PUSH IT

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Engagement Catalogue

Guidance and inspiration for engaging communities with underground thermal energy storage

April 2026

This catalogue is the product of a collaboration between members of the PUSH-IT consortium and external engagement experts. The collaboration was led by Dr. Merryn Thomas, Dr. Iain Soutar and Prof. Patrick Devine-Wright at the University of Exeter, and Dr. Melanie Rohse and Dr. Madeleine Kechagia at Anglia Ruskin University.

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Welcome

Underground Thermal Energy Storage (UTES) offers the potential to contribute to decarbonising the energy system and managing seasonal demand for heat. The Horizon EU project PUSH-IT (Piloting Underground Storage of Heat In geoThermal reservoirs) is testing three ways to store heat up to 90°C, in mines, boreholes and aquifers at six sites. These are in Delft (Netherlands), Litoměřice (Czech Republic), Bochum, Darmstadt and Berlin (Germany) and United Downs (Cornwall, UK). More information can be found at www.push-it-thermalstorage.eu.

As well as the technical feasibility of UTES, PUSH-IT explores governance, business models, and societal engagement. Engagement is essential for such technologies to be supported, fair and legitimate (Soutar et al, 2022), but for many people, UTES is invisible and unfamiliar, making engagement particularly challenging. And because UTES engagement is in its infancy, it can be difficult to know where to start when planning engagement activities.

This catalogue provides guidance, inspiration, and resources for a range of engagement approaches, from school science projects to in-depth deliberative workshops. It has been co-created with engagement practitioners, and partners at each of the PUSH-IT sites (see inside front cover for contributors). We hope you enjoy it.

How to use this catalogue

This catalogue is designed to inspire and guide engagement around underground thermal energy storage, but many of the ideas are also applicable to other energy technologies and engagement practice more broadly. It is organised into four sections:

1. **Introduction**	Tips and advice on public engagement, including 'best principles', timelines, recruitment and ethics.
2. **Engagement Formats**	An overview of engagement formats, from town hall meetings to questionnaires.
3. **Engagement Activities**	Catalogue of activities, designed to be adapted and used however and with whomever you wish. A guide to suggested ages and formats at the beginning of each section may be useful for choosing activities for your particular engagement.
4. **Resources**	Answers to quizzes, glossary, and references.

Adapt activities to your audience, context and timeframe. We would be delighted to hear your own engagement ideas and find out how you are using the catalogue, so please get in touch at m.j.thomas@exeter.ac.uk.

Contents

01 Introduction to engagement

Engagement describes the ways that communities and project developers interact, connect and communicate. This can range from one-way communications from industry to community, through to communities taking control of project decisions.

1.1 Why engage with the public?

It is important to recognise and be transparent about why we want to engage. Rationales for engagement include:

- Engagement is **the right thing to do** (normative rationale)
- Engagement **leads to better decisions** (substantive rationale)
- Engagement **serves an end**, e.g. building alliances (instrumental rationale)
- Engagement is **required** (mandatory rationale)

(Fiorino 1990; UK Government 2022)

> "Resistance to renewable energy projects is often not about the technology. It's about the process. Communities do not reject clean energy; they reject being left out of the conversation" - Gerdien de Vries, Professor of Climate Psychology, Delft University of Technology

1.2 'Best principles'

While there may be no single 'best practice' in public engagement (Dietz and Stern 2008), the following could be described as (evolving) PUSH-IT 'best principles':

- **P – Participative:** Foster active involvement and (if possible) decision-making, not just one-way communication. Processes should strive to be fair and equitable (Ryder and Devine-Wright 2022).
- **U – Useful:** Engagement doesn't have to be fun, but it should be a useful and positive experience for organisers and participants – e.g. gaining understanding, a voice to be heard, or increased agency (Gallagher 2025). It is also a space for innovation and provides opportunity to experiment and develop engagement practice.
- **S – Sensitive:** Actively listen to and respond to community values, emotions, and perceptions before designing your engagement (Pidgeon and Fischhoff, 2011). Use trusted communicators (UK Government, 2025) and be aware of local histories and contexts (Roberts et al., 2023).
- **H – Honest:** Be transparent about reasons for engagement, project plans, intended outcomes, risks, and the potential (and limits) for the public to influence projects. Provide clear and open information about the science (UK Government, 2025).
- **I – Inclusive:** Ensure diverse voices are heard and engagement is tailored to different needs (Rohse, et al. 2024). Consider power dynamics and ensure all voices have an opportunity to be heard, including those who are local and distant from a project (Cotton, 2017).
- **T – Timely:** Engage early and sustain meaningful participation (Rowe and Frewer, 2000). Engagement processes can occur throughout the project life course (see page 9), but will evolve over time, dependent on shifting knowledges and the stage of deployment.

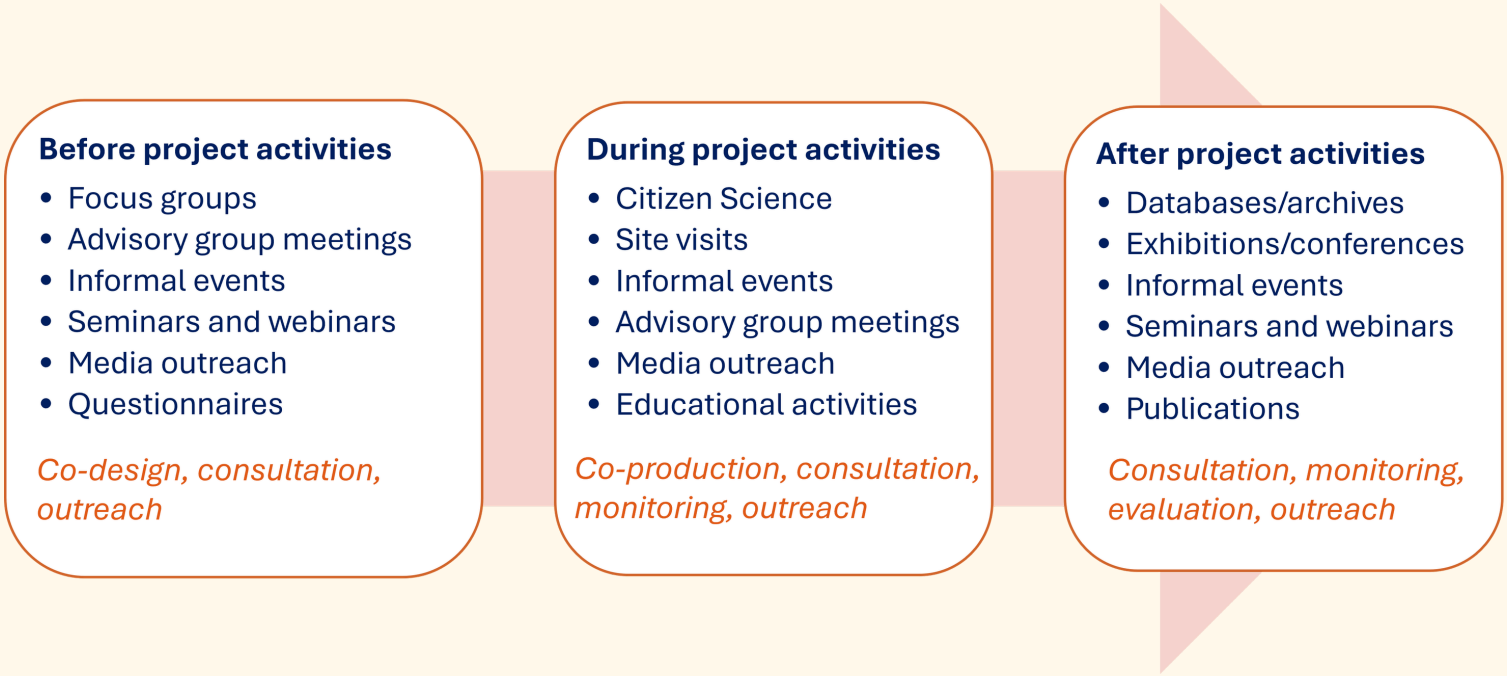
1.3 Engagement timeline

When designing an engagement strategy:

Adapted from Martell, 2024

1.4 When to engage, and how?

Public engagement is not a one-off event, but a continuous process that evolves with the project lifecycle, and should continue after the drill rigs have left (see Boven et al, 2025). This diagram provides just a few examples of engagement activities that can be appropriate before, during, and after UTES project activities.



adapted from NCCPE, 2023

As well as the stage of the project, several other factors come into play when deciding which format (Section 2) and activities (Section 3) to use for your engagement. During focus groups with members of the public living close to PUSH-IT sites, cultural contexts likely influenced how participants interacted with each other and with engagement activities:

> "In the Czech Republic, at school we do not ask teachers almost at all ... That's probably why we are not trained to express our opinions, especially in public and especially when we are not sure whether the answer is correct" – Dr. Vít Peřestý, Czech Geological Survey

1.5 Who to engage?

Public views are diverse, context-dependent, and shaped by knowledge, values, and experiences. It is therefore vital to carefully consider who to engage. While not an exhaustive list, consider:

- Invited publics (community organisations, individuals), who may be selected to represent a broad range of views, a specific area or context
- Uninvited publics (activists, pressure groups, concerned citizens), who participate without a formal invitation and often bring diverse and challenging perspectives
- 'Stakeholders' including municipalities, regulators, government, landowners
- Non-local publics, e.g., climate interest groups, wider national publics
- Uninterested publics, vulnerable and marginalised groups
- Interested publics, already curious or knowledgeable about topics being discussed

Effective participation requires sensitivity to local and national contexts. Research your target audience so you are aware of any issues that might influence how people respond to your engagement. You could try:

- Museums
- Social media
- Planning portals
- Google News

Finally, remember that 'who to engage?' changes over time and during the course of a project. Return to this question throughout.

> "Quite often people complain because you're the straw that broke the camel's back... So also you need to be aware of the smaller problems" - Jane Charman, United Downs, describing how public experiences with previous developments (energy or otherwise) may affect how citizens respond to engagement

1.6 Forgotten Layers of a Subsurface Project

Fabiën Dekker

Whether the subsurface is suitable for thermal systems depends on many factors, including temperature stability, permeability and thermal properties of local rock types. Yet, it is not only the subsurface conditions that determine a project's feasibility. The surface, the people living above, also plays a crucial role in shaping whether a project can succeed. Consider factors such as risk perception, trust in the developer, and environmental impacts.

Technical scans must be carried out to assess the subsoil. No two project sites are the same: millions of years of sedimentation, tectonic activity and erosion have resulted in unique underground layers. The same principle applies to communities' topsoil: no community is the same.

The topsoil consists of different cultural layers shaped by local habits, histories, relationships with the landscape and shared values. These layers form a cultural lens through which a community views the project. They shape whether communities perceive a project as an opportunity or a threat.

Just as drilling operations require careful and contextual preparation, community engagement demands a similarly thoughtful and site-specific approach. Simply identifying commonly known influencing factors is not enough. Sensitivity to local context is essential. Some key cultural layers to consider include:

1. Place-based identity: What meaning does this place hold for residents? Is it a site of pride, trauma, or resilience?
2. Previous projects: Have there been previous underground or energy projects?
3. Previous engagement experiences: Have people previously felt included or excluded? Is there trust in project developers or authorities?
4. Local values and relationships with nature: How are the land, heat, energy and underground resources perceived? Is the underground viewed as a sacred, economic or community resource?

Engagement strategies require attention to these layered contexts, both above and below the surface.

1.7 Recruitment

When you have decided *who* to engage and *how* (Pallett et al., 2017; Thomas et al., 2018) plan your recruitment strategy. Some tips:

- Join **existing events** (such as community science days), which provide a captive audience, transport and participation spaces.
- Consider ways to attract visitors by **making the underground visible** - this could include using drill core samples, virtual reality, subsurface video footage, or art.
- Work on **relationships**. Jane Charman and Claudia Malam at the United Downs site *actively* form relationships with schools by reaching out to individual schools, and *passively* when schools approach them. Sometimes they will be contacted via LinkedIn, or outside of work at community events. Jane and Claudia build links with local politicians by providing information and keeping them updated with occasional friendly emails, and always **carry business cards and flyers.**

> "There is the age group of around mid-30s to late-50s who are really difficult to get hold of... We found that talking to young people is the easiest way to get to their parents" - Jane Charman

*Incentives may also be relevant for researchers and other stakeholders, not just publics!

1.8 Design your space

Top tips from Jane Charman:

> "Do you need a kitchen with an oven? Do you need cleaning equipment, tables, chairs, recording equipment? How long will it take to set up and clear away? Are you going to need flip chart, pens, papers, overhead projector...?" - Jane Charman

Benefits of a dedicated engagement space:

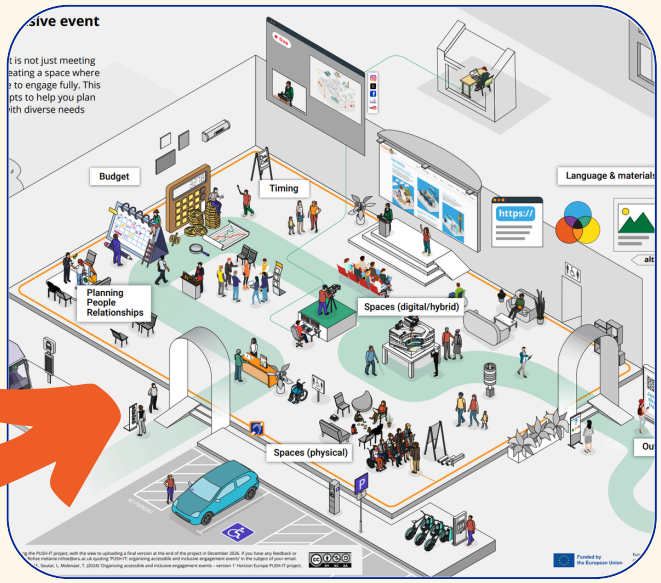
- Display project-specific information
- Keep participants focused
- Manage visitor numbers
- Reduce setup and clean-up time
- Adapt layouts to suit different events or visitors

However, the engagement space doesn't *have* to be permanent or located at the project site. Select a venue that meets the needs of your audience. For example, rent a hall at a convenient location, equipped with mobile exhibition resources and presentations. Consider visiting schools to reduce transport barriers. Wherever your event is, good food, a welcoming environment, and activities encourage visitors.

> "If local authorities are part of a project, bringing citizens into official public spaces can be significant, but can also make participants feel uneasy - so engagement spaces need to be carefully considered" - Dr. Anna Pellizzone, PUSH-IT Advisory Board

> "People quickly perceive "chic" surroundings and promotional gifts as bribery. Some PUSH-IT focus group participants suggested that the atmosphere should be friendly, but not go beyond tea and cookies" - Dr. Katrin Keiling, Geothermal Project Coordinator, GFZ, Germany

For tips on how to organise an accessible and inclusive event, see the PUSH-IT infographic here



1.9 Risk assessment *Jane Charman*

You may need a risk assessment if people are coming to visit, or if you are taking equipment to others. Templates can be downloaded from the UK Health and Safety Executive website, or your country's equivalent.

Risk assessment

Company name: **Date of risk assessment:**

Area Covered:

What are the hazards?	Who might be harmed and how?	What are you already doing?	Do you need to do anything else to control this risk?	Action by who?	Action by when?	Done
Slips, trips and falls e.g. uneven surface of car park, wet internal and external floors, misplaced furniture etc.	Staff and visitors may be injured if they trip over objects or slip on wet floors, extra care to be taken where metal strips are exposed on floors	▪ General good housekeeping is carried out. ▪ Floor mats inside all external doors. ▪ All areas well lit, including stairs and ramps. ▪ No trailing leads or cables. ▪ Classroom prepared before visitors arrive. ▪ Staff to keep public areas clear, eg no boxes or objects left in walkways or foyer. ▪ Wet floor/cleaning in progress signs are positioned in relevant areas. ▪ Access to roof restricted.	▪ Public areas to be checked before visitors arrive. ▪ Sufficient lighting for parking / roof viewing platform. ▪ All visitors to read evacuation procedure	Visit organiser	Prior to all visits. When signing in.	
Vehicle movement	Visitors and staff could suffer serious injury if struck by vehicles entering/leaving car park, moving in it or whilst crossing the road.	▪ Entrance to car park clearly marked. ▪ Car park sufficiently lit. ▪ Contractors trained to be vigilant of visitors ▪ Groups will be sent information prior to their visit about parking and vehicle awareness.			Prior to all visits	

EXAMPLE ONLY

Jane's example risk assessment for a community event (showing 1 of 4 pages)

Consider:

- Allergies
- Slips, trips and falls
- Vehicles in the carpark
- Hazardous substances
- Electricity
- Objects on display
- Fire safety and evacuation
- Safeguarding

1.10 Event structure

The structure of your engagement will depend on the goal, audience and setting. The examples below are inspired by Jamie Gallagher (2025) and adapted by Jane Charman and Veronika Slavíková.

School event	Open day	Webinar
Presentation	Greeting and presentation with quiet kids' activities	Presentation inc. video
Activity / quiz	Refreshments	Discussion / activity
Q&A / roundup	Visit labs or drill site	Q&A

Remember the hospitality...

A thoughtful selection of biscuits or fresh fruit can go a long way. For those who enjoy baking, homemade treats add a personal touch:

> "...my colleagues and I each brought home-baked cakes to the community workshops to be shared in the breaks. This may seem a simple gesture on the face of it, but we felt these were a valuable help towards building relationships with participants, by demonstrating our personal investment in the project and appreciation of our participants' respective input."
> - Dr Roger Auster, Environmental Social Scientist, University of Exeter

1.11 Event checklist *Veronika Slavíková and Merryn Thomas*

Adapt this checklist to plan and distribute important tasks. Some will not be relevant, and you may need to add others.

Responsible person	Task	Deadline	Done	Note
	Design engagement strategy: who, what, when, why, where			
	Design engagement materials			
	Book event space, make table plans, check accessible toilets etc.			
	Promotion			
	Plan transport to / from event			
	Book catering			
	Print materials, assemble equipment			
	Direction signs: print, place			
	Charge batteries if recording, ensure memory cards are clean and inserted			
	Reminder to participants			
	Check on catering			
	Prepare space: place seating, clean tables, tape down wires, etc.			
	Meet and greet			

months to go... 1 week to go.... 1 day to go... Event

Veronika's direction signs and event info.

1.12 Ethics and reflexivity

There are several ethical considerations when organising engagement activities, particularly if you will be recording data. The British Psychological Society (2021) and Welsh Government (2020) provide useful resources. You may need to consider:

The high-quality practitioner

According to the National Coordinating Centre for Public Engagement (NCCPE, 2025) high quality engagement practitioners:

- **Reflect** on the context of their engagement, including ethical considerations
- Actively listen to others, tailoring **communication** methods and **content**
- Are **sensitive** to others, respecting and caring for diverse world views

> "Tolerate resistance. Criticism isn't the enemy. It's a sign people care. Listen and learn." - Prof. Gerdien de Vries

1.13 Evaluation

Evaluating the effectiveness of your engagement activity is essential to gauge the impact of your work and to allow for improvements. The UK Government (2022) suggests evaluators consider:

- What evidence are you looking for? Changes in attitudes, knowledge, support?
- How do you define effective engagement? Effective for what and for whom?
- Over what timescales do you want/need to measure impacts?

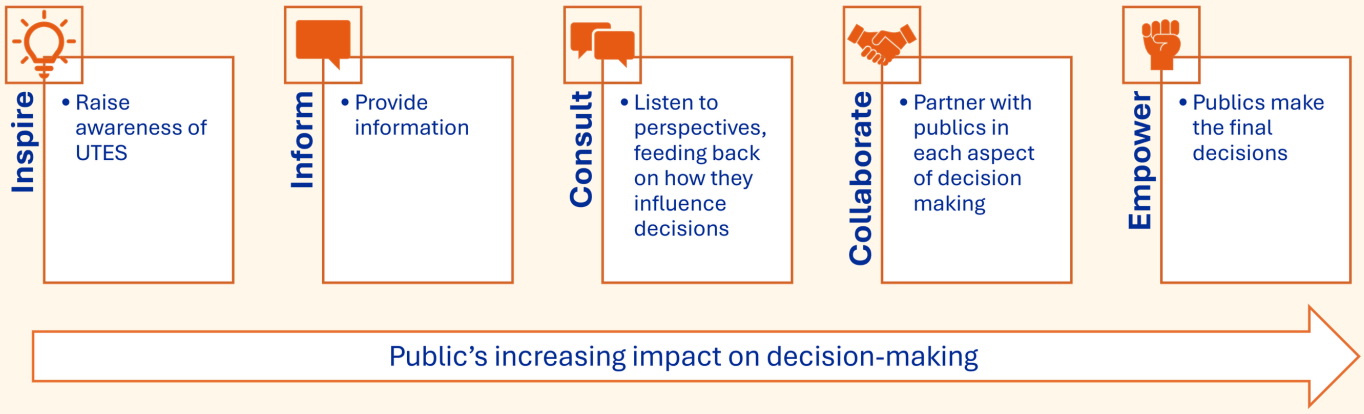
There are several methods to evaluate engagement activities. These include standard methods such as counting participants, recording feedback comments, and pre- and post-event surveys that measure changes in perceptions. Other methods are more creative. For example, Jamie Gallagher (2025) describes an evaluation exercise in which half of exhibition-stand attendees were asked to draw a picture of a drone before engaging with the stand; half were asked to draw a picture afterwards. Researchers then compared before- and after-pictures to gauge changes in attendees' perceptions of drones.

02 Engagement formats

2.1 Which engagement format?

This section provides a brief introduction to 17 engagement formats. These are categorised by whether they aim to Inspire, Inform, Consult, or Collaborate. This typology is adapted from the International Association for Public Participation (IAP2) spectrum (2024). We have added *inspire*, which aims to raise awareness of UTES without providing information (e.g. in simple kindergarten games). In this catalogue, we have not categorised any engagement formats as *empower* because within PUSH-IT, sites and operational practices were established before the project commenced, meaning the potential for communities to make final decisions was very limited.

Note that while *collaboration* typically occurs at a project's inception, with publics identifying research questions and co-designing projects, a degree of collaboration *can* occur later in a project with citizen science (page 23) and community co-creation of events or materials (page 24). Furthermore, categories in the spectrum overlap. For example, to facilitate informed deliberation and decision-making among the public, it is essential to first inspire and inform them. Likewise, during an activity designed to inform, valuable public opinions may be gathered (consultation).



Adapted from © Federation of International Association for Public Participation 2024. All rights reserved. This work was created with contributions from Lewis Michaelson, Martha Rozelle, and Doug Sarno. www.iap2.org.

> "Meet people where they are; and I think that means different things in different places, doesn't it? Whether it's mums at the school gate, people in the pub..." - Jillian*, 61-70 F, PUSH-IT Cornwall Focus Group

*Focus group participant names changed for anonymity

This section is organised as follows. For more information, see the references and resources, or contact us at m.j.thomas@exeter.ac.uk.

Engagement format	Goal	Page	Example activity (Section 3)
On-the-fly engagement	Any	22	One-minute melon
Citizen Science	Collaborate	23	n/a
Co-creating engagement materials	Collaborate	24	n/a
Public hearings	Consult	25	Panel discussions
Focus groups	Consult	26	Perspective spinner
Deliberative workshops	Consult	27	Risk/benefit task
Interviews	Consult	28	Underground blocks
Community liaison groups	Consult	29	Participatory mapping
Informal public-facing events	Consult	30	Children's book
Questionnaires	Consult	31	n/a
School visits	Inform	32	Heat storage competition
Open days	Inform	33	Colouring sheets
Banners, posters, reports, factsheets	Inform	34	n/a
Online engagement	Inform	35	n/a
Videos	Inform	38	n/a
Presentations - hook your audience!	Inform	39	n/a
Sci-art collaborations	Inspire	40	n/a

2.2 On-the-fly engagement

If you don't have time to organise an engagement event right now, try the ideas below. **Piggy back** on events already happening, such as school careers fairs and seasonal fetes, which can provide a captive audience.

Badges can be a good conversation starter at events - great for when you don't have a dedicated space such as a stall. Alternatives include ambiguous earrings or t-shirts, which prompt the question, 'What's this about'?

Activities for when you're short on time:

Activity	Main objective	Time	Example applications	Age	Page
Colouring	Inspire, Inform	2–30 mins	Open days, town hall meetings, exhibitions and conferences	1+	57
UTES dice game	Inform, Consult	2–30 mins	Schools, open days, focus groups, interviews	8+	71
One-minute melon	Inspire, inform	1 minute	Schools, open days, on-the-fly engagement	3+	55
Underground riddles	Inspire, Inform	2-30 mins	Schools, open days, exhibitions and conferences	8+	48
Children's book	Inspire, inform	1 min-30mins	Schools, open days, exhibitions, conferences, informal events	4+	50

And when you have more time...

2.3 Citizen Science

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Collaborate	mins-days	medium	publics	1+	low-high	low-high

"Citizen science is a collaborative approach where volunteers, often without formal scientific training, participate in scientific research" (Gooding et al 2025, p.1). It can include identifying problems and research agendas, collecting and/or mapping data, monitoring, testing technologies, and advocacy. There are several potential benefits and challenges (Peacock et al., 2025; Bremer et al., 2026):

Benefits include:

- Increased scope of data collection, analysis and dissemination
- Increased cost-effectiveness by involving volunteers
- Improved outcomes by incorporating local knowledge
- Citizen education, awareness, empowerment and ownership
- Democratisation of knowledge and enhanced transparency

Challenges include:

- Data quality and consistency can mean decision makers are sceptical of data
- Engagement and retention of citizen scientists
- Safety and ethical concerns, including potential exploitation

Case study: DeepStor, Karlsruhe Institute of Technology

DeepStor is exploring high-temperature heat storage in depleted oil reservoirs beneath the Karlsruhe Institute of Technology campus in Germany. Building on prior participatory work, the project is providing Raspberry Shake seismometers (right) to non-geoscientists based on campus, before rolling out to local residents. They will monitor seismicity in the local area and co-design applications for data input, access and visualisation.

Image: https://raspberryshake.org/ licensed under CC BY-ND 4.0

Reference:
Bremer, J., Azzola, J., Moczek, N., Kohl, T. (2026). Participatory monitoring in geothermal projects: a combined socio-geophysical approach to seismicity, risk perception and acceptability. Geothermal Energy. https://doi.org/10.1186/s4051 7-026-00373-w

2.4 Co-creating engagement materials

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Collaborate	days-months	high	publics, stakeholders	1+	low-high	low-medium

Co-creation is “the coming together of actors across organizational boundaries to create mutually beneficial outcomes” - Gjørtler Elkjær et al., 2021 (p.2). All sorts of ‘things’ can be co-created, including designs, markets for new technologies, knowledge, community spaces, events, siting decisions (Devine-Wright and Sherry-Brennan 2019), and engagement materials.

Co-creative practice goals:

- Mutually beneficial outcomes (Elkjær et al., 2021)
- Clear, iterative, flexible process (e.g., Itten et al., 2021)
- Defined roles, responsibilities, respect (Thomas et al., 2021)
- Sufficient time and resources (RENEW, 2023)
- Transparent, shared goals (e.g., Ryszawska et al, 2021)

Case study: Co-creating intergenerational climate change engagement materials

The Climate Comic and Activity Book are bilingual resources created with communities, children, care homes, teachers and other stakeholders in Wales, UK. A range of activities aim to foster intergenerational dialogue and action to tackle climate change.

> “[the experience was] enriching for the [care home] residents; they are showing how important their perspectives are but also engaging in conversation with new people from different ages and backgrounds.”
> - Dr. Deb Morgan, ENabling Research In Care Homes (ENRICH) Cymru

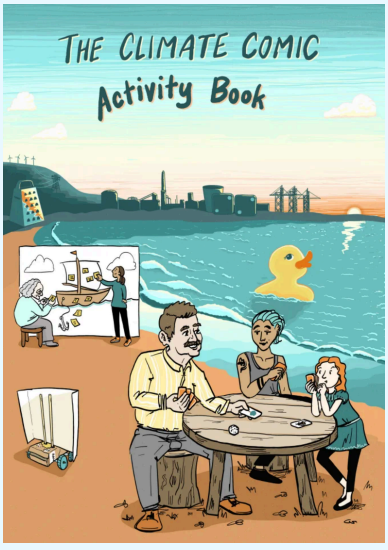


Illustration by Laura Sorvala

Reference: Thomas, M., Sorvala, L., Williams, A., Singleton, A., Maddock, C., Morgan, D., ... & Musselwhite, C. (2024). Co-creating a climate comic book: reflections on using comics in intergenerational research and engagement. Journal of Global Ageing, 1(2), 219-237.

2.5 Public hearings

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	1.5-2hrs	medium	publics, stakeholders	20+	med-high	med-high

VEŘEJNÉ PROJEDNÁNÍ

Špičkový výzkum geoenergie se rozjíždí

Litoměřická veřejnost se mohla již podruhé dozvědět, jak probíhá realizace unikátního výzkumného projektu na využití geotermální energie a dalších obnovitelných zdrojů, které budou v příští dekádě hrát klíčovou roli v takzvané dekarbonizaci české energetiky.

Prezentace odborníků z Univerzity Karlovy a Českého vysokého učení v Praze probíhající 30. října v sále hradu se tentokrát zaměřila na konkrétní výstupy, kterých bylo za první období dosaženo a mezi něž patří zejména měření 2D seismických profilů do hloubky pěti kilometrů a zahájení vrtání pilotních ověřovacích vrtů. Přítomní se ale mohli ptát na vše, co je na probíhajícím výzkumu v bývalých Jiřikových kasárnách zajímá.

Setkání s veřejností se uskutečnilo v rámci strategického projektu SYNERGYS. Jeho hlavním cílem

Více než stovka lidí se zúčastnila veřejné diskuse odborníků s veřejností. Nechyběly ani dětské dotazy. Foto: Michaela Rozsypalová

žívat zemské teplo i z velkých hloubek, a jak ho efektivně kombinovat s dalšími šetrnými zdroji energie, ať již tepla nebo elektřiny.

„Proto je součástí výzkumu i vodík a jeho výroba ze sluneční energie. Při jeho produkci vzniká velké množství tepla, které ale v létě nikdo nechce, proto ho bu-

ho odsud zase pomocí tepelných čerpadel vezmeme a využijeme pro vytápění," popsal hlavní řešitel projektu Tomáš Fischer z Přírodovědecké fakulty Univerzity Karlovy.

Právě integrace různých zdrojů a technologií a jejich vhodná kombinace a využití v letním nebo naopak zimním období jsou klí-

„Proto je projekt rozdělen na čtyři dílčí systémy tak, aby pokryl většinu situací, které mohou v reálné energetice nastat, ať se to týká zdrojů energie nebo jejich velikosti či způsobu využití například v průmyslové oblasti, nemocnicích či dálkovém vytápění," upřesnil Bořivoj Šourek z Univerzitního centra energeticky efektivních budov ČVUT.

Důležitými partnery projektu jsou město a provozovatel místní sítě dálkového vytápění ENERGIE Holding, která by se na nově vybudované zdroje tepla měla v závěru napojit. „Věříme, že se podaří postupně nahrazovat uhlí novými, čistými zdroji, které ale musí někdo ověřit v praxi a prokázat, za jakých podmínek jsou efektivní, stabilní a dlouhodobě bezpečné, abychom je mohli využít," shodují se starosta Radek Löwy a předseda představenstva ENERGIE Holding Jan Ne-

Coverage of public hearing in the Litoměřice Town Newsletter, December 2024

Public hearings invite individuals from a specific geographic area to participate in public discussions about an issue. All attendees are given opportunity to speak.

Public hearings provide opportunity to:

- Provide information about projects
- Understand community views
- Learn how the community wishes to engage in future

PUSH-IT case study: SYNERGYS public hearing, Litoměřice Castle, October 2024 *Veronika Slavíková*

3-5pm	Individual consultations with experts (food available from 3:30pm)
5-5.30	Coffee, registration, and filling out a questionnaire to enter a prize draw
5.30-7.30	Academic talks, mayor's speech, Q&A
7.30-8	Electric bike prize draw, coffee break

> "Use different channels to address different parts of society. For younger people, web and social media are effective, while older people may prefer paper newsletters, posters, and flyers" - Veronika Slavíková, PUSH-IT communications manager, Czech Republic

Cooperation from the municipality was instrumental in organizing and running the event. The meeting was covered by local TV and journalists, with an article and report published, including Q&A. Consider whether filming is necessary, as it may influence participants' willingness to speak.

2.6 Focus groups *Anna Pellizzone*

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	1.5-2hrs	medium	publics, stakeholders	6-12	med-high	med-high

Focus groups are qualitative methods that bring together a small group of 6-12 people to elicit their views and opinions about a specific topic. They originated in market research and are often paired with quantitative approaches (e.g., surveys) to integrate in-depth but not statistically significant qualitative information with more quantitatively significant data.

Depending on the scope of the research, participants can either be homogeneous (same group of stakeholders) or heterogeneous (different stakeholders brought together). Researchers may recruit groups that are of particular interest (e.g., marginalized groups, specific stakeholders). The conversation is normally recorded and analysed.

Focus groups require:

- Skilled facilitator (normally also an observer) able to engage everyone with the conversation.
- Only the people that are needed to run the focus groups in the room, otherwise participants may be reluctant to share their views.
- A comfortable venue (not too small, neither too big) and informal setting.
- Incentives for participants, and possibly supporting arrangements, such as childcare.

Case study: Atlante Project Focus Groups, Viterbo (Italy), 2012

The research was conducted within the framework of a larger project (Atlante Geotermico) on the feasibility of further geothermal developments in Italy, funded by the Italian government and coordinated by the Italian National Research Council.

- Four homogeneous focus groups with 8 participants each, recruited by a survey agency:
  - university students
  - general public of Viterbo
  - local politicians
  - local activists in environmental associations
- Each focus group began with a 10-minute presentation on “geothermal resources”
- Discussions were recorded, transcribed and analysed (Pellizzone et al, 2017).

Useful resources:

https://www.involve.org.uk/resource/focus-groups
http://actioncatalogue.eu/method/7409
https://www.sciencedirect.com/science/article/abs/pii/S0301421516306097
https://publications.cnr.it/api/v1/documents/download/186333

2.7 Deliberative workshops

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	1-2 days	medium	publics	8-16	med-high	med-high

Qualitative deliberative workshops are designed to engage participants in in-depth discussions on complex issues, allowing attitudes to emerge through dialogue (Pidgeon et al 2009). Individuals are often recruited to form 'quasi-representative' groups that reflect local demographics. Recruitment may be 'topic-blind', meaning participants know they will discuss a broad subject but not the specific topic of interest.

Case study: Deliberating hydraulic fracturing in the UK and USA

Day-long deliberative workshops were held in four locations: Los Angeles and Santa Barbara (US), and London and Cardiff (UK) to explore public perceptions of shale oil and gas extraction by hydraulic fracturing, or 'fracking'. The workshops consisted of a range of activities to prompt and guide discussion:

- Pre-and post-workshop surveys to gauge familiarity and attitudes
- Welcome, introduction, and ice-breaking session
- Top-of-mind associations with terms like 'Climate Change' and 'Energy'
- 20-minute PowerPoint presentation
- Whole-group discussion
- Small group discussions using posters detailing advantages and disadvantages
- Role-playing exercise to debate energy infrastructure proposals (see page 48)
- Final discussion and reflections

References:

Partridge, et al (2017). Seeing futures now: emergent US and UK views on shale development, climate change and energy systems. Global Environmental Change, 42, 1–12.
Thomas, M., et al (2017). Deliberating the perceived risks, benefits, and societal implications of shale gas and oil extraction by hydraulic fracturing in the US and UK. Nature Energy, 2(4), 17054.

2.8 Interviews

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	20mins-2hrs	medium	publics, stakeholders, experts	1-2	low	low

Interviews are used to gather in-depth understanding of people's perceptions, experiences, and values. They allow researchers to explore complex issues in detail and capture nuanced perspectives that might be missed by e.g., questionnaires. **Structured interviews** ask predetermined questions in a set order, while **semi-structured interviews** use a flexible interview guide that enables participants to bring up new ideas and themes. They can be useful for exploring unfamiliar and value-laden issues such as new energy technologies. Techniques also include mobile/go-along Interviews where the researcher accompanies participants as they move through a meaningful environment.

Integrating **tools** can help elicit difficult-to-articulate values or experiences. Examples include (Thomas et al., 2022):

- Photo elicitation: participants discuss photographs of significant places or experiences
- Mapping: participants annotate maps with places, memories, or feelings
- Word associations: word cards prompt discussion on themes

When designing interviews:

- Consider open-ended questions, for thicker descriptions and new directions
- Tailor questions and materials to the local and national context
- Present carefully calibrated, balanced information
- Be mindful that the researcher's presence can influence interactions
- Be realistic about the time required for interviews and consider offering an honorarium
- Obtain written informed consent, detailing how data will be used, anonymity/confidentiality
- Plan how data will be recorded, analysed, and reported
- Consider the safety of interviewers and participants, particularly if lone working

Useful resources:

Bryman, A. (2016). Social research methods. Oxford university press.
Helen Kara (webpage): https://helenkara.com/2015/03/26/creative-research-methods/

2.9 Community Liaison Group Meetings

Jane Charman

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	~1hr	medium	local stakeholders	10-20	low	low

A Community Liaison Group brings together representatives from a company and the local community for open, two-way communication. The company shares updates about its projects, while community members raise concerns, ask questions, and share feedback. Everything discussed is minuted and made publicly available, ensuring transparency.

- Duration & Frequency:
  - Timing is agreed upon by the group based on project needs
  - Sessions are typically held at the project site, a nearby hall, or online
- Preparation:
  - The company prepares project updates
  - Community members gather local concerns
  - An agenda is set and minutes are taken and shared
- Example participants:
  - Parish and County councillors
  - Environment Agency representatives
  - Local business owners and residents
  - Company representatives
- Consider:
  - Venue hire (if needed), refreshments, printing
  - Equipment: projector/screen (if presenting), recording tools for minutes, internet access for online meetings

2.10 Informal public-facing events

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	hours	medium	publics	10-100	medium	low-med

Informal public-facing events, such as barbecues and coffee mornings, serve as valuable settings for public engagement and relationship building between communities and projects. These gatherings provide an informal setting for conversation, sharing ideas, and gathering insights from diverse groups, including stakeholders and the wider public. They can be particularly effective for discussing sensitive issues by creating a relaxed and engaging atmosphere.

These events can often integrate disarming activities such as those found in Sections 3.3 and 3.4, or can simply provide space and time for conversations over a cup of coffee. Remember:

- Ensure chosen community spaces are accessible
- Run activities in participants' first language where possible
- Provide comfortable seating, clear information, drinks, and snacks
- Ensure everyone feels valued and welcome

> “Have a sign in sheet for every event [and] wear a name badge with your job title so people know who they're talking to”
> -Jane Charman

2.11 Questionnaires

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Consult	minutes	high	publics, stakeholders	100+	medium-high	low-medium

Questionnaires can elicit perceptions from large populations.

They can be particularly valuable when combined with qualitative methods to gain deeper insights (a mixed-methods approach).

Consider:

- **Aims and Research Questions**: What exactly do you want to know? Do you need quantitative or qualitative data, or both? Decide how you will analyse your data before you begin designing questions.
- **Sampling**: Who should participate? Are you interested in local, national, or global perspectives? Should the survey be representative, or focus on a specific group? These decisions will dictate how you sample (e.g., purposive, snowball, representative, or stratified sampling).
- **Recruitment**: Consider online surveys for national samples, door-step surveys (expensive), or river sampling (geo-targeted internet traffic) for local samples. Simple paper surveys before and/or after events can gauge perceptions and attitude change (e.g., Thomas et al., 2017).
- **Questionnaire design**: Should the survey be topic-blind to minimize self-selection bias and framing effects? Should you provide balanced information to enable participants to make informed answers? Use understandable yet accurate terminology, considering open- and closed-ended questions. Avoid leading questions, which may bias results.
- **Piloting**: Pilot the survey extensively (e.g., cognitive interviewing, create online test links) to ensure understandability and flow. Refine based on feedback.
- **During data collection:** Keep tabs on what is happening in the news and around case sites. Might events influence respondents' answers? Monitor data to ensure the survey instrument is working correctly, especially if you have included logic.
- **Data Analysis:** Check for duplicates, inconsistencies, and invalid responses. Ensure categories and scales are coded correctly before analyses. Consider descriptive statistics to provide an overview of the findings, comparative analyses to compare different groups, and correlations/regressions to explore relationships. Qualitative data will need coding using a carefully designed codebook to identify patterns and themes.

Useful resource: Thomas, M., Kechagia, M., Soutar, I., Rohse, M., & Devine-Wright, P. (2026). A cross-national and local survey of underground thermal energy storage perceptions: survey instrument. Zenodo.

2.12 School Visits

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inform	hours	medium	students, teachers	10-500	low-med	low-med

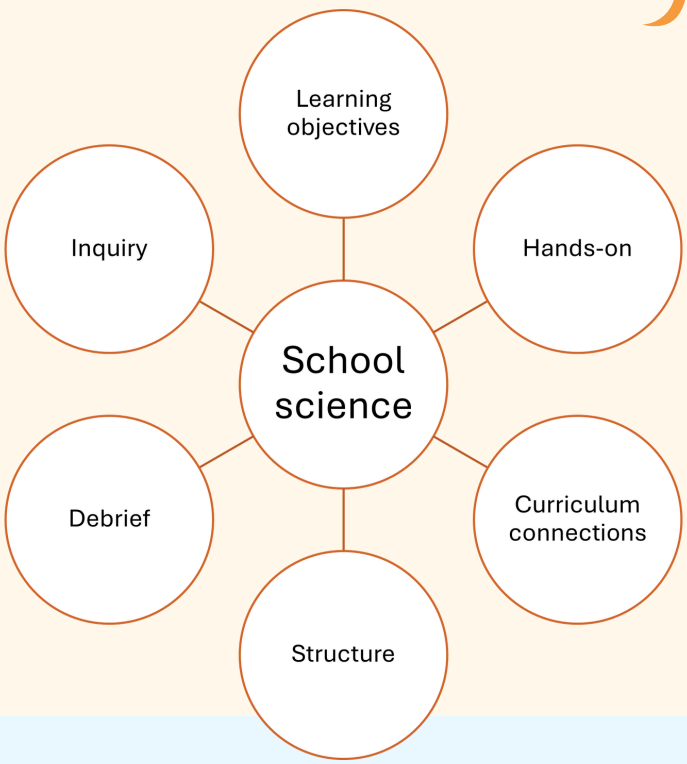
School visits may be on or offsite and can include:

- Underground Thermal Energy Storage lesson
- Curriculum topic-specific lesson, e.g., energy
- Mock job interviews
- School assembly
- Career fairs

-Jane Charman

> "Encourage schools to brief students before the visit and to have questions prepared" – Jane Charman

> "If you reach the kids you also reach the adults. But if you only reach the adults, you don't reach the kids" - Elke Mugova



PUSH-IT case study: Students visit Litoměřice *Veronika Slavíková*

In October 2024, 86 Dutch and Czech high school students took part in a school visit to Ringen, Litoměřice. The day included:

- 30-min presentation about SYNERGYS project
- Science experiment (see page 51)
- Questionnaire to feed back on the session and gauge attitudes towards the use of geoenergy

High school students take part in a science experiment, Litoměřice

2.13 Open days

Jane Charman

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inform	hours	medium	interested publics	10+	Low-medium	Low

An open day is an event where publics can visit and learn about a project. It may involve presentations, opportunities to meet staff, and tours (which may also be called a site visit). It can be a fully open event, or can invite local groups such as youth clubs or retirees.

- **Materials**: Provide information in multiple formats, including printed materials for attendees to take away. Promote the company website and social media channels, encouraging people to follow for updates. Consider providing logo merchandise such as pens & pencils.
- **Staffing**: Ensure adequate staff are available to answer questions and engage in conversations. Conduct staff briefings before and after events, noting any improvements for future events. Always carry business cards that include a phone number for those without internet access.
- **Timing**: Carefully select set times when members of the public can visit. Consider coinciding with existing events, for example a town sustainability event. Manage visitor numbers with a booking system like Ticket Tailor.
- **Resources**: Provide activities for children and younger visitors, comfortable seating, and refreshments.

PUSH-IT case study: University Open Campus Day

Markus Schedel

Photo by Hung Pham

In May 2025, the university-wide Open Campus Day was an opportunity to present the borehole thermal energy storage (BTES) Darmstadt demonstrator to interested visitors on site. As part of three guided tours, each lasting about one hour, up to 20 participants at a time had the chance to visit and receive information on geothermal energy and underground thermal energy storage.

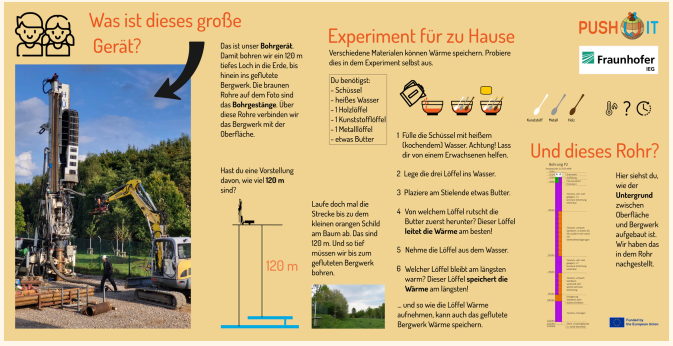
2.14 Banners, posters, reports, factsheets

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inform	minutes	low	publics, stakeholders	100+	low	low

Banners, posters, reports and factsheets can be an effective way to engage a large number of people using relatively little time and resources. To make them accessible to a wide range of users, consider:

- High colour contrast
- Avoid red/green combinations
- Uncluttered layout
- Clear and readable fonts
- Text 12pt+ for reports, 18pt+ for posters, 30pt+ for banners
- Logical structure (headings, lists)
- Alt text for images/graphics if online
- Plain language, avoid jargon
- Key information at eye-level
- Several contact options (email, phone, website, QR code)
- Photograph of key contact(s)

Large banners installed at the Bochum drilling site, designed by Elke Mugova to be eye catching and informative. A children's version (right) includes a walkable depth guide, a 3D underground profile, and an experiment to do at home.



2.15 Online engagement

Serge Santoo and Jesse Treurniet

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inform	minutes	medium	publics, stakeholders	100+	low	low

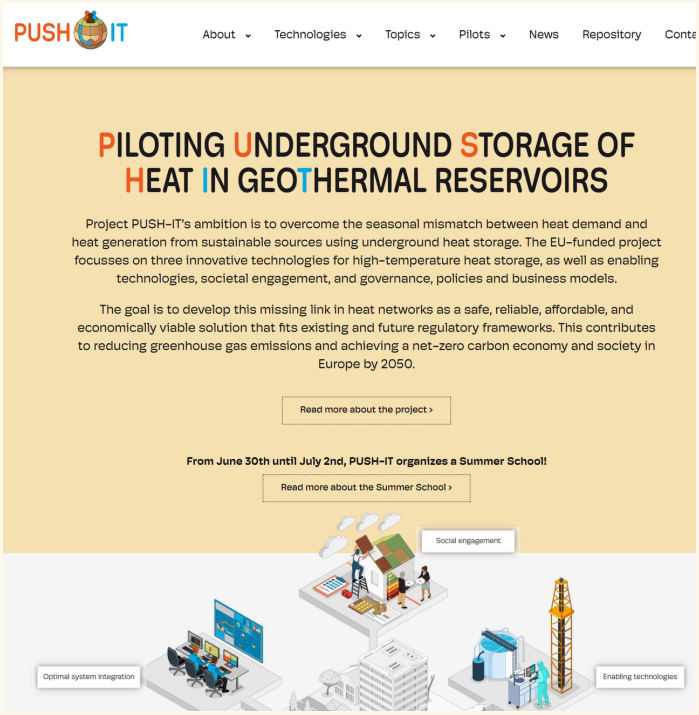
If we want to engage our audience, one of the key elements should be our online presence. This can take a variety of forms. From a website to a newsletter to social media channels, everything has its own function in engaging our audience.

Website – Existing audience engagement

The backbone of our entire communication process is our website. This is the place where we can tell about ourself very extensively. Focused on our specific target groups, it should be relatively easy to find general information about who we are and what we do, but also more detailed information for those that are interested. It is a good practice to have a “news” section on the website where updates are posted, while the rest of the site is more static.

This website is the point where all other channels refer to. It serves mainly to update the people who are already interested in the project, by the references from other channels or the occasional search engine result from people interested in UTES.

Part of good content management is organizing SEO (search engine optimization). This will improve the findability of the website.



The PUSH-IT website

Newsletter – Existing audience engagement

A newsletter is sent out by email to everyone who is subscribed. It can be a very useful tool to keep existing audiences engaged through these periodic updates. It is therefore important to encourage people on all channels to subscribe to the newsletter. It is also necessary to consider the frequency of a newsletter. If you send it too often with too little interesting information, people will ignore it, while people will lose interest when the updates are not frequent enough. In the newsletter, you can link to the news items on the website.


PUSH IT

Discover the project's latest developments

Warm greetings!

The PUSH-IT project is now halfway! A lot of work has been done and there is a lot still to be done. The PUSH-IT team has been working hard to accomplish our goals. With the winter behind us, we go into the spring with renewed energy!

This newsletter is full of exciting updates and publications, including: updates from the United Downs and Berlin pilot sites, a new infographic about Equitit Diversity and Inclusion, the publication of a new deliverable about regulations and more.

Remember to share this newsletter with your colleagues and friends. Let's together spread the word and PUSH the boundaries of large scale underground thermal energy storage systems!

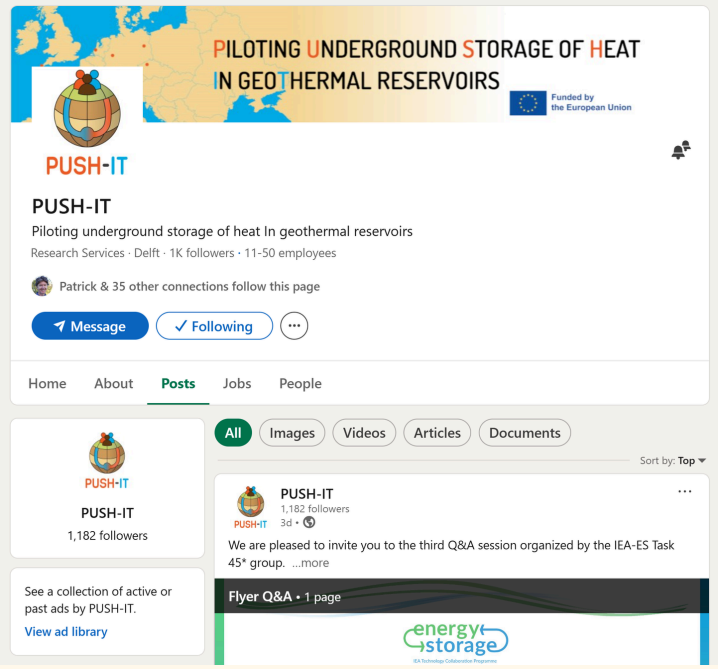
Kind regards,
Dr. Ir. Martin Bloemendal
Principal Investigator and Delft Site Lead

LinkedIn YouTube Website

The PUSH-IT newsletter

LinkedIn – Existing and new professional audience engagement

LinkedIn is a very important platform for engaging your existing and new professional audience. Key factors are frequency and relevance. By posting regularly and with interesting posts you can engage lots of people that are interested in the field of UTES, but mainly those that are professionally connected to it, like researchers, companies and other UTES projects. Don't forget to link to your website in almost every post!



The PUSH-IT LinkedIn page

Facebook and Instagram – Existing and new general audience engagement

Facebook and Instagram are the social media platforms where you can reach almost everyone in the general public. The younger generations will use Instagram more often, while the older generations will be more active on Facebook. By regularly posting engaging content, like updates or interesting reels (short videos), it is possible to reach an audience that was not acquainted with the concept of UTES before. Because this audience is generally less patient, it might not be necessary to use these media until there are actual results or when the project will actually have impact on the lives of the general public, for instance when the system will be connected to the heating system of the city where it is located.

YouTube – Various possibilities

Push It Mine Thermal Heat Storage Bochum

A PUSH-IT YouTube video

YouTube is a very versatile platform. You can use it to post the videos you want to use in your other social media posts and not really make use of YouTube as a platform. That way you can focus on creating content for the other platforms. You can also choose to use YouTube as a social media platform. Then it is important to post engaging content regularly and ask people to subscribe and share your content.

Turn the page for hints and tips on creating videos.

2.16 Videos

Veronika Slavíková and Elke Mugova

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inform	minutes	medium	publics, stakeholders	100+	low	low-medium

Short videos can communicate scientific work to broader audiences. Veronika and Elke create videos for platforms like YouTube and LinkedIn.

Veronika's approach for scientific videos:
When making videos with a scientific team:

- Build good relationships with collaborators
- Stay true to the research
- Ensure it's understandable for your audience

Step-by-Step

1. Introduce yourself, your role, and background to scientific colleagues
2. Explain the project, be clear about the purpose of the video and who it's for
3. Get approval – Ensure scientific accuracy and public communication standards are met
4. Notify on release – Let collaborators know when and where it's published

Elke's approach for social media videos:

- Use a smartphone – it's fast, easy, and accessible
- Shoot in vertical format
- Keep it to about 1 minute

For free editing software, see page 76.

One of Veronika's event advert videos

One of Elke's social media videos

Inspiration:

- Geothermal energy video: Geothermal energy - British Geological Survey (bgs.ac.uk)
- Miss Molecule animations (for 9-11 year olds): https://www.missmolecule.co.uk/
- Spoons and heat conductivity https://www.youtube.com/watch?v=7YFRkyQedul

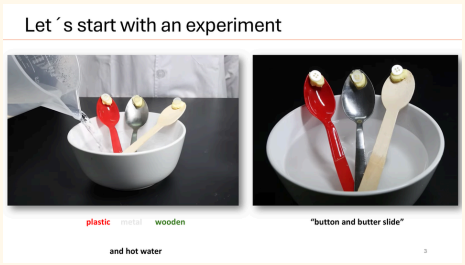
2.17 Presentations - hook your audience!

Elke Mugova and Merryn Thomas

A strong presentation starts by hooking your audience's attention. This could be something relatable, surprising, strange or funny to pique curiosity. Try a provocative question, surprising fact, striking image or personal story. Some examples...

A true story about my grandmother My gran used to say in summer, "It would be so wonderful if we could preserve the sun and heat in summer and release it in winter when it's cold." Gran's dream comes true with PUSH-IT. Final slide: "Gran would have understood this story as well" [see Elke's children's book, p. 50]. *AI-generated image.*

From our office window You can see the University's technical centre with heating (left chimneys) and cooling at the same time (right chimneys) - is this efficient? Return on final slide, showing UTES schematic beneath the image. *Photo by Stefan Klein.*



Butter slides "Which spoon stays warm the longest and therefore retains heat?" Use as a hook to explain the topic of heat storage. The final slide of the presentation answers the question. *Screenshots from YouTube video: Heat Conductivity – Spoon Test.*

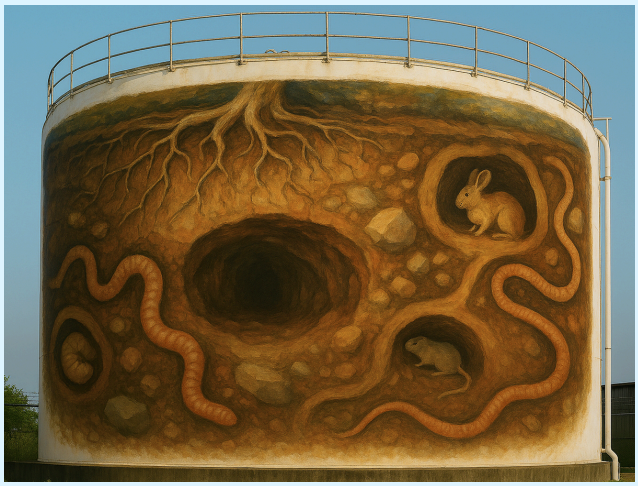
Two faces of engagement This is my daughter's friend eating jelly laced with pepper, after a UTES kitchen science experiment. Next slide: This is a protest about geothermal energy. Two different kinds of engagement, two different outcomes... *Photo substituted with AI-generated image to protect anonymity.*

For the next ten minutes, Don't Look Up! When we think about energy transitions, we often look up — to the sun, wind turbines, cables and pylons. But part of our energy future lies underground. And as with any unseen or unfamiliar technology, its success depends not just on engineering, but on how people respond to it... *Lawrence and DiCaprio in 2021 film, Don't Look Up, by Adam McKay. Poster by A. Oliveiraah.*

2.18 Sci-art collaborations

Aim	Duration	Prep.	Participants	Participant #	Cost	Equipment
Inspire	months-years	medium	publics, artists, scientists	varies	med-high	med-high

Art-science collaborations integrate knowledge from multiple disciplines to produce new understanding. They can be especially effective in fostering personal connections with complex topics, and can build deeper engagement through enjoyment and positive attitudes, rather than focusing on knowledge acquisition. Geoscience art-science collaborations can reach new audiences and provide a way for people to experience landscapes and concepts they have not been exposed to (Wright et al 2023).



Underground mural on a storage tank. Image generated by Microsoft Copilot in response to user requests

Considerations for art-science collaborations (Thomas et al., 2021; Wright et al., 2023)

- Begin collaboration as early as possible to co-develop aims and outputs
- Research previous collaborations for ideas and guidance
- Develop strong relationships built on trust and respect
- Allow plenty of time and space for adaptation, reflection, and idea exchange
- Respect creative freedom and be open to unanticipated contributions
- Avoid using art as merely a 'tool' to communicate - it is so much more than this!

Ideas for Sci-art collaborations:

- Murals: Use children's underground drawings to inspire a professional mural on a storage tank
- Comics: Co-create a UTES comic with local communities and illustrators
- Poetry: poem-bomb the neighbourhood with UTES poems, linking to the wider project
- Photo Exhibitions: Create an exhibition of valued underground places to spark conversation

References:

Thomas, M. J., Giannoulatou, I. D., Kocak, E., Tank, W., Sarnowski, R., Jones, P. E., & Januchowski-Hartley, S. R. (2021). Reflections from the team: co-creating visual media about ecological processes for young people. People and Nature, 3(6), 1272-1283.

Wright, R. A., Jackson, K., Girardin, C., Smith, N., & Wedding, L. M. (2023). GC Insights: Enhancing inclusive engagement with the geosciences through art–science collaborations. Geoscience Communication, 6(1), 39-43.

03 Engagement activities

This section provides ideas and resources for activities that can be adapted to suit a variety of engagement formats. A table at the beginning of each section summarises activities by their main objective, the time required, suitability for different formats, age-appropriateness, and the corresponding page number. The activities are broadly categorized into the four key types of engagement outlined on page 20: Inspire, Inform, Consult, and Collaborate, adapted from the International Association for Public Participation (IAP2).

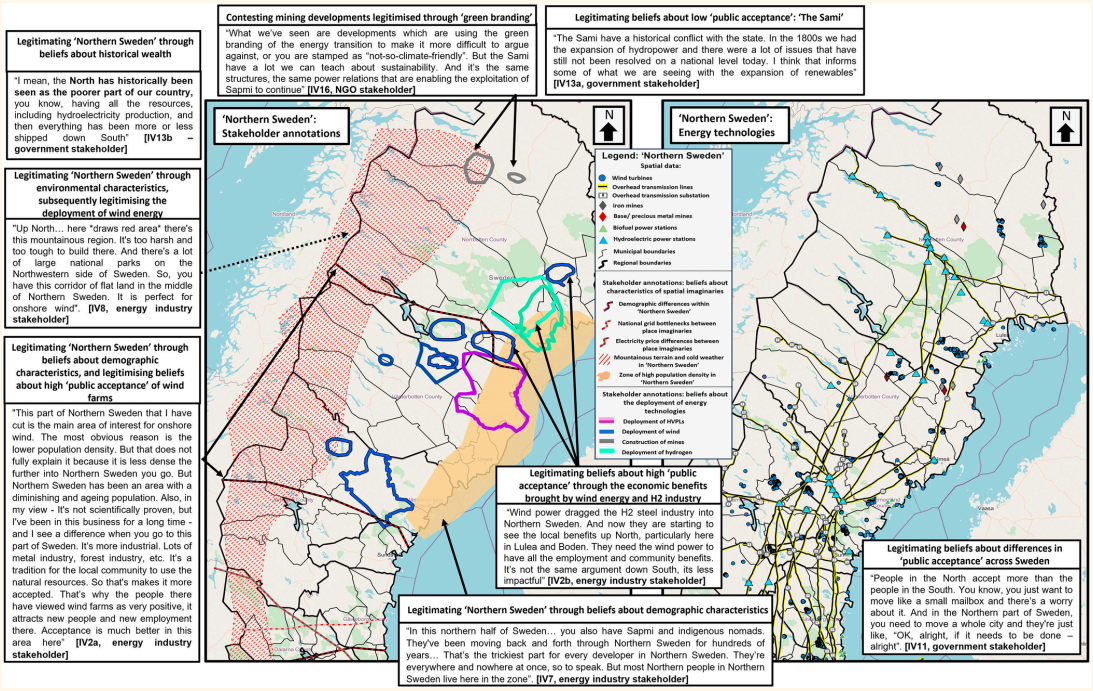
3.1 Subsurface Conversations

- **Two-way conversations** — These activities focus on generating conversation and learning between participants and facilitators
- **Active listening** — They offer space for participants to deliberate and explore various perspectives, concerns and opportunities

Activity	Main objective	Time	Example applications	Age	Page
Participatory mapping	Consult	1.5-3hrs	Focus groups, community liaison groups, interviews. Online or in-person.	11+	43
Risk / benefit poster task	Inform, Consult	30 mins-2hrs	Focus groups, community liaison groups, interviews. Online or in-person.	8+ (with modifications)	44
Panel discussions with Q&A	Inform, Consult	30 mins-2hrs	Public hearings, community liaison groups, seminars and webinars	8+ (with modifications)	45
Quotes activity	Consult	10–30 mins	Focus groups, interviews	8+ (with modifications)	46
Book club	Inspire	30 mins – 2hrs	Informal events	8+ (with modifications)	46
Perspective spinner	Consult	2 mins – 20 mins	Focus groups, schools, interviews	8+	47
Political role play	Consult	40 mins-2hrs	Focus groups, schools	11+	48
Underground riddles	Inspire, Inform	2 mins – 30 mins	Schools, open days, exhibitions and conferences	8+	49
Children's book	Inform, inspire	1 min-30mins	Schools, open days, exhibitions, conferences, informal events	4+	50

3.1.1 Participatory mapping

Participatory mapping can include sketching, mental mapping and using participatory geographical information systems (GIS). While it is often used to map spatial areas (e.g., places perceived to most benefit / disbenefit from UTES) it can also be used to map other kinds of knowledge like the role of UTES in the energy system (c.f. Dickie et al 2020). In this way, maps can be cartographical or metaphorical (Roberts et al., 2024). Participatory mapping methods can be used in-person or online (Peacock and Devine-Wright, 2025).

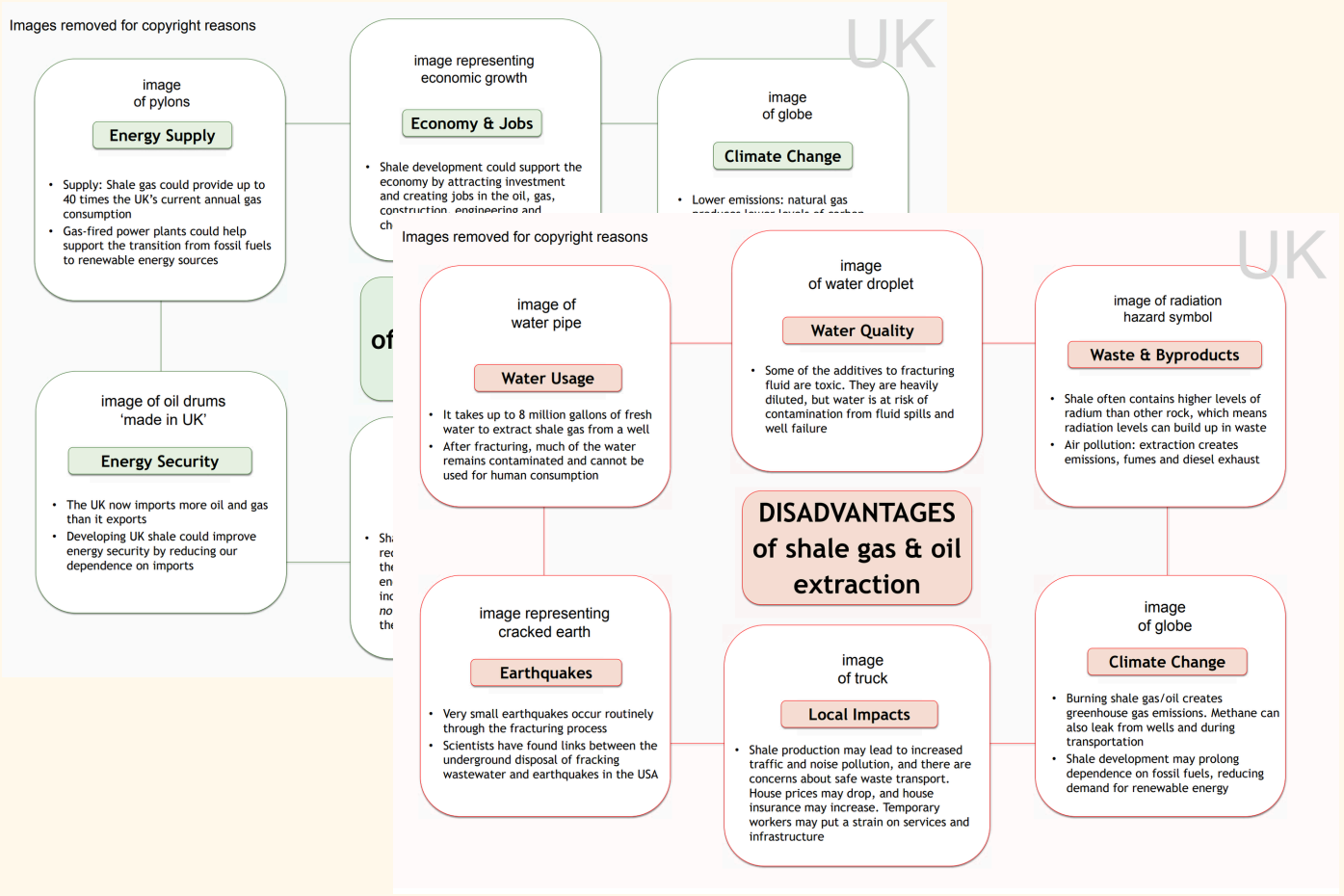


From Peacock, A., & Devine-Wright, P. ERSS (2025): Stakeholder annotations (left) and the distribution of energy technologies (right).

- Annotating and drawing on large-format maps can be an enjoyable way for groups to generate conversation and insights.
- Bear in mind that individuals have different levels of 'map literacy', so provide examples, be prepared to support, and offer alternative methods. Use print-outs and photocopies because some people don't feel comfortable drawing on 'official' maps.
- A variety of open-source and paid-for interactive mapping tools are available, including Open Street Map, QGIS and ArcGIS.
- Consider recording sessions to document conversations, but ensure you have the relevant permissions.

Key resource: Peacock, A., & Devine-Wright, P. (2025). How stakeholders legitimate 'acceptable' national energy transitions through spatial imaginaries and imagined publics: A Swedish case study. Energy Research & Social Science, 120, 103854. Accessible here.

3.1.2 Risk / Benefit poster task



Posters used during deliberative workshops to explore public perceptions of advantages and disadvantages of shale gas and oil extraction (Thomas et al., 2017)

During day-long deliberative workshops in the US and UK, Thomas et al (2017) used large format posters depicting potential advantages and disadvantages of shale gas and oil extraction. Two groups of participants were asked to rate the most important advantages and disadvantages, placing sticky notes with comments or questions on the posters. The groups then swapped to do the same with the other poster, before discussing the task as a group. Additional information sheets for each potential advantage and disadvantage were provided.

Key resource: Thomas, M., Partridge, T., Harthorn, B. H., & Pidgeon, N. (2017). Deliberating the perceived risks, benefits, and societal implications of shale gas and oil extraction by hydraulic fracturing in the US and UK. Nature Energy, 2(5), 1-7. Accessible here.

3.1.3 Panel discussions with Q&A

Panel discussions and Question and Answer (Q&A) sessions can form an effective part of town hall or advisory group meetings, seminars and webinars, either in-person or online. They can allow specialists and members of the public to communicate diverse points of view, answer questions and address conflicts. Some tips:

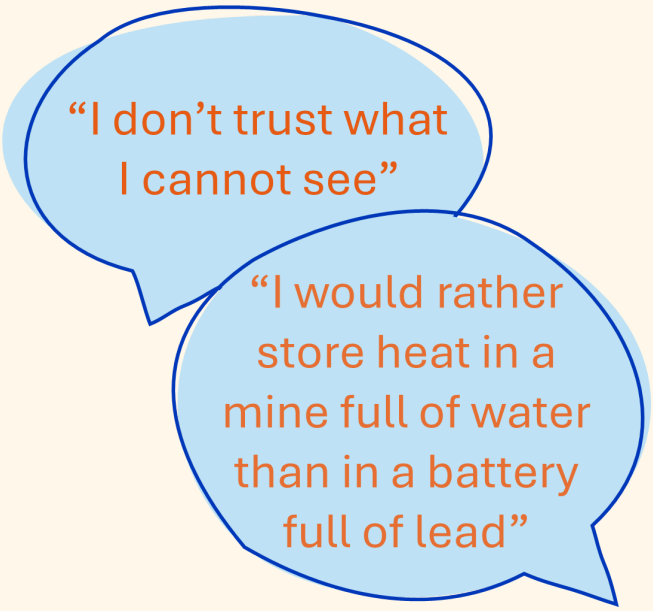
1. **Select panellists** with varied backgrounds and perspectives to enrich the discussion. Ensure each panellist is engaging and knowledgeable about the topic.
2. **Define the goals** of the discussion, plan the sequence of topics and questions, and allocate (and stick to) timings for introductions, discussion, and Q&A.
3. **Employ a neutral moderator** who can guide the conversation and ensure balanced participation.
4. **Plan interactions,** explaining how the audience can submit questions (e.g., online, via microphone). Remember that the mode of interaction may include or exclude participants. Ask participants beforehand to keep questions relevant and concise, and encourage panellists to respond directly to audience questions.
5. **Prepare** by ensuring all technical aspects (microphones, video, slides) are checked and functioning. Conduct a rehearsal.
6. **Follow-Up** by collecting feedback from audience and panellists to understand what worked well and what could be improved. Share recordings or summaries of the discussion for those who couldn't attend.

adapted from Meyrowitz (2025) and Dearnell (2023)

> "People want to hear not only from the operator, but also from neutral parties (mining authority, mayor, scientists, citizens living at other locations near an ATES, drilling company)"
> -Dr. Katrin Keiling

3.1.4 Quotes activity

Participants are invited to read and comment on quotes laid out on a table. While this is a relatively simple activity, it can generate lively and insightful discussion (Thomas et al., 2017). Quotes can be drawn from listening exercises early on in a project, be formulated by the team to address particular themes, or be based on research literature. For example:



- "UTES is like a natural underground battery"
- "I don't trust what I cannot see"
- "I am excited by new inventions"
- "Fracking showed we shouldn't mess with the underground"
- "UTES could be the key to sustainable energy for future generations"
- "I would rather store heat in a mine full of water than in a battery full of lead"
- "We should leave the water underground"
- "I'm concerned about what the heat will do to the underground - what about bacteria?"
- "We have enough rain in this part of the world to use the water for storage"

3.1.5 Book club

Use prompts to discuss underground books, such as:

Journey to the Centre of the Earth, Jules Verne (1864)
Underland: A deep Time Journey, Robert Macfarlane (2019)
The Street Beneath My Feet, C. Guillan & Y. Zommer (2017)

- How is the underground portrayed in the book?
- How are scientific facts balanced with imaginative elements?
- What does the writer think and feel about the underground?
- What drives the characters to explore the unknown?
- How does the book reflect the spirit of the time when written?
- How are women portrayed?

Other book ideas here.

3.1.6 Perspective spinner

The perspective spinner (Thomas et al., 2025) can be used as a tool to think about UTES from someone else's viewpoint, encouraging empathy (the ability to take someone else's perspective) (Brown et al., 2019).

Cut out the spinner, insert a pencil through the hole, and spin. Whomever it lands on, discuss UTES from their perspective. What would be their hopes, aspirations, fears about the technology? If working in a classroom setting, participants can then be asked to draw, write or collage from the view of another person. The spinner can be used alongside other activities such as political role play, quotes activity, and dice game.

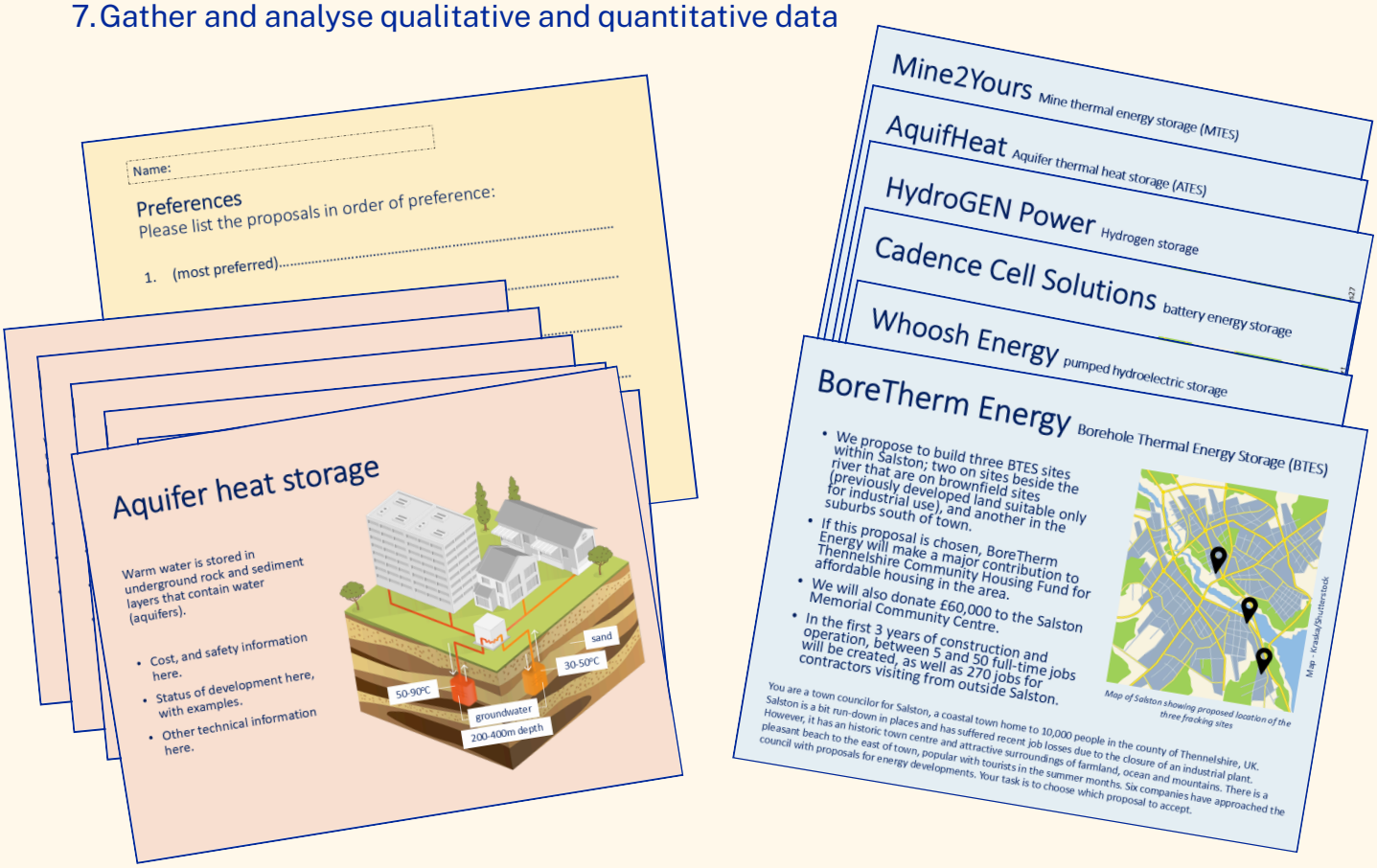
adapted from Thomas et al., 2025

3.1.7 Political role play

Participants are divided into groups to play the roles of local politicians, tasked with debating and ranking UTES proposals for a fictional town. This activity can foster lively, in-depth discussions on preferences, decision-making criteria, conditions, and trade-offs (Thomas et al., 2018).

Method:

1. Introduce each energy storage type, providing information sheets
2. Participants assume the role of a politician for a fictional town
3. Each is provided with copies of six proposals for the town
4. Participants individually rank proposals in order of preference
5. In groups, participants reach a consensus ranking
6. Groups report back on their consensus ranking and discuss
7. Gather and analyse qualitative and quantitative data



adapted from Thomas et al. (2018)

This activity provides benefits for researchers and participants by providing a forum to:

- Think about alternative realities and futures
- Consider multiple viewpoints, key concerns and priorities
- See the world from other perspectives
- Find freedom to voice opinions
- Gain learning, interest, motivation and participation

Consider using personas such as an organic farmer or water company manager (c.f. Torma and Aschemann-Witzel, 2024).

3.1.8 Underground riddles

Answers on Page 77

1 Beneath the earth at six pilot sites,
I'm storing heat both day and night.
At United Downs, Litoměřice, and Berlin,
In rock and water, warmth stays within.
At Delft, Darmstadt, and Bochum too,
I demonstrate what I can do.

What am I?

2 The sun shines bright, the wind blows free,
But only when they choose to be.
So deep underground, heat, I store
To make energy systems more secure.

What am I?

3 I was carved by people, deep in the ground,
Left behind when no more riches were found.
Now filled with water, up to 90 degrees warm,
Local energy systems, I may transform.

What am I?

4 I'm drilled down deep, a hundred metres or more,
Not to get water, but for warmth to store.
In summer I gather, in winter I share,
A hidden cycle, but always there.

What am I?

5 In layers of rock and sediment deep,
I store the warmth for you to keep.
Down in the water (200 meters or more),
I hold the heat, way beneath the floor.

What am I?

Can you write your own riddles or poems?

"By evoking emotions such as wonder, awe, or concern, poetry can inspire people to care about geoscience issues and take action to address them" - Illingworth 2023, p.132

3.1.9 Children's Book *Elke Mugova*

Development of the Children's Book "Dive into the Mine"

The project focuses on creating an educational children's book titled "Dive into the Mine" [German: "Tauchfahrt ins Bergwerk"], designed for children aged 4–10. The story introduces young readers to the fascinating world of geothermal technologies, especially mine thermal energy storage (MTES) in an engaging and age-appropriate way.

Storyline

The narrative follows a father and his children on a walk where they discover a drilling site. Curious, they meet a drilling supervisor and a geologist who explain the purpose of the site. The geologist demonstrates a dive into the mine using a special underwater camera, allowing the children to watch the exploration. Through this adventure, the MTES concept is explained in simple terms, and an experiment on heat storage is presented. The book concludes with an information page for adults and an invitation to visit a real drilling site and its information board.

Format & Distribution

- Formats: printed as a small book and available digitally as an interactive PDF
- Distribution:
  - 2026 information events at kindergartens and primary schools
  - As educational material at conferences and trade fairs

Purpose & Impact

This initiative aims to make complex geoscientific concepts accessible to children while also providing non-expert adults with valuable insights. Similar small educational books from other institutions have proven highly popular and effective.

Development Process

The story is based on real fieldwork experiences to ensure technical accuracy. Illustrations were created in close collaboration with a graphic designer, who visited the drilling site to capture authentic details. This hands-on approach guarantees a scientifically correct and visually appealing representation of MTES technology.

3.2 Kitchen Science

- **Exploration** — These activities encourage active learning and critical thinking. They can be used to raise awareness of scientific methods, focusing on evidence and experimentation.
- **Discussion** — The activities also provide opportunity to discuss UTES technologies, raise concerns, hopes and questions while engaging with hands-on activities.

Activity	Main objective	Time	Example applications	Age	Page
Jelly UTES	Inspire, Inform	1 hour	Schools, open days	6+	52
Heat storage competition	Inspire, Inform	1 hour	Schools, open days	6+	53
Baked drill bits and geological layer cake	Inspire, Inform	1 hour	Home, schools, open days	6+	54
One-minute melon	Inspire, inform	1 minute	Schools, open days, on-the-fly engagement	3+	55

3.2.1 Jelly UTES *inspired by Veronika Slavíková*

Learning Outcomes

- Understand the concept of heat storage
- Create models of BTES, ATES and MTES
- Learn how water moves through boreholes, aquifers and mines

Materials

- plastic containers
- Jelly
- Water
- Straws/pipes
- Pipettes
- Food dye
- Balloon

1. Preparation (30 mins, day before)

- Mix jelly as per pack instructions
- Use different coloured jellies to layer colours as the jelly hardens, representing rock layers
- For the ATES model, break up the lower layer before adding the upper layer
- For the BTES model, place connected bent straws into the lower layer before it hardens
- For the MTES model, place a water-filled balloon into the lower layer. Once the jelly has set, carefully empty the balloon

2. Activity (15 mins)

Allow students to inject coloured water into the models to explore how the water behaves. It should stay within the BTES straws and MTES cavity. The water should spread through the gaps in the ATES jelly, but not the 'cap rock' jelly. Optional: provide students with Lego/Monopoly houses and people.

3. Discussion (10 minutes)

- [If using Lego/Monopoly] discuss scale, and the importance of environment and social factors
- How does the water move through the different types of UTES?
- How do rocks behave compared with jelly?
- What are the advantages and challenges of each type of UTES?

remember risk assessment and ingredients list

3.2.2 Heat storage competition

Learning Outcomes

- Understand the concepts of heat storage, thermal conductivity and insulation
- Conduct a simple experiment to observe thermal properties of different materials
- Recognise the importance of controls in an experiment

Materials

- Good quality latex balloons
- Measuring cup and funnel
- Glass tumblers
- Various insulating materials (e.g., wool socks, kinetic sand, gravel)
- Meat thermometers
- Hot water (60°C)

Lesson Structure

1. Introduction (10 minutes)

- Discuss heat and how it moves from warm objects to cooler surroundings
- Introduce underground thermal energy storage
- Explain that some materials keep heat in better than others (e.g., coats, blankets)

2. Activity: Heat Storage Competition (35 minutes)

1. Heat water to around 60°C (with adult supervision)
2. Adults use a funnel to pour 60ml of hot water into each balloon. Tie the balloon securely
3. Give one balloon to each participant
4. Participants wrap or cover their balloons using insultation materials
5. Include a control balloon with no insulation
6. Spend 30 minutes on another task (see pages 56 and 63)
7. After 30 minutes, use thermometers to measure temperature of water inside the balloons
8. The warmest water wins!

3. Discussion (10 minutes)

- Why do some balloons stay warmer than others?
- How do different materials affect heat retention?
- Discuss surprising results (e.g., kinetic sand absorbs heat, cooling the balloon faster)
- Connect this experiment to UTES

> "Good science communication explains not only what we know, but how we come to know it" - Lukas Seib, Research Fellow, Darmstadt

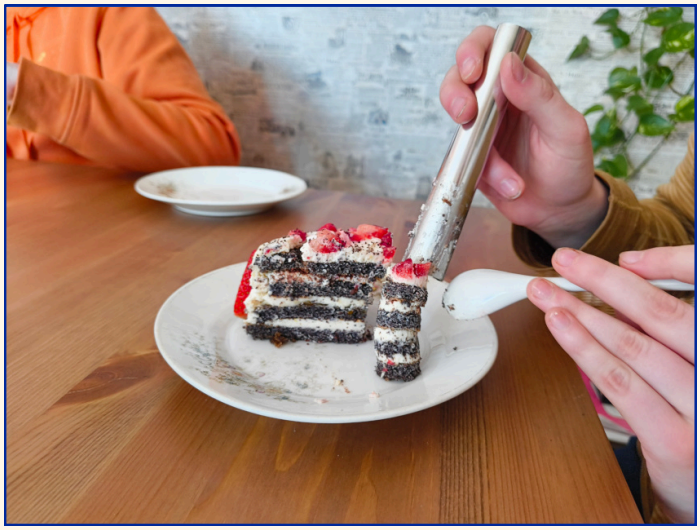
Key takeaways

Some materials keep things warm better than others
Heat moves from warmer objects to cooler ones
Experiments need controls to compare results
Understanding heat storage helps us in real-world applications like UTES

remember risk assessment and ingredients list

3.2.3 Drill-bit biscuits and geological layer cake *Veronika Slavíková*

As discussed on page 15, home-made bakes can demonstrate a personal investment in the project and respect for participants. Why not bake an easy yoghurt pot cake, make UTES themed biscuits or a geological layer cake, like these by Veronika? To combine your baking with a science experiment, try Baked Alaska, whereby whipped egg whites insulate a frozen ice cream core when baked in the oven, here.



Veronika's drill bit biscuits (left) and geological layer cake with core (right)

Easy Yoghurt Pot Cake

1 x pot plain live yoghurt (individual sized pot ~150g)
2 x pots self-raising flour
1 x pot caster sugar
1 pinch salt
½ pot sunflower or vegetable oil
3 eggs
2 tsp vanilla extract
Up to 1 pot raspberries, blueberries, or chocolate chips

- Use the yogurt pot to measure the ingredients into a bowl
- Stir until mixed, then pour into a greased or lined loaf tin
- Bake at 170°C for 45-60 minutes or until a skewer comes out clean

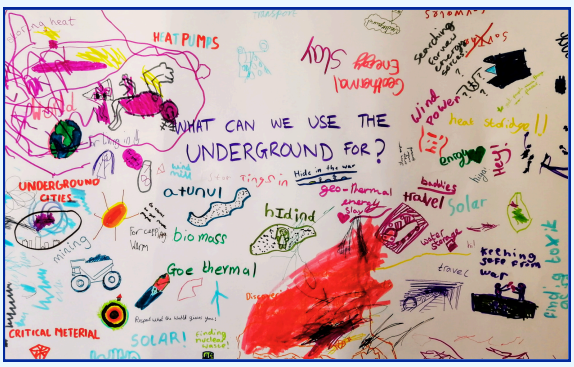
remember risk assessment and ingredients list

3.2.4 One-Minute Melon

For a quick and effective way to engage young people with the concept of underground thermal energy storage, cut away a quarter of a melon. Poke a straw and a monopoly house into the crust. Children will be intrigued to know what it is about, giving you the opportunity to tell them about UTES. Use the melon as a prop to describe how:

- The melon represents the Earth.
- The crust is around 30km thick. This is from about here to [name a place 30km away] and would take about 8 hours to walk.
- Beneath the crust is the mantle, which contains hot liquid rock. The heat from the mantle warms the crust.
- Scientists are testing ways to use this natural warmth to store heat in old mines, in aquifers, and in the rocks themselves. On this scale, it would be just beneath the surface.
- Heat that is produced in the summer (e.g., from solar panels) can then be stored underground until it is needed in the winter. This is called underground thermal energy storage.

The one-minute melon was a useful hook for a school careers fair, where children found out about different jobs. It was used alongside an A1 sheet of paper, on which children wrote down what we can use the underground for. The children learned about UTES and linked this new knowledge with what they had been learning in class, including renewable energy (inc. geothermal), history and biology.



3.3 Underground Creativity

It can be hard for people to imagine the underground, and difficult to engage people with something they can't see. Creative activities can make the underground more relatable and provide a way to grapple with the unknown.

- **Creativity for complexity** — Creative approaches can offer accessible and enjoyable ways to explore complex and unfamiliar issues. By creating something that can be seen and felt, such approaches can make intangible subjects more tangible – particularly useful for exploring topics that are underground and out of sight.
- **Versatility** — Such methods are versatile and can be adapted to be used by different groups. They also offer various wellbeing benefits, such as facilitating flow states — moments of deep focus — while fostering curiosity and accomplishment.
- **Inclusivity** — Creative methods can help break down 'hierarchies of intellect' where one person is perceived as an expert and another is not, hindering dialogue (Illingworth 2023).

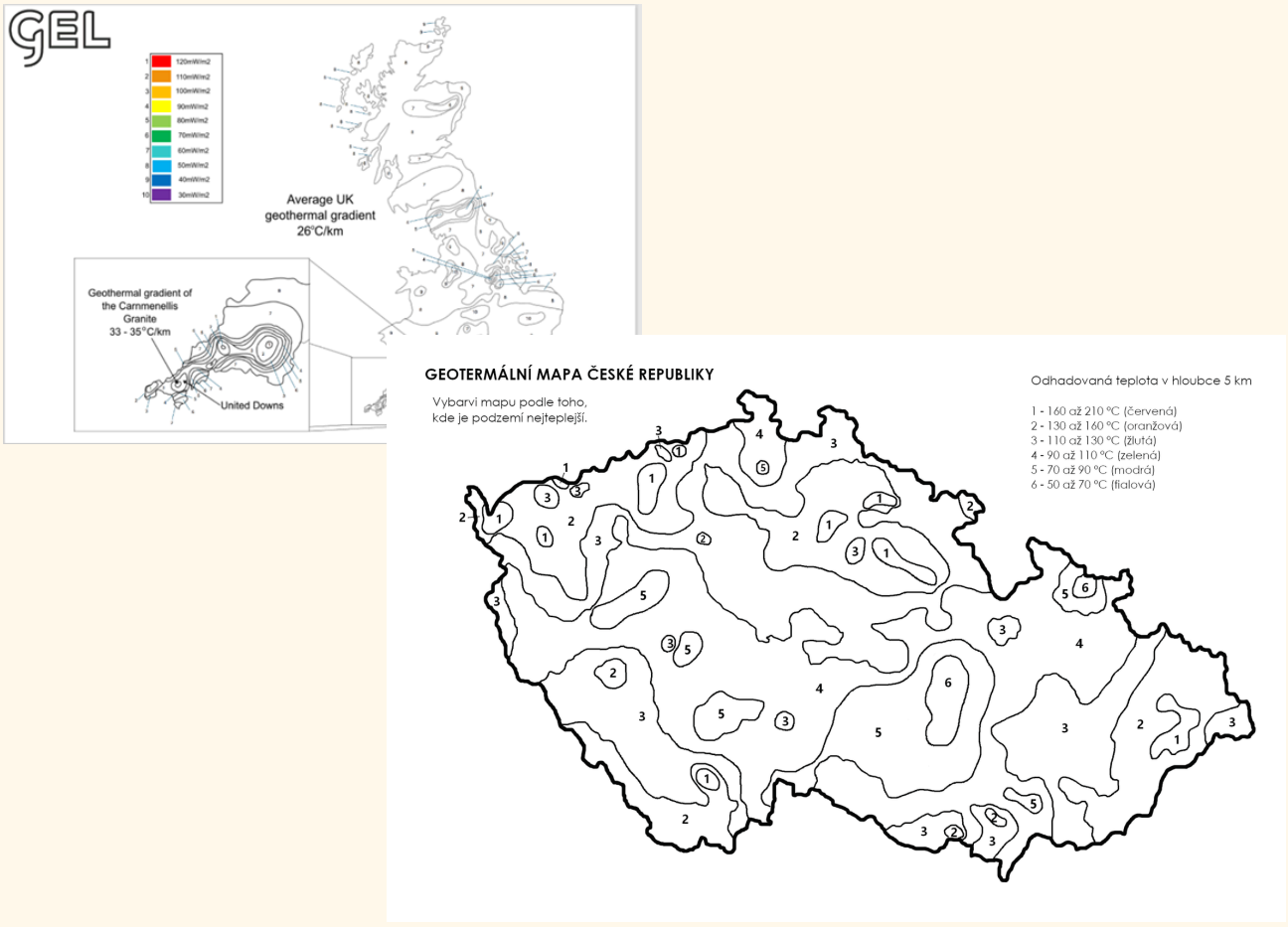
Activity	Main objective	Time	Example applications	Age	Page
Colouring sheets	Inspire, Inform	2 mins – 30 mins	Open days, public hearings, exhibitions and conferences	1+	57
Rock, paper... geothermal gradients	Inspire, Inform	30 mins – 1 hour	Schools, open days	6+	58
Underground blocks	Inspire, Inform, Consult	30 mins- weeks	Schools, open days, focus groups, interviews	8+	59
Underground clay tiles	Inspire, Inform, Consult	30 mins – 2 hours	Schools, open days, focus groups, interviews, conferences	6+	60
Junk drill rig	Inspire, Inform	30 mins – 2 hours	Schools, open days	6+	61
3D drill rig	Inspire, Inform	20 mins	Schools, open days	6+	62

> "Effective [geoscience] communication demands a creative approach" - Illingworth (2023) p.131

3.3.1 Colouring

Colouring can be popular with children, older people (e.g., in care homes), and increasingly others as a mindfulness activity. Colouring sheets could include:

- **The energy network**
- **UTES technologies (BTES, ATES, MTES)**
- **Geological maps showing distribution of rock types**
- **Geothermal gradients**



Geothermal gradient colouring sheets used at the United Downs and Litoměřice sites (thanks to Jane Charman and Veronika Slavíková)

Extension activities:

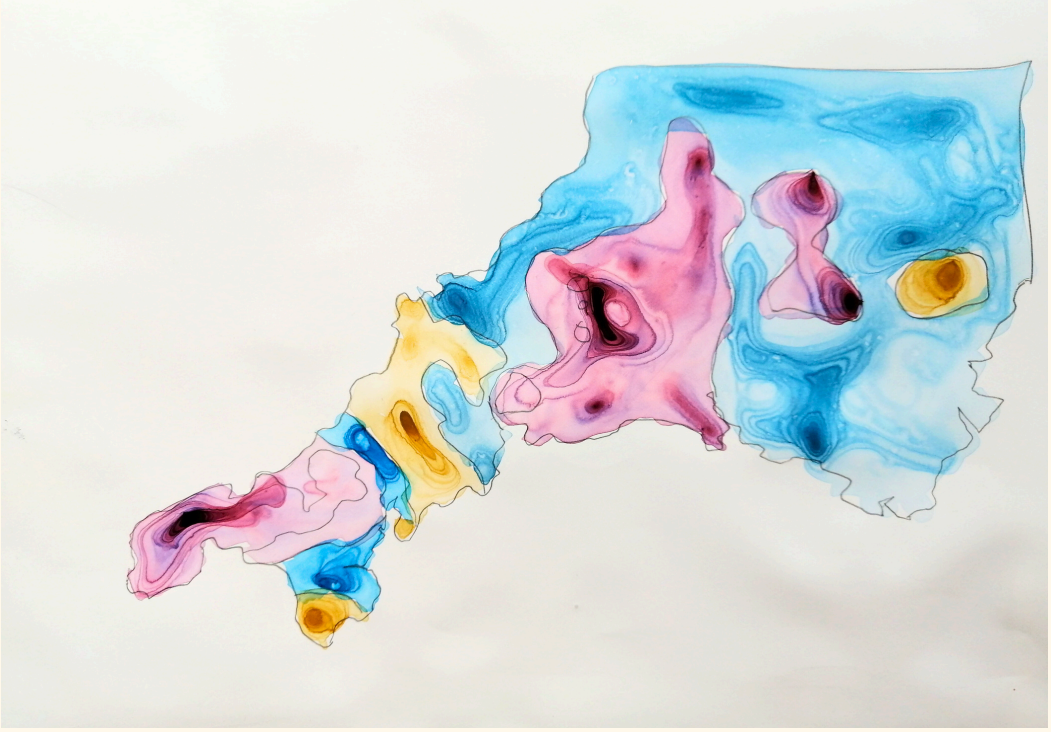
- Arithmetic colour-by-numbers
- Paint by numbers
- Include spaces to label regions, rock types or technologies

3.3.2 Rock, paper... geothermal gradients

This activity uses karst paper, which is made with crushed rocks rather than wood pulp. Due to it's low absorbency, paint can be blown around the page with a hairdryer to create beautiful effects that resemble isotherms. Do not expect accurate maps, but do expect inspiration, conversation and a sense of achievement. This activity was inspired from a tutorial found here.

Materials

- Karst paper
- Stencil (optional)
- Watercolour paints
- Hairdryer



Geothermal gradients in Cornwall (not accurate!)

Extension activity:

Try creating your own paint from rock pigments. There are several online guides, including one from the Victoria and Albert Museum here.

3.3.3 Underground blocks

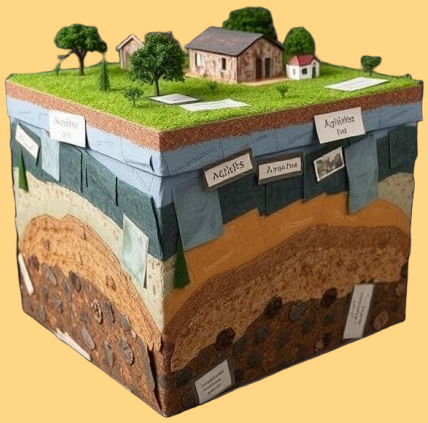
This activity uses a method developed by Dr Hazel Gibson and colleagues to understand public and expert perceptions of the subsurface. In their study, 29 participants were interviewed and invited to draw onto a 1m^2 cube. On the top surface of each cube was a topographically moulded aerial photo of the study location. In combination with verbal interview findings, the models provided insights into how people visualised their local underground.

Materials

- Cardboard box(es)
- Pens and pencils
- Optional: clear plastic/laminate and whiteboard markers for wipe-clear boxes
- 3D-printed aerial photograph of local area

Extension activities:

- If in a group setting, organise a gallery walk to view and discuss each others' boxes. Encourage sharing between experts and non-experts
- Adapt the method for a school art-science project
- Use collage instead of drawing (Thomas et al., 2025)



Left: 3D participatory models created by experts and non-experts (Gibson et al., 2016; reproduced from Hydrology and Earth System Sciences 20(5):1737-1749). Above: image created with DeepAI Image Generator in response to user requests

Key resource: Gibson et al., (2016) A "mental models" approach to the communication of subsurface hydrology and hazards. Hydrology and Earth System Sciences 20(5):1737-1749

3.3.4 Underground tiles

This activity is designed to spark conversation about the nature of the underground, perceptions of UTES and our relationship with the world beneath our feet. Questions to explore include: how to people perceive the underground? What do they value about the underground? What do they think is at risk?

Materials

- 2 cups all-purpose flour
- 1 cup salt
- 1 cup warm water
- rolling pin
- items for imprints, e.g. toy dinosaurs, shells, straws

Directions:

1. Combine 2 cups of all-purpose flour with 1 cup of salt in a mixing bowl.
2. Gradually add 1 cup of warm water.
3. Stir to form a dough, and knead for 5 minutes.
4. Roll the dough to around 5mm thickness and cut into tiles.
5. Encourage conversation between participants while decorating the tiles. Use prompts such as, ‘what have you included?’, ‘what did you omit?’, ‘why did you include this?’, and ‘tell me more about your tile’. Explore surprising themes.

Underground salt dough tiles featuring caves, litter, invertebrates, mines and fossils

Extension activity:

- Make clay tiles with natural clay
- Paint or glaze them to make a wall display or turn your tiles into simple slab pots
- After a short UTES lecture, challenge participants to include UTES elements on their tile

3.3.5 Junk drill rig

Make a junk model of a UTES drill rig or an invention to develop UTES in your area. You can use items such as cereal boxes, barbeque skewers, toilet rolls, milk bottle tops, elastic bands, tin foil, corks, cans, cartons, lollypop sticks, pipe cleaners and tape.

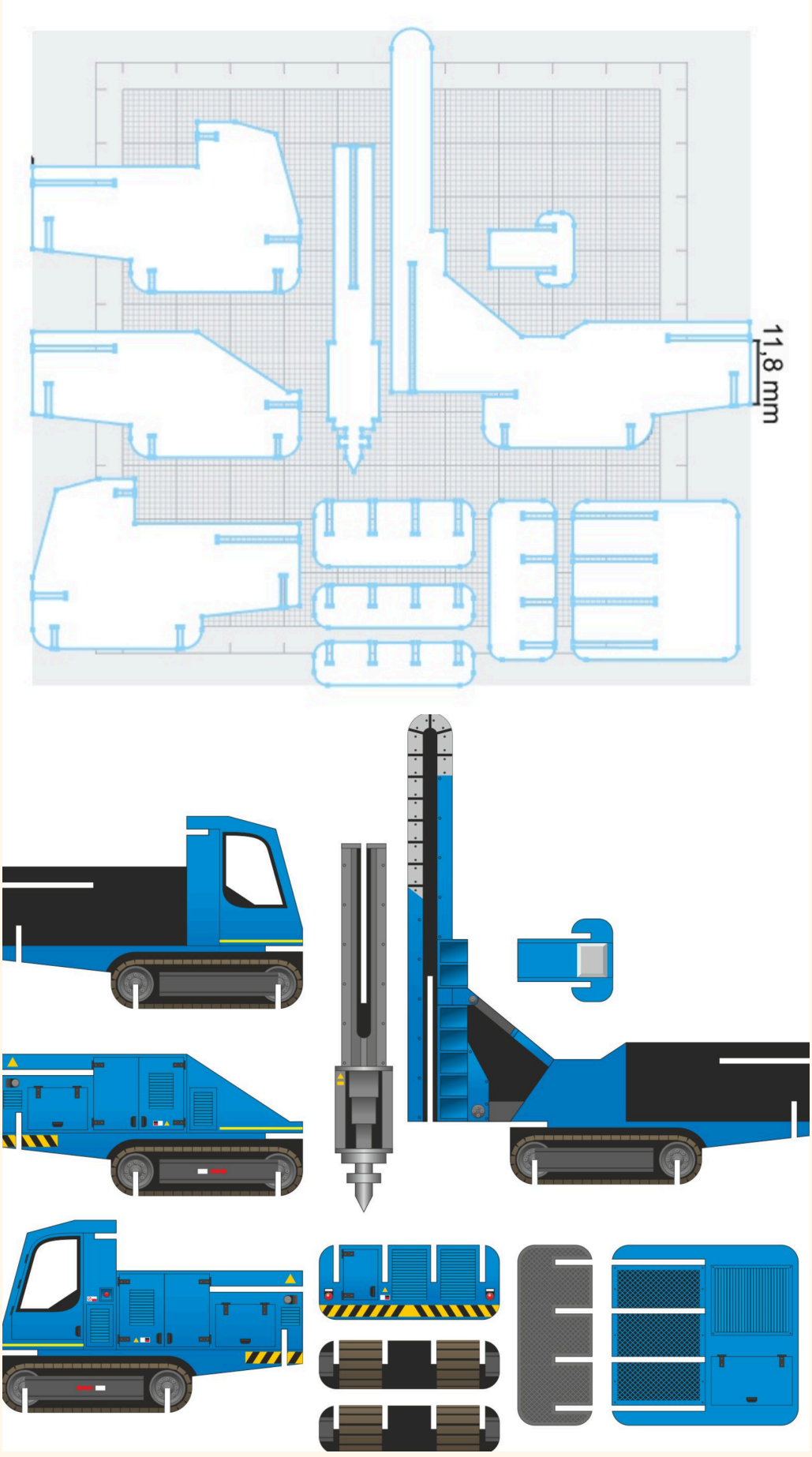
1. What is your invention called?
2. What does it do?

Image created with DeepAI Image Generator in response to user requests

Extension activities:

- Make a fact sheet about real UTES drill rigs. Consider: what shapes are used? What components are there? What does each part do?

3.3.6 3D drill rig *Veronika Slavíková*



3.4 UTES Games

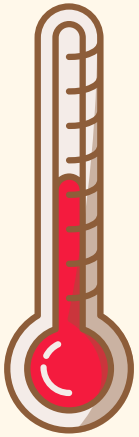
- **Playfulness** — Playful methods can enhance engagement by providing interactive experiences that sustain interest.
- **Collaboration** — Games can encourage collaboration and dialogue, creating opportunities to share ideas, perspectives, and questions in a relaxed environment.

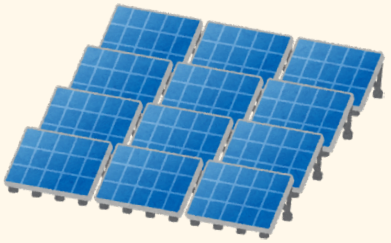
Activity	Main objective	Time	Example applications	Age	Page
What's gone underground?	Inform, inspire	2-20 mins	Kindergartens, care homes	2+	64
Pin the Bits on the BTES	Inform	2-20 mins	Kindergartens, schools	3+	65
Matching pairs	Inform, inspire	2-20 mins	Schools, care homes, open days	4+	66
Mineral match-up	Inform	5-20 mins	Schools, open days	8+	67
UTES quiz	Inform	20 mins	Schools, open days	11+	68
UTES snakes and ladders	Inspire	20 mins	Schools, open days	6+	68
UTES crossword	Inform	5–20 mins	Schools, open days	11+	70
UTES word search	Inform	5–20 mins	Schools, open days	6+	71
UTES dice game	Inform, Consult	2–30 mins	Schools, open days, focus groups, interviews	8+	71
Design an underground game	Inform, Consult	Hours–days	Schools	11+	73

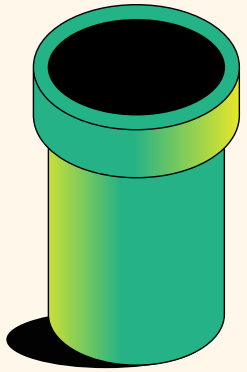
> "You get the parents playing as well, and quite often our children's area is fully populated with adults and the children are off reading the wall panels" - Jane Charman

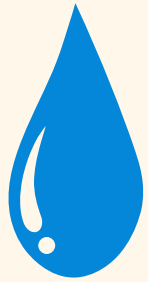
3.4.1 What's gone underground?

Have participants close their eyes. Cover one of the pictures (e.g. with a leaflet or piece of paper). When they open their eyes, ask, "uh-oh, what is missing"? Once they guess, tell them what each symbol represents.





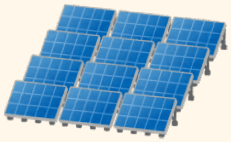


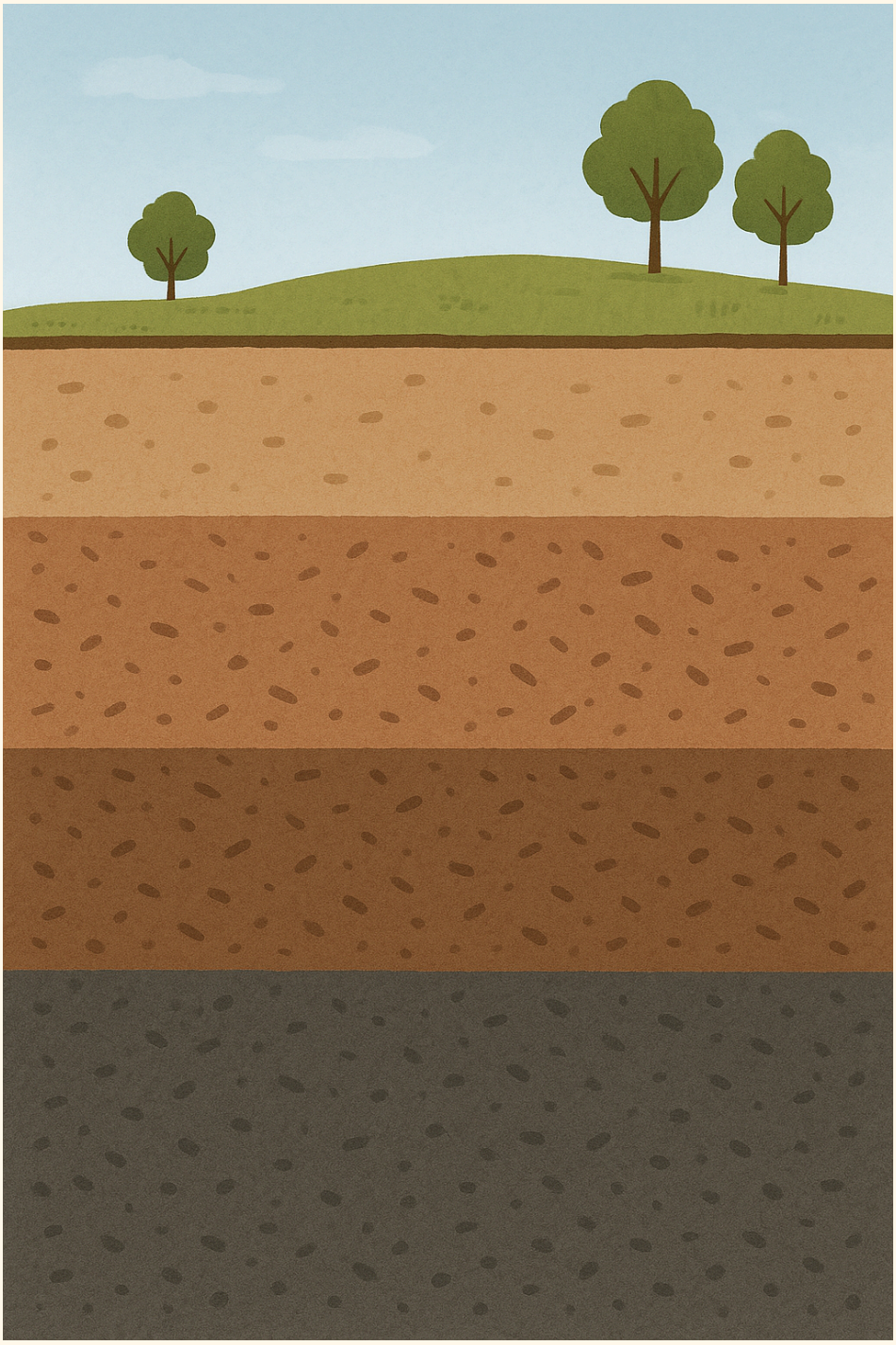


3.4.2 Pin the bits on the BTES

Stick the large poster to the wall. Younger children can put the ‘BTES bits’ in the right place. Older children can be blindfolded first to make it more difficult. Give hints like, ‘the sun in shining! Where should we put the solar panels?’, and ‘Uh-oh! We need to store some heat for winter - where should we put it underground?

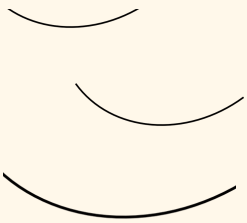
bedrock

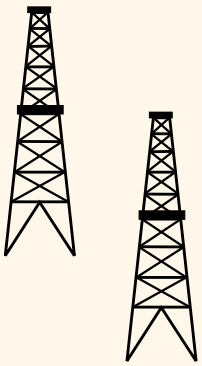


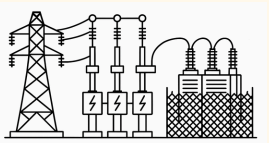


topsoil

hot rocks

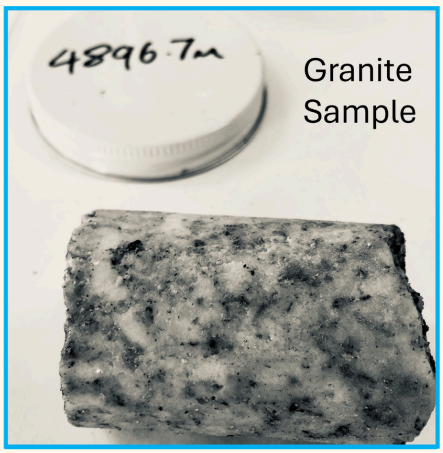


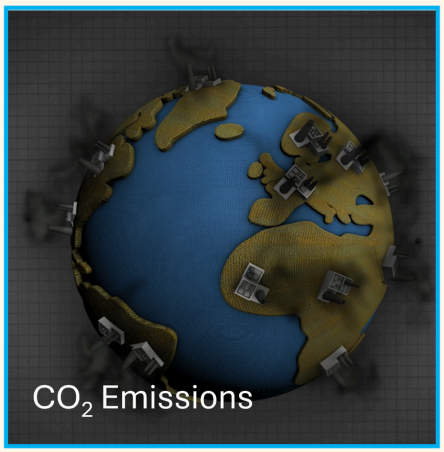


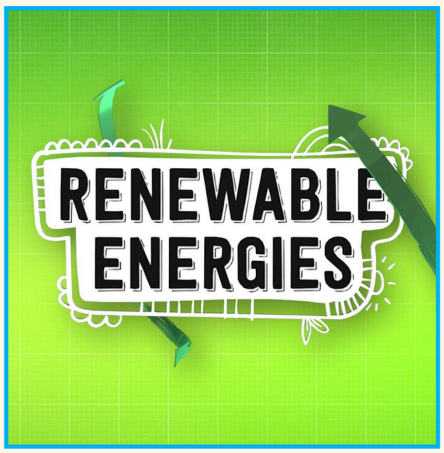


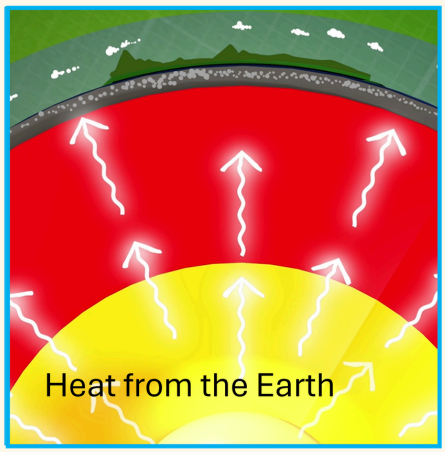
3.4.3 Matching pairs *adapted from a game by Jane Charman*

Print two copies, cut out, place face down, and turn over pairs to win. Also use as a Snap game.



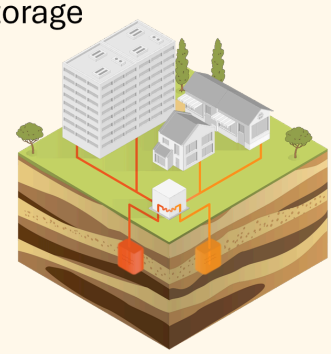


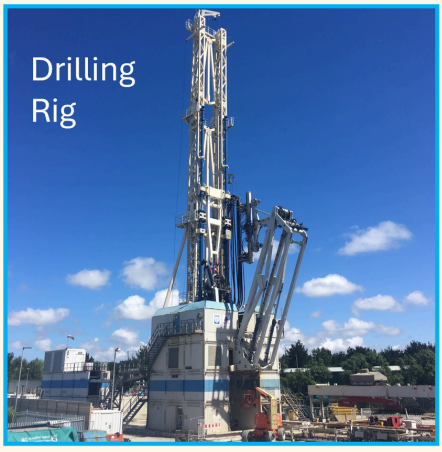




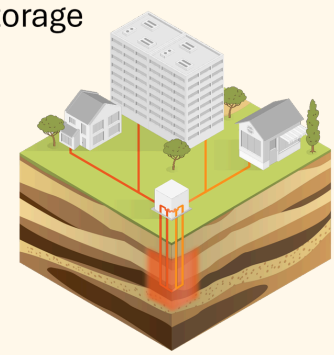
Sandstone sample

Aquifer thermal energy storage





Bore hole thermal energy storage



Mine thermal energy storage

3.4.4 Mineral match-up

Inspired by Geo Energy Northern Ireland

Can you identify which rocks are involved in the PUSH-IT project? Draw arrows to match the picture to the correct description. The first one has been done for you. Answers on page 77.

1

2

3

4

5

Granodiorite is an igneous rock with large, visible crystals. Like granite, it is composed of quartz, feldspar, and darker mica or hornblende, which together give it a speckled appearance. Unlike granite, which can be pink or dark grey, granodiorite is usually paler in colour. Borehole thermal energy storage (BTES) is being tested in granodiorite at the Darmstadt site.

Sandstone is a sedimentary rock formed from compacted sand-sized grains. It often has visible layers, and can be a variety of colours. Aquifer thermal energy storage (ATES) systems, like those in Delft and Berlin, store heat in aquifers. These permeable layers often consist of sandstone.

Claystone is a sedimentary rock composed of tiny clay-sized particles. Due to the small particle size (less than 1/256 of a millimetre) claystone formation occurs in calm water, such as river deltas. It can be a variety of colours. Claystones are found between 180 - 780 m depth at the Litoměřice BTES site.

Chalcopyrite is the world's most abundant copper ore. It has a brassy appearance and can be mistaken for fool's gold (pyrite). Mines that include chalcopyrite are now being explored for their mine thermal energy storage (MTES) potential at United Downs in Cornwall.

Coal is a black or brown-black sedimentary rock formed from the remains of ancient plants. It has been extensively mined to provide fuel. Mine thermal energy storage (MTES) uses water in former coal mines at Bochum to store thermal energy.

Images from iStock (1-4) and Shutterstock (5). Activity inspired by Geo Energy NI: Discover the Heat Beneath your Feet: Teaching pack. Available here.

3.4.5 UTES quiz

Use the PUSH-IT website at www.push-it-thermalstorage.eu to answer the following questions (answers on Page 78):

1. What is the main goal of the PUSH-IT project?
2. What are the three types of heat storage technologies demonstrated by PUSH-IT?
3. At what temperature does PUSH-IT aim to store thermal energy?
4. What is an aquifer?
5. Which countries have PUSH-IT sites?
6. How does underground thermal energy storage help achieve the EU's climate goals?
7. What is the role of the Delft demo site in the PUSH-IT project?
8. What is the purpose of the follower sites in Germany, Czechia, and the UK?
9. Where is mine thermal energy storage (MTES) carried out in the PUSH-IT project?
10. To what depth is the borehole for geothermic measurements at the Litoměřice site?

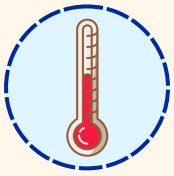
3.4.6 UTES snakes and ladders

Inspired by Jane Charman

Climb the ladders and avoid the snakes to be the first to have an operational UTES site!

Directions: Cut out the counters below, or make your own counters using buttons, shells or seeds. Each player places their counter on square 1. Take turns rolling a die, moving forward the number of squares rolled. If you land on a square with the bottom of a ladder, climb to the square at the top of the ladder. If you land on a square with the head of a snake, slide down to the square at the tail. The first player to land exactly on square 50 wins.

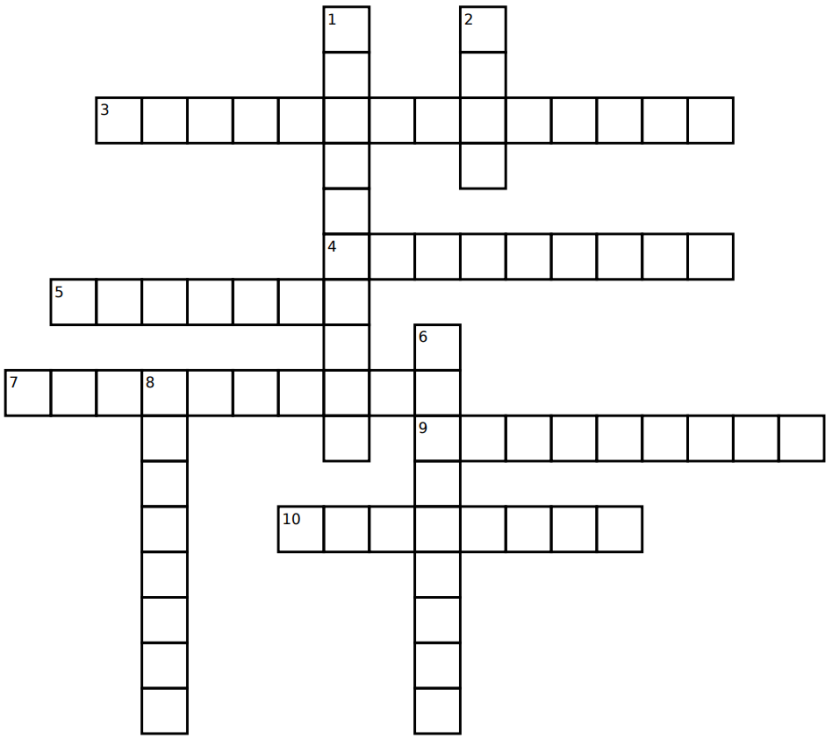





50 Your UTES site is operational!	49	48 Supply chain delays	47	46
41	42	43	44	45
40 Efficient permitting process	39	38 Regulatory challenge	37	36
31	32	33	34 Technological breakthrough!	35
30 Equipment failure	29	28	27	26
21	22 Positive media coverage	Lack of skilled workforce	24	25
20	19		17 Visual impacts	16
11 Community support	12	13	14	15
10		8	7	6
1	2	3 Obtain funding for a test well	4	5

3.4.7 UTES Crossword

Write answers to the clues in the spaces and check your answers on page 77.

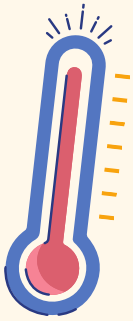


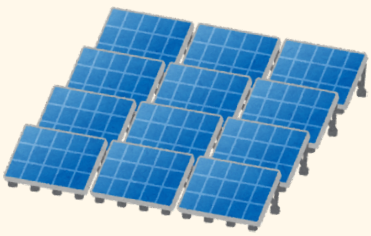
Down:

1. Heat from the Earth's interior (11)
2. Site where minerals or metals are extracted from the Earth (4)
6. Allows fluids or gases to pass through it (9)
8. Changing with the seasons (8)

Across:

3. Branch of science that deals with heat, energy, and their transformations (15)
4. Device that transfers heat between different materials (8)
5. Layer of rock or sediment underground that holds water (6)
7. Beneath the Earth's surface (10)
9. Energy sources that are naturally replenished, such as geothermal energy (9)
10. Deep, narrow hole drilled into the ground (8)



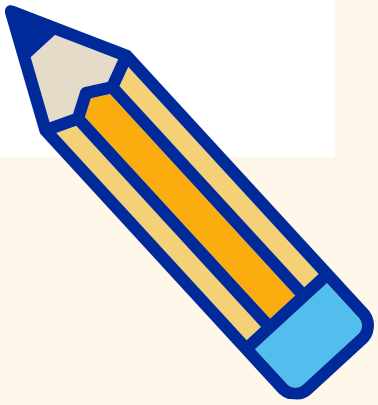


3.4.8 UTES Word Search

Highlight or circle the listed words on the grid. Words can be vertical, horizontal, or diagonal. Answers on Page 78.

Y	G	G	Y	E	N	E	R	G	Y	X	W	J	I	S	R	V	K
D	R	B	D	S	C	U	D	O	E	X	R	U	P	P	X	A	M
V	O	O	I	R	F	S	U	B	S	U	R	F	A	C	E	Q	G
J	U	I	C	J	T	G	E	O	T	H	E	R	M	A	L	U	N
L	N	E	F	K	B	J	V	F	H	E	A	T	I	A	W	I	C
L	D	P	Q	W	S	Y	X	M	I	N	E	Q	D	D	T	F	E
F	W	H	S	D	Q	G	T	S	E	A	S	O	N	A	L	E	X
J	A	R	E	N	E	W	A	B	L	E	O	T	J	D	I	R	S
Z	T	Y	T	H	E	R	M	O	D	Y	N	A	M	I	C	S	G
Y	E	V	M	G	X	R	B	O	R	E	H	O	L	E	O	A	R
H	R	K	O	F	D	T	N	C	F	H	W	T	E	X	H	Y	U
D	Z	H	K	F	H	Q	H	Q	J	F	B	S	U	Z	F	I	Z

THERMODYNAMICS
GROUNDWATER
GEOTHERMAL
SUBSURFACE
RENEWABLE
SEASONAL
BOREHOLE
AQUIFER
ENERGY
ROCKS
MINE
HEAT

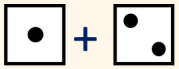


3.4.9 UTES dice game (overleaf)

Use the dice game to generate discussion about perceptions of underground thermal energy storage. Modified from Thomas et al. (2024).

Roll two dice and finish the sentence *about underground thermal energy storage*

Re-roll the dice if nothing comes to mind or use one die

Example:  = “I imagine underground thermal energy storage….”

I imagine	the underground…
I wish	UTES…
I remember	energy systems…
I want to know if	the public…
I hope	energy companies…
I like	politicians…

3.4.10 Design an underground game for 8-108 year olds

While *playing* games can enhance active learning, engagement and motivation (Hayse, 2018), *designing* them requires learners to construct new relationships with that knowledge (Kafai, 2006). Designing a game to play with a different generation fosters intergenerational engagement and discussion. It also requires in-depth understanding to enable clear communication.

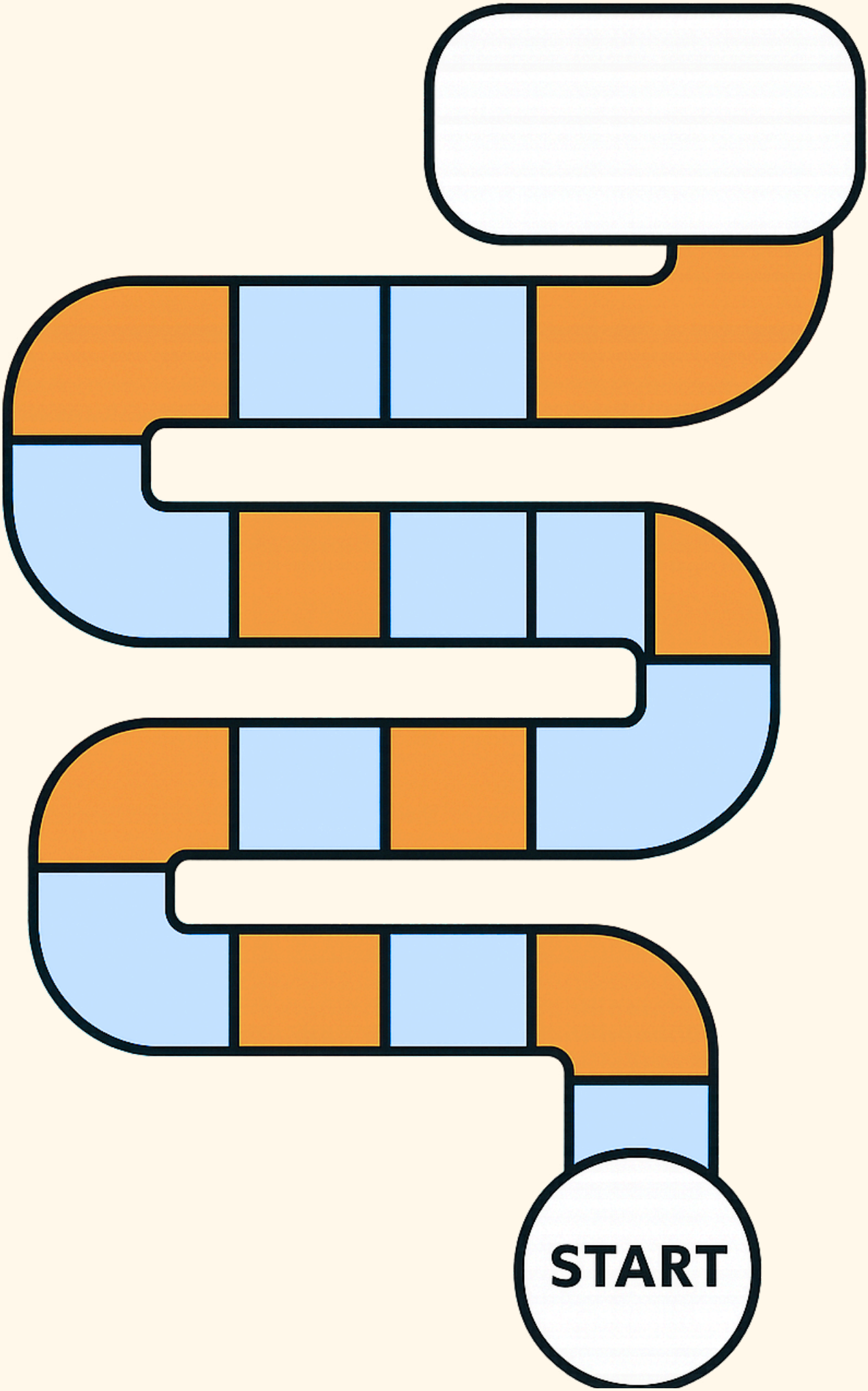
Try this:

- Use game templates available online, or the board overleaf. Try top trumps, snakes and ladders, snap, bingo, board games, drawing games or storytelling games.
- Use Q&A sheets and glossaries to create question cards
- When playing your game with another generation, don't worry about sticking to the rules - it's the playing and conversation that are important.

Use the following guide to be a GAME ACE

Gameplay: What are the rules? Are there goals, rewards, strategies?
Aesthetics: Does it look good?
Mechanics: Is the game intuitive and usable?
Engagement: Does it encourage collaboration, learning, discussion?
Accessibility: Is the game usable? Consider text size, imagery, colour.
Content: Is information about UTES appropriate and accurate?
Effectiveness: Does the game stimulate understanding, discussion?

Adapted from Thomas et al (2025) The Climate Comic Activity Book (available at www.climatecomic.co.uk); and Thomas, M., Urbanek, E., Ladd, C. J. T. (2025) Intergenerational Tabletop Game Design for Exploring the Climate Emergency: Insights from an Undergraduate Field Course. Journal of Geography in Higher Education.


START

04 Resources

Here you will find links to free software, answers to Section 3 quizzes and activities, a glossary of useful terms, and references.

4.1 Free software for creating materials

GIMP: GNU Image Manipulation Program - free software for photo manipulation and original artwork creation

Kdenlive: Free and Open Source Video Editor for multi-track editing, effects, transitions, rendering and visual effects.

Canva: Visual Suite for Everyone - graphic design platform for creating a wide range of graphics, presentations, promotional material and so on.

Inkscape: a free design tool for creating vector art - useful for drawings and text.

Napkin AI: generates graphics from text, so may be useful for diagrams, logos and so on.

uMap: open source platform for creating maps with OpenStreetMap layers

4.2 Answers

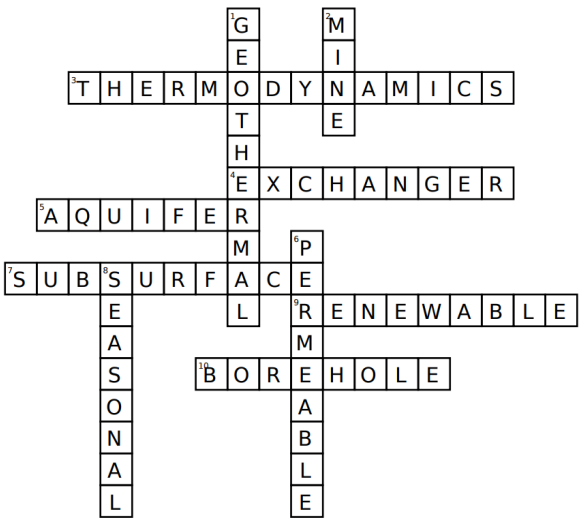
Underground riddles

1) the PUSH-IT project; 2) underground energy storage; 3) an abandoned mine used for mine thermal energy storage; 4) borehole thermal energy storage 5) aquifer thermal energy storage

Mineral match-up

1) Sandstone; 2) Coal; 3) Granodiorite; 4) Chalcopyrite 5) Claystone

Crossword



Down:

1. Heat from the Earth's interior (11)
2. Site where minerals or metals are extracted from the Earth (4)
6. Allows fluids or gases to pass through it (9)
8. Changing with the seasons (8)

Across:

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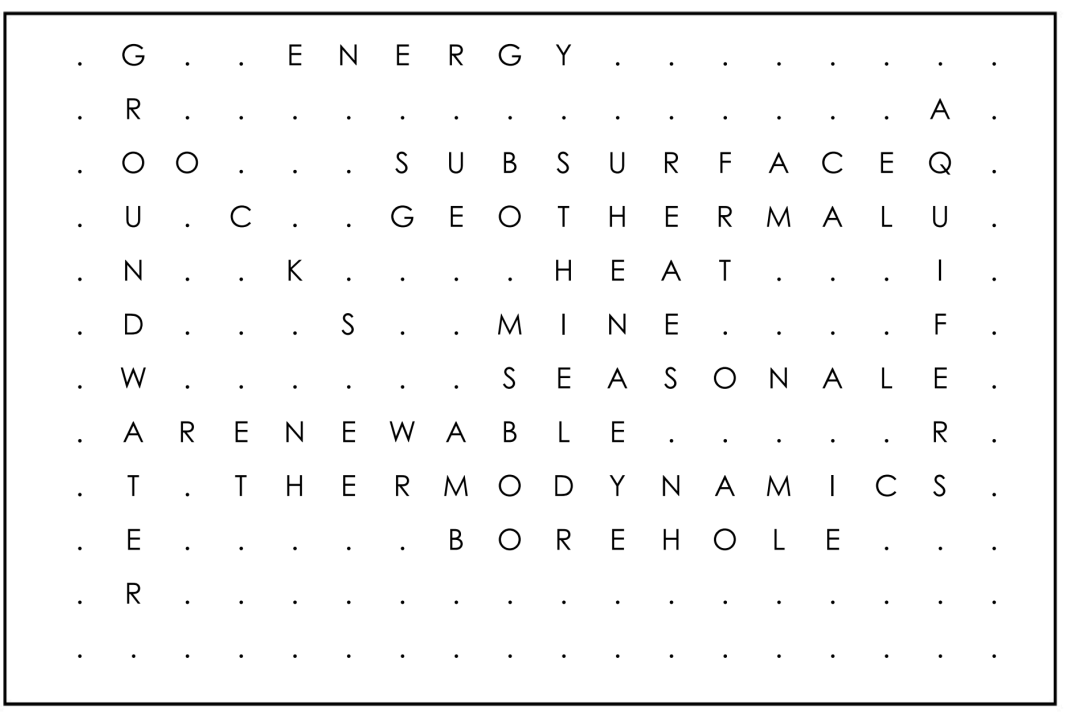
7. Beneath the Earth's surface (10)
9. Energy sources that are naturally replenished, such as geothermal energy (9)
10. Deep, narrow hole drilled into the ground (8)

Word search



UTES quiz

1. The main goal of the PUSH-IT project is to overcome the seasonal mismatch between heat demand and heat generation from sustainable sources using underground heat storage.
2. The three types are aquifer thermal energy storage (ATES), borehole thermal energy storage (BTES), and mine thermal energy storage (MTES).
3. PUSH-IT focuses on extending storage temperature ranges to high temperatures, up to 90°C.
4. Aquifers are permeable layers that contain groundwater. Aquifer thermal energy storage (ATES) is the storage and recovery of heat in aquifers. It is taking place at Delft (Netherlands) and Berlin (Germany).
5. The Netherlands, Germany, Czechia, and the United Kingdom
6. Underground thermal energy storage helps reduce greenhouse gas emissions by storing surplus energy for when it is needed. It therefore supports the EU's goal of achieving a net-zero carbon economy by 2050.
7. The Delft demo site in the Netherlands is used to demonstrate aquifer thermal energy storage (ATES) technology.
8. The follower sites in Germany, Czechia, and the United Kingdom are intended to prepare for future pilots and expand the implementation of underground thermal energy storage technologies.
9. Bochum (Germany). Its potential is also being explored at United Downs (Cornwall).
10. In April 2025, a cored borehole was drilled on the RINGEN research center site at Litoměřice, providing rock samples from depths ranging from the surface to 550m.

4.3 Glossary

Aquifer: A layer of rock or sediment underground that holds water, sometimes used for aquifer thermal energy storage (ATES).

Aquifer thermal energy storage (ATES): an underground thermal energy storage technology where warm water is stored in underground rock and sediment layers containing water (aquifers).

Borehole: A deep, narrow hole drilled into the ground sometimes used for transporting heat to store in rocks. This is known as borehole thermal energy storage (BTES).

Borehole thermal energy storage (BTES): an underground thermal energy storage technology where warm water is pumped underground in closed pipes. Surrounding rocks and sediment store the heat.

Geothermal: Relating to heat from the Earth's interior, often used as a renewable energy source.

Sustainability: The practice of using resources in a way that meets current needs without compromising future generations' ability to meet theirs.

Exchanger: A device that transfers heat between different media (e.g., water and rock) in underground thermal energy storage.

Groundwater: Water naturally occurring underground.

Mine: A site where minerals, metals, or other geological materials are extracted from the Earth. Some unused mines can be used for mine thermal energy storage (MTES).

Mine thermal energy storage (MTES): an underground thermal energy storage technology where heat is stored in water that fills former mines. Some heat is also stored in the surrounding rock.

Permeability: The ability of materials (like soil or rock) to allow fluid or gas to pass through.

Renewable: Energy sources that are naturally replenished, such as geothermal and solar energy.

Seasonal: Processes that change with the seasons, e.g., our need for energy to heat our homes.

Subsurface: Layers of soil, rock, and groundwater beneath the Earth's surface.

Thermodynamics: The branch of science that deals with heat, energy, and their transformations.

Underground thermal energy storage (UTES): Underground thermal energy storage is a technology that stores energy as heat beneath the earth's surface. Heat from power plants, factories, and renewable energy sources (e.g., solar, geothermal) can be collected in summer. The heat is then stored underground until it is needed in winter, for example, to supply local or district heat networks. This can help reduce the use of fossil fuels such as coal, oil, and gas. The hotter the temperature, the more energy stored. In PUSH-IT, scientists are testing three ways to store heat up to 90°C, in boreholes (BTES), mines (MTES) and aquifers (ATES).

3.3 References

Bremer, J., Azzola, J., Moczek, N., Kohl, T. (2026). Participatory monitoring in geothermal projects: a combined socio-geophysical approach to seismicity, risk perception and acceptability. Geothermal Energy 14, 3.

British Psychological Society Code of Ethics and Conduct (2021) available at https://www.bps.org.uk/guideline/code-ethics-and-conduct

Brown, K. Adger, N.A., Devine-Wright, P., Anderise, J., Barr, S. Bousquet, F., Butler, C., Evans, L., Marshall, N. and Quinn, T. (2019) Empathy, place and identity interactions for sustainability. Global Environmental Change, 56, 11-17.

Cotton, M. (2017). Fair fracking? Ethics and environmental justice in United Kingdom shale gas policy and planning. Local Environment, 22(2), 185-202.

Dearnell, A. (2023) 7 Golden Rules For Successful Panel Discussions – Forbes. Available at 7 Golden Rules For Successful Panel Discussions

Devine-Wright, P., & Sherry-Brennan, F. (2019). Where do you draw the line? Legitimacy and fairness in constructing community benefit fund boundaries for energy infrastructure projects. Energy Research & Social Science, 54, 166-175.

Dickie, J., Watson, E., & Napier, H. (2020). Evaluating the relationship between public perception, engagement and attitudes towards underground energy technologies. Available at https://nora.nerc.ac.uk/id/eprint/529041/1/OR20056.pdf.

Dietz. T., and Stern, P. C., (2008) Public Participation in Environmental Assessment and Decision-Making. National Academy Press, Washington DC, 2008.

Elkjær, L. G., Horst, M., & Nyborg, S. (2021). Identities, innovation, and governance: A systematic review of co-creation in wind energy transitions. Energy Research & Social Science, 71, 101834.

Fiorino, Daniel J. "Citizen participation and environmental risk: A survey of institutional mechanisms." Science, Technology, & Human Values 15, no. 2 (1990): 226-243.

Gallagher, J. (2025) Science Engagement and Impact. Presentation for the New Scientist, available at (1) On-demand - On-demand Recording: Impact Through Engagement

GeoEnergy NI: Discover the Heat Beneath your Feet: Teaching pack. Available at https://geoenergyni.org/wp-content/uploads/2024/01/GeoEnergy-NI-Teachers-Resource.pdf

Gibson et al., (2016) A "mental models" approach to the communication of subsurface hydrology and hazards Hydrology and Earth System Sciences 20(5):1737-1749.

Gooding, L., Pateman, R. M., & West, S. E. (2024). Citizen science and its potential for aiding low carbon energy transitions. Energy Research & Social Science, 117, 103702.

Hayse, M. (2018). Tabletop games and 21st century skill practice in the undergraduate classroom. Teaching Theology & Religion, 21(4), 288-302.

IAP2, International Association for Public Participation (2024), available at https://www.iap2.org/page/pillars

Illingworth, S. (2023). A spectrum of geoscience communication: from dissemination to participation. Geoscience Communication, 6(4), 131-139.

Itten, A., Sherry-Brennan, F., Hoppe, T., Sundaram, A., & Devine-Wright, P. (2021). Co-creation as a social process for unlocking sustainable heating transitions in Europe. Energy Research & Social Science, 74, 101956.

Kafai, Y. B. (2006). Playing and making games for learning: Instructionist and constructionist perspectives for game studies. Games and culture, 1(1), 36-40.

Martell, N. (2024) How to plan a community engagement strategy in 10 steps. Available at How To Plan A Community Engagement Strategy In 10 Steps - Delib

Meyrowitz, R. (2025) Planning & Organizing a Panel Discussion: Complete Guide. Available at Planning & Organizing a Panel Discussion: Complete Guide | Demio Blog

NCCPE (2023) Tools for talking... about public engagement. Resources to help you initiate purposeful conversations about public engagement. National Co-ordinating Centre for Public Engagement. Available at tools_for_talking_about_public_engagement_-_final_version_september_21.pdf

NCCPE (2025) Quality Practice. National Co-ordinating Centre for Public Engagement. Available at https://www.publicengagement.ac.uk/quality-practice

Pallett, H., Chilvers, J., Hargreaves, T. (2017) Mapping energy participation: A systematic review of diverse practices of participation in UK energy transitions, 2010-2015. UK Energy Research Centre Decision Making report. Available at https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/ukerc-systematic-mapping-of-energy-participation-2010-2015.pdf

Peacock, M., Ghilardi-Lopes, N. P., Turra, A., Rech, T. F., Kawabe, L. A., Gatersleben, B., & Wyles, K. J. (2025). The future of citizen science for marine litter research: What are the benefits to be realised and the challenges to be overcome? Marine pollution bulletin, 117914.

Peacock, A., & Devine-Wright, P. (2025). How stakeholders legitimate 'acceptable' national energy transitions through spatial imaginaries and imagined publics: A Swedish case study. Energy Research & Social Science, 120, 103854.

Pellizzone, A., Allansdottir, A., De Franco, R., Muttoni, G., & Manzella, A. (2017). Geothermal energy and the public: A case study on deliberative citizens' engagement in central Italy. Energy Policy, 101, 561-570.

Pidgeon, N., Harthorn, B. H., Bryant, K., & Rogers-Hayden, T. (2009). Deliberating the risks of nanotechnologies for energy and health applications in the United States and United Kingdom. Nature Nanotechnology, 4(2), 95–98.

Pidgeon, N., and Fischhoff, B. (2011) The role of social and decision sciences in communicating uncertain climate risks. Nature Climate Change, 1, 35-41.

RENEW (2023) A ‘living’ guide to fostering collaborative practices in RENEW. https://renewbiodiversity.org.uk/reports/

Roberts, J. J., Gooding, L., Ford, R., & Dickie, J. (2023). Moving from 'doing to' to 'doing with': community participation in geoenergy solutions for net zero – the case of minewater geothermal. Earth Science, Systems and Society (ES3), 3.

Roberts, E., Thomas, M., Henwood, K., & Pidgeon, N. (2024). Using creative mapping methods to analyse multimodal data. In The Handbook of Creative Data Analysis (pp. 285-298). Policy Press.

Rohse, M., Barich, A., Bossennec, C., Loschetter, A., Manzella, A., Pellizzone, A., ... & Soutar, I. (2024). Prioritise Inclusive, Early, and Continuous Societal Engagement to Maximise the Benefits of Geothermal Technologies. In Strengthening European Energy Policy: Governance Recommendations From Innovative Interdisciplinary Collaborations (pp. 31-43). Springer Nature, Cham, Switzerland.

Rowe, G., & Frewer, L. J. (2000). Public participation methods: a framework for evaluation. Science, technology, & human values, 25(1), 3-29.

Ryder, S. S., & Devine-Wright, P. (2022). Environmental justice implications and conceptual advancements: community experiences of proposed shale gas exploration in the UK. Environmental Politics, 31(7), 1161-1181.

Ryszawska, B., Rozwadowska, M., Ulatowska, R., Pierzchała, M., & Szymański, P. (2021). The power of co-creation in the energy transition — DART model in citizen energy communities projects. Energies, 14(17), 5266.

Soutar, I., Devine-Wright, P., Rohse, M., Walker, C., Gooding, L., Devine-Wright, H., & Kay, I. (2022). Constructing practices of engagement with users and communities: Comparing emergent state-led smart local energy systems. Energy Policy, 171, 113279.

Torma, G., & Aschemann-Witzel, J. (2024). Sparking stakeholder support: Creating personas for renewable energy innovation adoption based on qualitative data analysis. Energy Research & Social Science, 109, 103407.

Thomas, M., Partridge, T., Harthorn, B. H., & Pidgeon, N. (2017). Deliberating the perceived risks, benefits, and societal implications of shale gas and oil extraction by hydraulic fracturing in the US and UK. Nature Energy, 2(5), 1-7.

Thomas, M., Pidgeon, N., & Bradshaw, M. (2018). Shale development in the US and Canada: a review of engagement practice. The Extractive Industries and Society, 5(4), 557-569.

Thomas, M. J., Giannoulatou, I. D., Kocak, E., Tank, W., Sarnowski, R., Jones, P. E., & Januchowski-Hartley, S. R. (2021). Reflections from the team: co-creating visual media about ecological processes for young people. People and Nature, 3(6), 1272-1283.

Thomas, M., Roberts, E., Pidgeon, N., & Henwood, K. (2022). ‘This funny place’: Uncovering the ambiguity of saltmarshes using a multimodal approach. People and Nature, 4(3), 804-815.

Thomas, M., Sorvala, L., Williams, A., Singleton, A., Maddock, C., Morgan, D., ... & Musselwhite, C. (2024). Co-creating a climate comic book: reflections on using comics in intergenerational research and engagement. Journal of Global Ageing, 1(2), 219-237.

Thomas, M., Urbanek, E., & Ladd, C. J. T. (2025). Intergenerational tabletop game design for exploring the climate emergency: insights from an undergraduate field course. Journal of Geography in Higher Education, 1–11.

Thomas, M., Williams, A., Maddock, C., Morgan, D., Singleton, A., Musselwhite, C., Murray, T., and Sorvala, L. (2025). The Climate Comic Activity Book. Swansea University. Available at www.climatecomic.co.uk.

Thomas, M., Kechagia, M., Soutar, I., Rohse, M., & Devine-Wright, P. (2026). A cross-national and local survey of underground thermal energy storage perceptions: survey instrument. Zenodo. Available at https://zenodo.org/records/18256260.

UK Government (2022) Review of Public Engagement. Available at https://assets.publishing.service.gov.uk/media/65c106fbc4319100141a45a7/Public_Engagement_Review_10_Oct_2022.pdf

UK Government (2025) Communicating climate change information for flooding and coastal erosion. Available at https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/communicating-climate-change-information-for-flooding-and-coastal-erosion#:~:text=The%20report%20makes%20suggestions%20based,accessible%20to%20a%20range%20of

van Boven, F., van Vliet, B., Bush, S., & Stremke, S. (2025). Inclusive intent, instrumental outcomes: how developer rationales shape participation in solar energy projects. Energy Research & Social Science, 125, 104110.

Wright, R. A., Jackson, K., Girardin, C., Smith, N., & Wedding, L. M. (2023). Geoscience Communication Insights: Enhancing inclusive engagement with the geosciences through art–science collaborations. Geoscience Communication, 6(1), 39-43.

Welsh Government (2020) Practitioners' Manual for Public Engagement. Available at https://wcva.cymru/wp-content/uploads/2020/11/Practitioners-manual-for-public-engagement.pdf

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