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Using the underground to fight climate change

Brief 2, SRI 29
29 Sept 2020

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In this policy brief, we introduce a suite of technologies which use underground assets to store heat and energy, or provide a low carbon means of energy generation. These present regional authorities with an opportunity for low carbon economic regeneration which is sympathetic to local industrial heritage.

Overview

- **In order for the UK to reach its Net Zero goals, new approaches are needed to decarbonise heat and energy storage**
- **Old mines can be used to store heat, extract geothermal heat or house gravity-operated energy storage**
- **Examples of similar schemes in action highlight the need for proactive leadership and engaging early with key stakeholders**
- **Local Authorities should act now to investigate their local underground assets, prior to agreeing above ground developments**

If the UK is to reach its Net Zero goals, proactive leadership and joined up solutions are needed. The decarbonisation of energy generation has shown significant progress, but urgent action is required on storage of intermittent renewable energy and heat for the UK to meet its Net Zero targets (Committee on Climate Change 2020).

Government ambitions to build back better post-COVID 19 will be realised at a regional scale by a place-specific mosaic of initiatives. Investment in low carbon infrastructure made now will shape performance over the crucial next decades.

There is potential for underground assets, such as old mines, to be used for low-carbon heat and energy storage. However, without exploratory work this potential cannot be assessed. Proposals to streamline the planning system in England to allow 'automatic' planning permission for new homes (MHCLG 2020), must ensure the new process allows for geoasset assessment. If not these opportunities could be lost.

Subsurface heat and energy solutions

For centuries, the UK mined fossil fuels to power its homes and industries; but the underground can also be used to generate and store low carbon energy. Local authorities have a key enabling role to play in kickstarting this transformation.

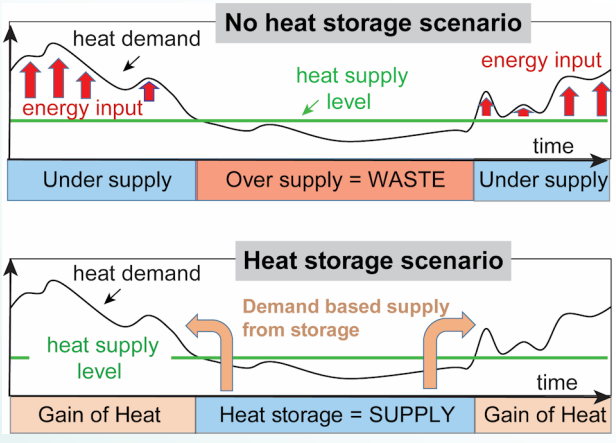
Underground development provides opportunities for short, mid and long-term energy solutions. Underground assets can be both naturally occurring features such as aquifers, and man-made features such as disused mine workings. In the short to mid-term, flooded underground assets provide the opportunity for thermal storage projects, providing interseasonal storage to support district heating schemes and energy storage. Longer term solutions include energy generation schemes such as the use of geothermally-heated mine water in district heating.

Thermal storage in water

Thermal storage systems preserve heat at times of low demand and provide a heat source at times of peak demand. They will form an integral part of renewable-powered district heating networks as they balance fluctuating renewable heat generation. Without heat storage, discrepancies between heat demand and heat supply will result in under and over supply at different points of the year, leading to a need for extra energy input during cooler seasons and energy waste when it is warmer. If instead, heat is stored in water when heat supply is high relative to demand, it can be subsequently retrieved at times when demand is above supply. This reduces overall necessary energy input.

Centralised forms of thermal storage such as pit storage, where water is pumped into an existing underground cavern or man-made reservoir such as flooded mine workings, or aquifer thermal energy storage, where heat is stored in subsurface aquifers, offer mature technology options for large scale thermal storage.

Schematic illustration of the concept of thermal storage in water

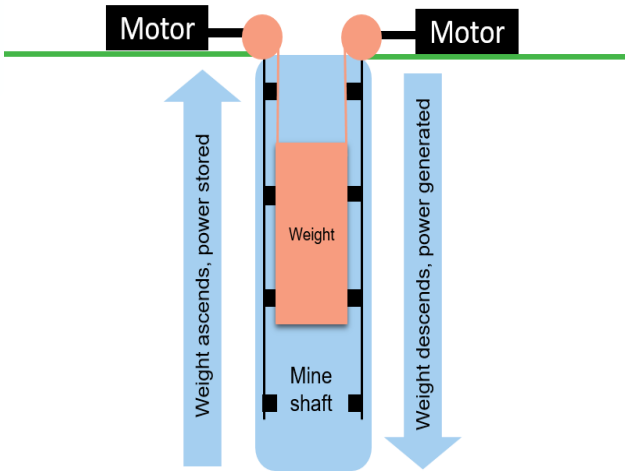


Energy storage by suspended weights

Energy storage technologies balance the intermittent generation outputs of renewable energy by storing energy at times of high production and releasing it at times of peak demand. This adds flexibility to the system and mitigates avoidable increases in peak load.

Suspended weight gravity storage (SWGS) systems draw power from the electrical grid to raise a suspended weight at times of high production. Power is returned to the grid in times of high demand by releasing the weight and recovering energy using regenerative braking. While the amount of energy stored is locality dependent, unlike batteries performance does not degrade over time. Disused mineshafts are one promising option for SWGS, using pre-existing infrastructure while offering low visual intrusion.

Schematic illustration of suspended weight gravity storage using mine shafts

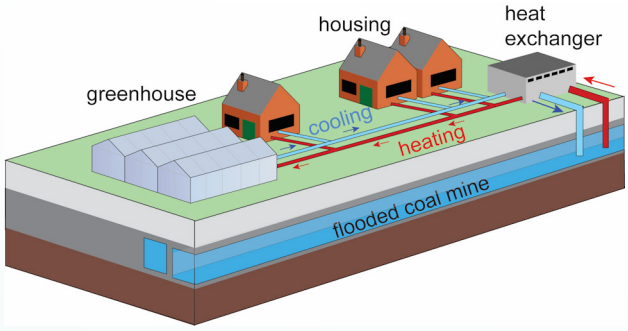


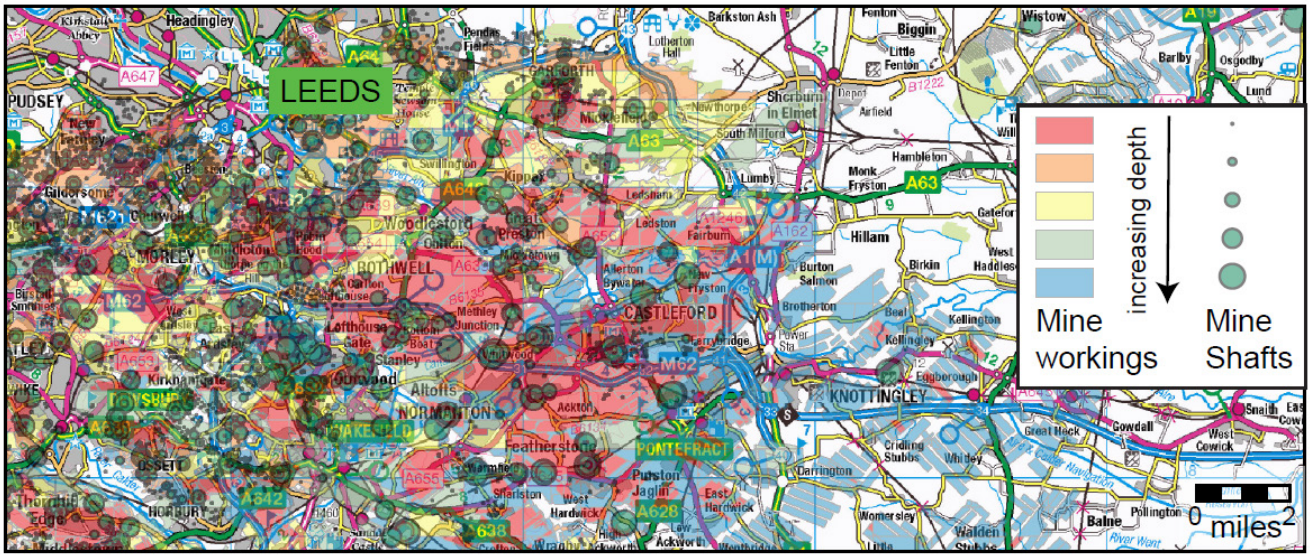
Mine water energy generation

Heat from flooded mine workings can be used to power district heating schemes. A heat exchanger extracts heat from the geothermally warmed water which is then used to heat the surrounding properties for both domestic and commercial applications. The process can also be reversed to provide cooling if required.

Reuse of existing infrastructure has the potential to reduce the costs and environmental impacts of development, is in line with the National Planning Policy Framework guidance and provides development in keeping with local industrial heritage.

Schematic illustration of energy generation using mine water





Map of Leeds showing legacy mine workings (Coal Authority Data). Most of the area is underlain by mine workings with associated shafts at various depth illustrating the potential to use these for heat and energy storage as well as heat generation in cities with mining history.

Understanding the potential

Many UK cities are underlain not only by natural geological layers suited for the outlined technologies, but also - due to their industrial heritage - an extensive legacy of deep coal mining which dates back hundreds of years.

To assess the extent of potential geoasset opportunities for cities such as Newcastle, Stoke-on-Trent, Bristol and Birmingham, the University of Leeds undertook a desktop analysis in the summer of 2020. The group focused on the Yorkshire and Humber region which exhibits subsurface characteristics typical for such industrial cities. The map above reveals the extent of the mine workings beneath Leeds potentially available for decarbonisation technologies.

Case studies

Developing existing subsurface assets to support the low carbon transition is a new departure for the UK. However, the existing Leeds district heat network and the development of the UK's first large scale mine water energy scheme in Seaham Garden Village, County Durham, provide two examples of good practice.

Learning from Leeds district heating: proactive leadership

The Leeds Pipes district heating scheme is the UK's largest district heating scheme. It is a council-led project delivered with Vital Energi. It connects almost two thousand council owned homes and numerous businesses around the City Centre to a heat network, reusing heat from Veolia's Cross Green Recycling and Energy Recovery Facility. Proactive Local Authority leadership has been an essential part of the scheme's success and the city council has facilitated development in the following ways:

- Allowing use of council-owned building stock to provide an anchor load of demand, de-risking investment and opening up the possibility of future expansion
- Agreeing the commercial terms of heat sale early in the project to provide assurance to developers of customer demand
- Creating positive local planning policy in favour of district heat

"We looked at what other influence we had as a council to make it easier to develop district heating and make it more likely that people would connect". Council Officer, Leeds City Council

Seaham Garden Village mine water heat: engage early with key stakeholders

Seaham Garden Village is a new development immediately adjacent to the Coal Authority's Dawdon Mine Water Treatment Plant in County Durham. Presently, geothermally heated mine water is treated and discharged into the sea. The scheme is a collaboration between the Coal Authority, Tolent Construction and Durham County Council and when complete will heat 1,500 new homes and community buildings.

Early engagement and an understanding of the sources of expertise available have been critical in mobilising development. The North East Local Economic Partnership (LEP) has commissioned a mine energy white paper, due in late 2020, to share best practice and provide a blueprint for the delivery of mine water energy schemes in the UK.

"We brought together all the stakeholders in the region who had an interest in mine energy, to get round the table and share their interests and their expertise and their learning". North East LEP

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Recommendations

Local Authorities have a key role to play

Local Authorities are essential for the implementation of low carbon heat strategies and the delivery of low carbon developments more generally, due to their regulatory responsibilities, their ownership of key buildings and housing stock, their links with regional stakeholders, their knowledge of local circumstances and their longevity. This regional focus is even more critical for the development of subsurface infrastructure which is, by definition, place-specific. Subsurface development has the potential to deliver on a range of council aims including addressing fuel poverty, air quality improvements, decarbonisation and economic growth. However delivery requires buy in from all levels of the organisation and a realistic understanding of what can be achieved.

In order to make the most of these opportunities we recommend that Local Authorities should share expertise, engage early and act now to lay the necessary groundwork.

Share expertise and engage

- While urban district heating networks are expanding in reach, using the subsurface to assist in the low carbon transition and perhaps supplement or power these schemes is a relatively new concept in the UK. A number of exemplar projects are underway, such as the mine water district heating at Seaham Garden Village, which provide the potential to act as a roadmap for other schemes.
- A key enabler is engaging early with key stakeholders. These may include the Coal Authority, the Environment Agency, British Geological Survey, BEIS, the local LEP, the Water Authority and private sector supply chain companies, consultancies and housing developers.
- The role of public engagement should not be overlooked. Subsurface development can be highly contentious but, if it is environmentally and socially beneficial, this is not inevitable. The UK has a legacy of coal mining and an engineering skills base which retains significant knowledge about the local subsurface. Working with communities to develop their local subsurface assets can deliver significant environmental and social benefits.

Assess potential assets early

- The status of subsurface assets should be assessed before plans for above surface developments are finalised to ensure opportunities for decarbonisation are not overlooked.
- Exploratory work will be needed to answer key questions such as the state of the shafts and mine workings. Drilling and dye-testing may be required to confirm the extent and connectivity of mine water resources. For aquifer heat storage, questions include the location and capacity of the aquifer. Consents may be need to be sought from the supervising regulatory bodies before investigation begins.

Build a supportive policy environment

- Locally, decision-makers should consider upfront the demand for any heat and storage services which the subsurface might provide, potential commercialisation models for these services and how local planning policy might enable this. Supportive local policy will be needed to ensure this window of opportunity is not missed.
- Nationally, dialogue is required between regional and national bodies to ensure proposals to streamline planning policy do not inadvertently rob Local Authorities of the opportunity to undertake the necessary appraisals.

About the project

The Geoassets in Yorkshire project aimed to understand the barriers and opportunities for the development of onshore subsurface assets within the Yorkshire and Humber region. It is part of the Sustainable Geoenergy Solutions programme, which seeks to identify the potential for geoscience to contribute to the low carbon energy transition.

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This is a joint brief by Policy Leeds and the **Sustainability Research Institute Policy and Practice briefing series**.

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