Mine-water Energy Toolkit

Boreholes and Drilling
Summary
Unless mine-water is already being pumped to surface or it is readily accessible via existing infrastructure, such as former mine shafts, boreholes will need to be drilled to access mine-water energy. This section aims to provide developers of mine-water energy project with a guide to the factors that need to be considered, and actions that must be taken, when planning and executing borehole drilling into former coal mine (FCM) workings. See the Procurement section of the Toolkit for detailed information about borehole specification.
Key Points
General 1. Consult the Coal Authority – both the Permitting team and the Advisory Services team prior to the commencement of a mine energy project and throughout its development. The Coal Authority has a wealth of essential technical, commercial, and regulatory knowledge. 2. The Coal Authority Permitting team will provide advice and templates for the permitting process. 3. The Coal Authority Advisory Services team will help project teams with Mining Reports, Environmental Information, Safety and Risk Assessment, and Technical Advice. 4. Not all FCM sites and mine blocks are suitable for Mine-water Energy Projects (MEP)s. An initial high level mining review by the Coal Authority would help provide more information on suitability at a specific site.

5. Drilling boreholes in FCM areas is a specialist drilling activity; it would be high risk to procure a borehole drilling contractor that did not have proven experience of successfully drilling boreholes into FCM workings for the purpose of abstracting water for a mine energy project.
6. With good planning and a good drilling methodology, risks and challenges can be mitigated and overcome.
7. A full feasibility study (techno-economic and commercial modelling) including establishing heat off-takers, is a minimum requirement prior to commencing the procurement of detailed designs and drilling contractors for MEPs.
8. The Coal Authority keeps records of FCM workings and other infrastructure.
9. FCM records and maps are not always reliable and, in some cases where workings and maps are very old, are difficult to reference accurately to the surface (as surface conditions and structures e.g. buildings, have changed over time and many of the maps are well over 100 years old and based on rudimentary surveying techniques). It is important to secure the services of individuals or organisations with the necessary experience in interpreting the vagaries of old mining plans.
10. FCM sites are typically part of a 'mine block' in which multiple sites are connected below ground i.e. water that fills the FCM workings typically flows freely between seams, roadways, and sites, sometimes for long distances.
11. The below ground water connections of FCM sites are essential to MEPs because they ensure that the mine-water can be recirculated, so temperature is consistent i.e. water flowing in to replace water extracted for heating is at a similar temperature to the extracted water.
12. The interconnectivity of FCM workings is an obstacle to using FCM workings for energy storage (i.e. where we put heat into the mine workings in the summer to be extracted during the winter) as the water may readily escape into surrounding areas. Ideally, isolated areas of workings which are self-contained may offer better storage potential by avoiding heat leakage.

Borehole Design

13. Borehole outline design specification will depend on each site's specifics and geology. However, the following points need to be included, considered, or addressed in the outline specification. Specialists should conduct the final specification.
14. Mine-water level is unlikely to be precisely known prior to drilling although information about mine-water levels is often available from the Coal Authority's monitoring of boreholes elsewhere in the same mine-water block.
15. Boreholes are often drilled vertically. They are drilled deeper than the mine-water level, allowing for drawdown, which is the lowering of the water level in the borehole that occurs when water is being pumped out.

16. Directional drilling is used to drill boreholes in some mine energy projects (e.g. in Bochum, Germany), where the underground target and surface position cannot be aligned, or to avoid workings overlying the target.
17. In Bochum, directional drilling was successfully used in 2022 to reach a mine-water target over 800 metres below the surface. This has enabled the boreholes to avoid mine workings other than the target workings.
18. Each set of mine workings above the target horizon should be solid cased and grouted. Casing is installed inside the shaft to provide structural support and to prevent the surrounding rock from collapsing into the shaft. This casing is typically made of concrete or metal, and it is designed to be strong and durable to withstand the pressures from the surrounding rock and to provide a smooth surface within the shaft. Each layer of casing results in a reduction in borehole diameter and so in designing the borehole drilling size, all workings which may be encountered (recorded or otherwise) should be assessed for casing to ensure that the minimum diameter at the base of the borehole is sufficient to house appropriately sized pumps.
19. The surface strata and / or superficial deposits should be solid cased and grouted to surface.
20. The innermost solid casing in the shaft should be from the surface to approximately 5m above the target horizon. Below this it could be “open-hole” or “slotted casing” – depending on pumping requirements and geological conditions. An open hole refers to a portion of a borehole that has been drilled but not cased. Slotted casing allows water or other fluids to flow into or out of the well while preventing the ingress of sand and other fine-grained materials.
21. Verticality & Deviation limits should be specified and surveyed at regular intervals during drilling (e.g. every 50 meters) and upon completion of the borehole. This will be required to confirm how vertical and straight the borehole is and to confirm how far from the target the bottom of the borehole is. A verticality target of 1 in 50, or ideally 1 in 100 should be specified.
22. Confirm connectivity of the borehole to the mine workings. Typically this would be undertaken by a “falling head test” after the borehole is completed. This test sees how quickly water disperses into the mine workings. Borehole development may be required if this test indicates poor connectivity between the borehole and the mine workings.
23. As a minimum the borehole will need to be cleaned out after drilling to remove residual drilling fluid.
24. The sizing of any borehole is dependent on the flow to be delivered and the size of the required pump.

Licenses and Permissions

25. Licenses and permissions to drill in FCM areas need to be secured before a drilling contractor can be procured.
26. Licenses and permissions are needed from:
    - Coal Authority
    - Environment Agency (England) **or**
      Natural Resources Wales (Regulator in Wales)
    - Local Authority
    - Land owners
27. Currently (2023), the Coal Authority will only issue drilling and access licenses to one project per mine block.
28. Planning permission is not necessarily needed for drilling but the Local Authority needs to be consulted.

Risk Management

29. CAPEX costs for borehole drilling in FCM areas are a high proportion of a MEP.
30. Based on discussions with drilling specialists, approximate CAPEX costs for FCM borehole drilling are £2,500/metre: note – this figure is included for guidance purposes only; drilling costs for each MEP vary substantially for a variety of reasons e.g. geological and FCM workings depths and conditions, casing specification etc.
31. Until boreholes are drilled and hydrogeological testing carried out in the FCM area, certainty about available mine-water heat cannot be definitively established.
32. Pilot boreholes are cheaper to drill than operational boreholes. This can be a way of de-risking MEPs by drilling first to establish geology, presence of mine workings and their connectivity. Pilots boreholes then inform the design of the final boreholes and provide more certainty prior to committing to the high cost of production boreholes.
33. FCM areas often feature multiple workings in multiple seams. Drilling is simpler and cheaper if non-target seams, roadways or other voids are avoided. This requires a careful assessment of the mine plans.
34. If other workings have to be drilled through, linings have to be inserted to seal the borehole – this increases risks and costs.
35. Where very old workings are targeted, boreholes might hit a pillar of coal rather than a seam or roadway void and require a re-drill a few metres away.
36. Water connectivity between the FCM workings and the bottom of the borehole could be poor. Pump testing is a process used to evaluate the characteristics and performance of the water that

is being used as a source of energy. Here's what is typically assessed during pump testing for a mine-water energy supply:

- The **temperature** of the mine water is measured to determine its thermal energy content. The higher the temperature, the more energy can be extracted from the water. This is an important parameter because it affects the efficiency and feasibility of the geothermal energy system.
- The **flow rate** of the mine water is assessed to determine how much water is available for energy extraction. This is important for designing the geothermal system and for estimating the potential energy output.
- The **reliability** of the mine-water supply is evaluated to ensure that there is a consistent and adequate supply of water for the geothermal system. This involves assessing the variability in water flow and temperature over time, as well as any potential issues that could affect the supply.

37. During drilling, "flush" refers to the use of fluids, such as water, to clear cuttings and cool the drill bit. When there are fractures in the geology, these fluids can escape into the fractures. This is a problem because without the flush, the drill bit can overheat, and the cuttings can build up, hindering the drilling process. Mining activity often causes fractures in the surrounding rock and geology due to the removal of material and the associated stress changes. When drilling in areas affected by mining, these fractures can be more prevalent, increasing the risk of losing flush. To mitigate this risk, solid casings can be installed. The casing provides a sealed conduit for the flush, preventing it from escaping into the fractures. This ensures that the flush can perform its function of cooling the drill bit and removing cuttings, facilitating the drilling process.
38. The main risk of drilling into FCM workings is from mine gas, particularly emanating from unflooded workings.
39. A mine gas risk assessment by a suitably qualified and experienced person is needed ahead of all FCM borehole drilling.
40. The mine gas risk assessment should follow the ‘source/pathway/receptor’ framework for environmental risk. It should take into account history of mine gas in the locality, geology, monitoring data available, presence of mine entries, surface sensitive receptors and mitigation measures.
41. Mine gas risks:
    - Borehole acts as a pathway for mine gas to reach the surface
    - Gas can migrate along mine working and natural pathways linked to the boreholes and emerge to surface

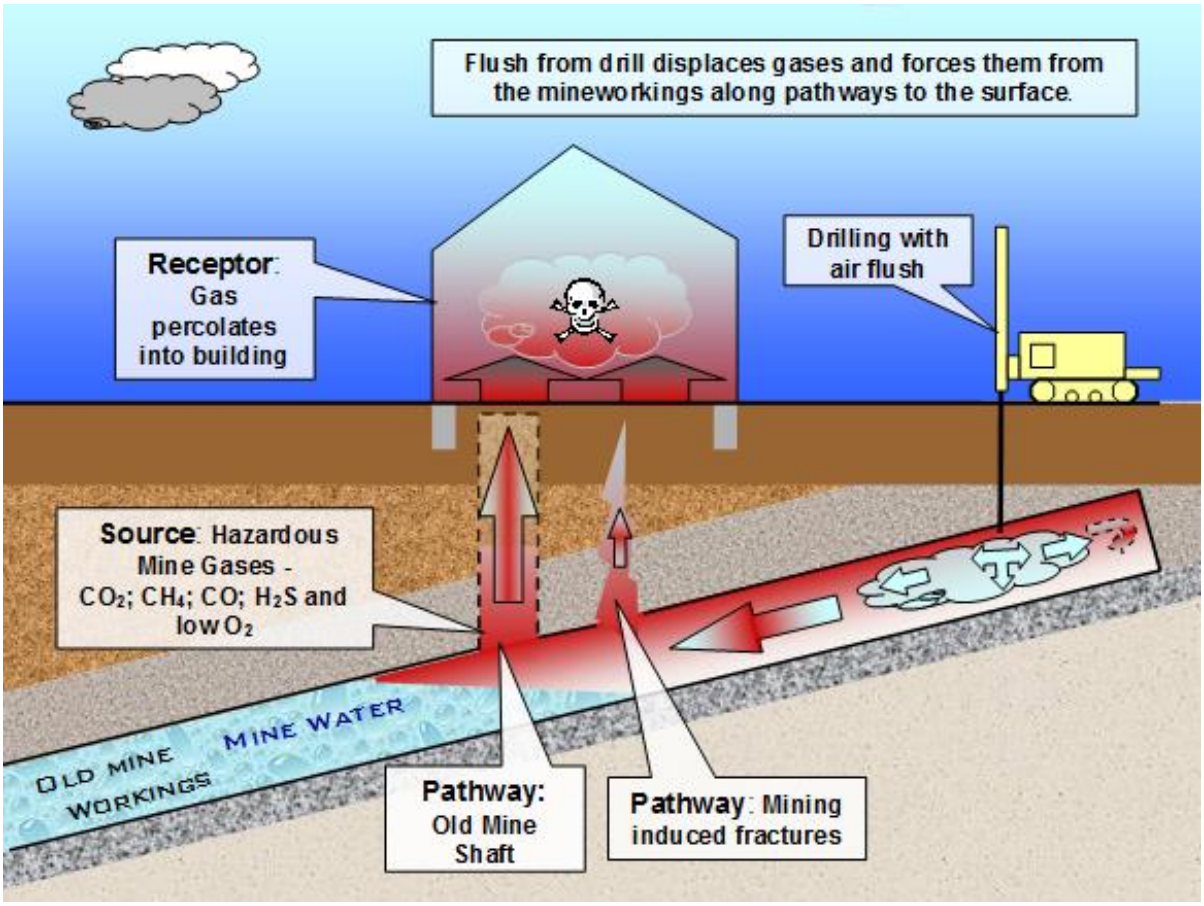
- Properties near to the top of the borehole and other mine entry points can be at risk from mine gas – explosion and air quality risks
- Mitigation measures such as monitoring and well control should be adopted by drilling contractors based on the findings of the generic risk assessment.

42. Noise Reduction measures may be necessary during drilling.
43. Drilling hours may be restricted if drilling takes place near to population centres.
44. The age of the workings and plans can have a significant impact on the number of boreholes required to secure successful connections. This will influence contingency sum to be held for drilling aspects.

Further Sources of Information and References

45. See Procurement section of the Toolkit for detailed drilling specification information
46. See 'Library' of References
47. Other Sources:
    - Coal Authority https://www.gov.uk/government/publications/guidance-on-managing-the-risk-of-hazardous-gases/guidance-on-managing-the-risk-of-hazardous-gases-when-drilling-or-piling-near-coal
    - British Geological Survey (BGS)
    - BGS – UK GEOS Observatory

Coal Authority Graphic – Risk and Challenges of Drilling into Mine Workings



Key Actions

Action	Timeline
1. Consult the Coal Authority for advice and support at all stages of mine energy project development. 2. Ensure that only experienced specialist advisors and contractors are procured. See procurement section of the toolkit.	Prior to, or at, project inception