites £££

Step one: Co-production Identify Actions

Step 2: Proposal writing for funding

Step 3: Action

Lessons Learnt – Skills needed

"Best technical solution will never be implemented at the needed scale if there is
- no regulatory framework
- no economic feasibility
- no public buy-in/acceptance"

Geological

Technological challenges

Policy-regulatory-governance challenges

Geological Knowledge
Need to be smarter:
Built on Oil/Gas workflow

+

- Utilize Legacy data
  -> built open access data
- Work like a surgeon – targeted d
  (lowest interference with highes
  -> new approaches/AI aided/open
  communication
- Quantify uncertainty & commun
  (learn from hazard modelling/ pr
- Cheap monitoring (citizen scien
- Detailed knowledge (fluid – rock reactions are different, timescale are different to oil/gas)
- Advance modelling (cheaper than drilling)
  -> probabilistic inversion

Take home message
"Go beyond the technical report"
- Extract more info with less data
-> innovate
- Identify barriers - jointly create solutions
- Engage early, communicate, influence

You can influence policy/
Regulation decisions

nagement Skills
respect concerns

key / don't change a winning

volved (Remember Stakeholder
meeting tips)
- Communicate: Geology is place-based
  -> effect on policy making and regulatory planning
- Put Geology on the map early and continuously

Thank you to the Leeds Uni team:
David Barns, James Van Alstine, Fleur Loveridge, Emma Bramham, Simon Rees, Nick Shaw, Fred Pessu, Frin Bale
& Geosolutions Leeds support team

Geosolutions Leeds

Thank you to Stakeholders/Industry

NORTHERN POWERGRID

STAR REFRIGERATION

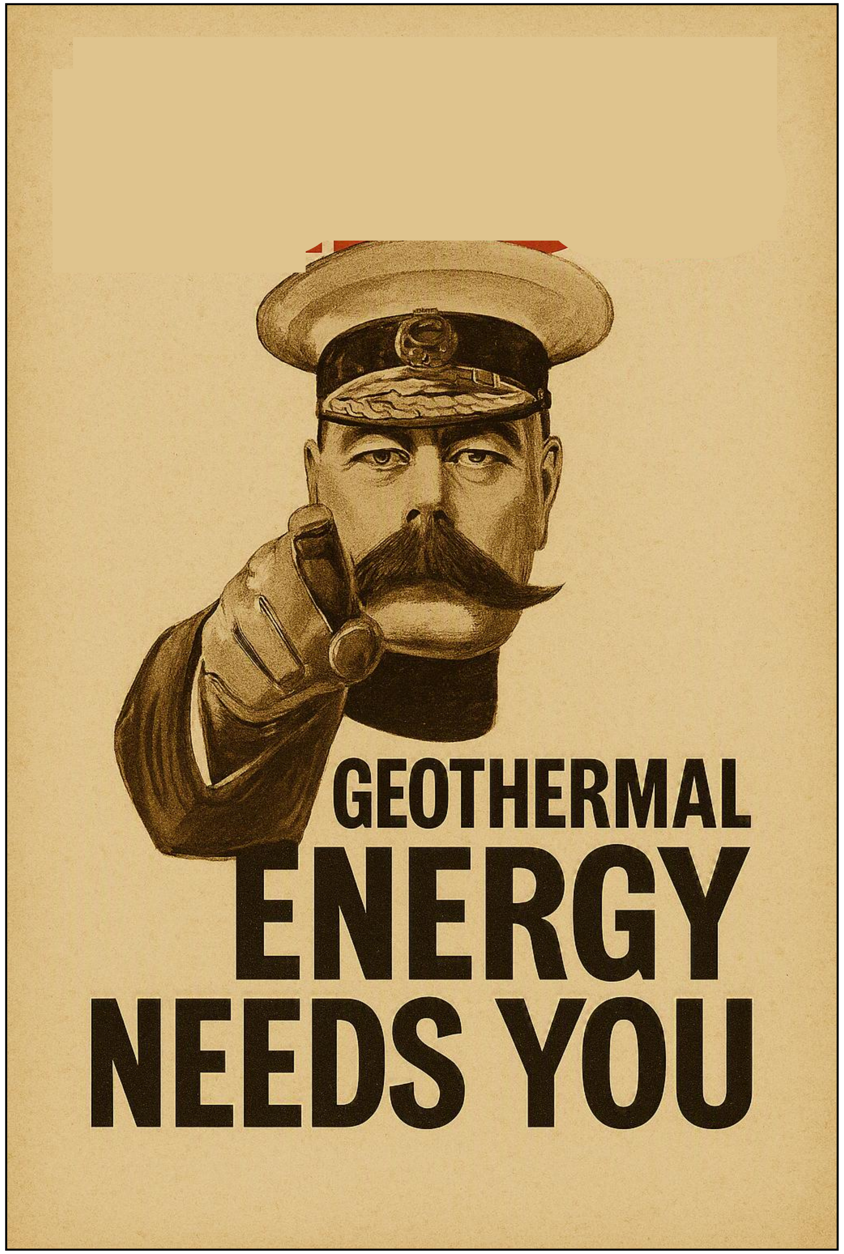
Leeds CITY COUNCIL

LCPDelta

e·on

Thank you for listening

Questions? Comments? Experiences to share?



www: geosolutions.leeds.ac.uk