Coal mines for heat decarbonisation

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SUMMARY:

What is needed from government

Beneath about a quarter of the cities and countryside across the UK sits the potentially huge energy resource of heat held in water which has filled the nation's disused coal mines: mine water geothermal heat (MWGH).

The technologies to extract and use this are well-established, quick to deploy, and could contribute significantly to the multiple goals of energy policy, in particular the decarbonisation of heating. Increased adoption of MWGH will also boost the wider UK geothermal sector.

Yet realising this potential is seriously constrained by mutually reinforcing costs and risks. Overcoming these requires **coordinated action and leadership from central government** across three broad fronts:

a. MWGH is recognised as a major potential contributor to decarbonising the UK's heat energy needs in a secure, equitable and sustainable way, and **should therefore be supported, as other renewable resources were at a similar stage in their development**. It should explicitly be included in broader energy and decarbonisation policy to maximise its use and avoid inadvertently undermining its potential.

b. **A roadmap is needed** which provides a clear and coherent approach to increased and accelerated uptake, and links MWGH to broader energy, housing, planning and industrial strategies. It needs to promise stability to attract investment but be flexible enough to support innovation. This implies a light touch, agile approach to regulation.

c. Unlocking MWGH will involve **direct financial support, regulatory change, leadership and support for research**. Regulatory change should reduce the amount of financial support needed by improving investability for the private sector.

The highest priority central government measures needed are:

- government-backed financial mechanisms to de-risk MWGH
- decoupling electricity and gas prices
- a single, streamlined regulatory and licensing regime for mine water heat exploitation, based on recognition of heat as a resource
- MWGH aligned more strongly and explicitly with heat network initiatives
- open and consolidated access to data.

Contents

Using this Policy Brief

This summary page gives the headline 'asks' from central government. The next section (Part A) is a 'quick read' introduction to the resource, how it fits into an increasingly favourable policy and institutional environment, the enduring challenges and what the central government needs to do to address these. Part B is a more detailed explanation of the same topics, backed by a comprehensive list of references and resources.

Note that the Brief focuses on the three mainland nations, and distinguishes between their policies where relevant. Northern Ireland has some limited potential for MWGH, but this is not considered here.

PART A:

The mine water geothermal heat resource, opportunities, challenges and necessary government action

(SUMMARY VERSION)

1

The resource and its uses

Mine water geothermal heat (MWGH) is:

- **geographically widespread:** a quarter of the UK's homes and businesses are sited on former coalfields
- **low temperature:** suitable for district heating systems and other concentrated demand for space heating (e.g. greenhouses)
- **stable and renewable:** able to provide predictable, sustainable energy over the long term
- **accessible** either at the surface from existing mine water treatment plants (relatively low cost and low risk, but limited locations) or through drilling bespoke boreholes (higher risk and cost, but tailored to demand and location)
- **geographically variable** in terms of suitability for extraction, depending on the specific geology, hydrogeology and layout of mine systems.

Its extraction and use is technologically proven at large scale, and versatile. Since 2023 the publicly-owned Gateshead Energy Company has used a 6.2 MW plant to heat major public buildings and 350 homes; Lanchester Wines has used 4 MW of mine water heating for its commercial operations at another site in Gateshead since 2019.

Mine water heat is one of several forms of geothermal energy which are receiving increasing research, investment and policy attention for their potential contribution to decarbonising the UK's energy supply. Some of what follows applies to all geothermal sources, while some is specific to the use of energy in coal mines.

2

An increasingly favourable environment

In the last few years the need for secure, affordable and sustainable energy supplies has become more central to government policy making, and the research and delivery capacities of the MWGH sector have increased considerably. The environment for developing MWGH has thus improved substantially, as detailed below.

2.1. Increasing policy relevance

a. **Decarbonising UK heating**. MWGH:
   - reduces demand for electricity and the need for new grid infrastructure, and at the same time
   - fits well with district heating systems and can support the roll-out of large-scale housing programmes.

   Mine water systems can also provide services beyond heating to contribute to energy storage, cooling (e.g. for data centres), grid stabilisation and avoiding wasteful curtailment of wind generation.

b. **Tackling poverty**. The provision of reliable, relatively low-cost and low-carbon heat will also contribute to the policy goal of reducing the burden of energy costs on poorer households. The location of the MWGH resource means that its exploitation can support business development in coalfield areas currently suffering from low economic output and deprivation.

c. **Integrated energy planning**. The new local authority energy plans explicitly recognise heating as a service, and mandate development of heat networks. In coalfield areas this opens opportunities for MWGH as an energy source for district heating systems.

2.2 Organisational development

MWGH development is supported by an expanding organisational ecosystem with increasing capacity to tackle some of the constraining factors identified in the North East Local Economic Partnership's 2021 Mine Energy White Paper. This includes:

- Mining Remediation Authority (MRA; previously Coal Authority), with a living lab and expanded (but not centrally-funded) capacity to support enquiries and licensing applications
- National Geothermal Centre, established to create policy, regulation and investment frameworks and maximise the impact of research and innovation
- expansion and strengthening of the Mine Energy Taskforce as the Geothermal Taskforce
- International Energy Agency's Geothermal Technology Collaboration Programme and mine water energy expert group
- UK Geoenergy Observatory in Glasgow
- British Geological Survey (BGS)'s Geothermal Energy team
- A strong research base in the university sector including Durham, Edinburgh, Glasgow, Leeds and Strathclyde Universities.

2.3 Increasing knowledge

The knowledge base shared through this ecosystem is growing rapidly, creating in particular a more nuanced and detailed understanding of the resource, with an evidence base allowing assessment of exploitation potential in different places.

2.3.1 Practicalities of delivering MWGH projects

Successful projects (e.g. Gateshead Energy Company, Lanchester Wines), closed schemes (e.g. Shettlestone, Lumphinnans) and uncompleted ones (e.g. Caerau, South Tyneside) have all increased technical knowledge and competencies, and understanding of the regulatory framework issues. The MRA in particular now has considerable expertise in successful borehole development.

2.3.2 Mapping and modelling the resource

Significant progress has been made since 2021 in:

- mapping and categorising the accessibility of the resource and linking it to potential demand
- detailed modelling of the available resource
- reducing the need for multiple boreholes to map the subsurface
- quantifying the risks associated with drilling
- creating a platform for data storing and sharing (the DESNZ-BGS UK Geothermal Platform, due to be operational in summer 2025)

2.3.3 Economic and social issues

Knowledge of the economics and social acceptability of MWGH is growing rapidly. A major piece of government (DESNZ) funded research on the economics of geothermal energy is ongoing (2025). Durham Energy Institute (DEI) has produced cost/benefit analyses for mine water and district heating, and examined public 'willingness to pay' for low carbon heating technologies.

3

Enduring challenges

Most of the principal challenges to large-scale MWGH exploitation identified in the 2021 White Paper endure, and many are mutually reinforcing.

3.1. The most important factor: competitiveness

At present, the upfront costs of new boreholes and distribution networks are high compared to other low-carbon heating technologies, in particular air source heat pumps (ASHPs) installed for individual households (the principle current 'competitor' with mine water heat in policy terms.) While running costs are comparable to, or slightly higher than existing gas heating, the latter is likely to be phased out in the coming years, and MWGH's running costs are now low compared to other, less efficient low-carbon sources (eg ASHPs). Overall, while levelised costs show mine water can be competitive, payback periods are relatively long.

Successful projects to date have relied on state support for either/both capital and running costs, and/or have reduced costs through accessing surface mine water (from treatment plants) or existing district heating infrastructure. Some of the funding sources (in particular the European funds and Renewable Heat Incentive) no longer exist and have not been replaced.

MWGH thus currently lacks a business model in the UK which is capable of attracting large scale private investment. Removing the relative advantage of gas now, by decoupling gas and [renewable] electricity prices, would make MWGH investable. In Scotland, new build homes cannot be heated using gas, and its use will be phased out entirely by 2045, creating opportunities for mine water heating. In England and Wales there are no current plans to completely phase out gas.

3.2 Risks associated with extraction boreholes

Extracting energy from the subsurface carries specific risks which translate into upfront costs and potential project failure.

- Failure to find an adequate mine water resource at an affordable depth, or physical collapse of a borehole
- Unanticipated reduction in the resource, due to the hydrogeology of the mine system or over-extraction
- Surface land use change or lack of development (e.g. of heat networks) exposes projects to risk of reduced demand for heat.

3.3 Regulatory and policy issues

- The current multi-agency regulatory and licensing system is reported to be complex and hard to navigate. This imposes significant costs on developers in time and resources, and demands specific administrative expertise alongside technical know-how.
- Geothermal heat is not recognised as a resource in law, and so it is not specifically regulated, precluding effective planning to prevent both over- and under-exploitation.
- Energy policy is currently in a state of flux, yet MWGH needs stability over several decades to make investment attractive.

3.4 Awareness and attitudes amongst stakeholders

- MWGH is largely absent from central government policy, even though district heating is promoted. This suggests a need to raise awareness in critical places within central government, if effective policy development and regulatory review is to be taken forward.
- While there has been increasing support and interest from Local Economic Partnerships, Combined Authorities, the Net Zero Hubs and Scottish Enterprise, this has been geographically uneven. In particular, North East England has a critical mass of support which is not evident elsewhere, particularly in the otherwise comparable S Wales coalfield.
- Despite their obvious commitment to the energy transition, none of the large environmental NGOs, nor the Confederation of British Industry, show explicit interest in MWGH.
- Volume housebuilders' general risk aversion appears to extend to MWGH, even in apparently very favourable (relatively low cost, low risk) circumstances (e.g. an existing surface source of heated mine water.)
- There is evidence that some coalfield communities welcome green repurposing of the mines, but also of widespread lack of engagement. The promise of cheaper energy appears to be a stronger influencing factor, and there is emerging evidence that the potential for recognition/restitution justice would be welcomed.

3.5 Distribution of the resource

- Spatial variation in the resource and the fact that it can only be approximately modelled remain significant challenges for new projects, imposing uncertainty, risks and costs.
- Aligning supply and demand remains challenging, especially for the cheapest, lowest-risk option of accessing mine water through existing treatment plants, many of which are distant from significant demand sources.

3.6 Human resources

The lack of experienced personnel and supply chain industries, particularly UK-based, remains an obstacle.

4

Government actions needed to unlock the resource

The principal barriers to a step change in MWGH exploitation are interrelated financial and risk-related factors. The technical challenges are secondary and manageable once the economic and regulatory framework is favourable. Consequently central government has a crucial role in providing direct support, introducing policy and regulatory changes, providing leadership to other organisations, and supporting research. The following paragraphs expand on each of these.

4.1 Direct support

- payment for MWGH e.g. a replacement for the Renewable Heat Incentive specific to geothermal heat (i.e. payment for heat produced), a development of the Contract for Difference approach (i.e. a guaranteed price in the market for heat), or other means of funding such as green bonds or forms of public-private partnership
- state-backed insurance to de-risk the exploratory phase of borehole drilling
- financial support for a national network of combined commercial/R&D boreholes
- financial support for supply chain development and stakeholder engagement.

4.2 Policy and regulatory change

4.2.1 Energy policy

- Include geothermal sources, including mine water, in energy and decarbonisation policies
- explicitly treat heat as a resource with distinct regulatory needs
- until gas is phased out, decouple electricity from gas prices
- direct local and regional authorities to consider MWGH, alongside other geothermal sources, in strategic energy and heat planning.

4.2.2 Regulation

- Create a bespoke regulatory and licensing framework which creates a single, speedy and easily navigable permitting process
- develop a transparent and equitable licensing framework for sustainable extraction by multiple users of thermal energy and groundwater within the subsurface.

4.2.3 Planning and building regulations

- Create a presumption in favour of proposals for development using MWGH in coalfield areas
- direct local and regional authorities to consider the potential for MWGH in strategic planning of residential and industrial development
- develop a comprehensive approach to planning in the subsurface.

4.3 Leadership

- MWGH should be explicitly recognised in energy and related policies across Britain
- unitary and combined authorities should be empowered to lead on the development of the resource, through e.g. strategic planning at the regional scale and developing supply chains
- workforce planning and skills development through education and training should be supported at national and regional levels
- policy and financial support should be provided for the key organisations in the sector to progress the development of MWGH
- Community participation throughout planning and decision-making for MWGH will be essential to secure local support for any proposed infrastructure development.

4.4 Research and knowledge

Central government should also play a support role in research and information management for the sector, covering at least:

- creation/collation of resource/demand maps at site planning scale for the UK to reduce costs and risks of MWGH developments
- further development of modelling and engineering approaches to assess the resource and the impacts of exploitation, including a national network of boreholes, to support both reduction of risks and costs, and the development of a robust licensing system
- exploration of the financial, carbon and social costs and benefits of various MWGH systems, to enable rational strategic planning of energy and heat systems and attract investment
- community and other stakeholders' beliefs, attitudes, perceptions and needs with respect to MWGH and heating, to guide the engagement work essential for supporting uptake of MWGH.

Coal mines for heat decarbonisation

PART B:

The mine water geothermal heat resource, opportunities, challenges and necessary government action

(DETAILED VERSION)

1

Introduction

Beneath about a quarter of the cities and countryside across the UK sits a potentially huge energy resource: mine water geothermal heat (MWGH) i.e. the heat held in the water which has filled the nation's disused coal mines. The technologies to extract and use MWGH are proven and well-established, and could contribute significantly to the multiple goals of energy policy:

- decarbonising the heating sector
- increasing reliance on secure, domestic, long term energy sources
- reducing energy costs
- providing high quality jobs in deprived areas and supporting new industries as part of a just transition to a low-carbon economy.

The general policy environment is increasingly supportive, the capacity and expertise of public and private sector bodies is growing rapidly, and the UK now has its first large scale district heating system powered by MWGH.

Yet unlocking the resource's full potential is seriously constrained by a mutually reinforcing set of costs and risks associated with:

- accessing the resource
- complex and time-consuming licensing processes
- lack of clarity and coherence in regulation and policy
- enduring skills and capacity issues across relevant sectors; and
- insufficiently widespread awareness and understanding of the technology and its potential within government, the private sector and general public.

The development of MWGH over many years in other countries demonstrates that these factors can be addressed successfully, and that the technology can offer environmental, economic and technical advantages in comparison to other renewable and non-renewable heating sources. Some of what is needed is in the hands of researchers and developers, but central government has the primary role in enabling and supporting change. The overarching challenge for the UK government (and the devolved administrations[1]) is to create a policy and regulatory environment in which the whole system, from exploration through extraction to distribution to end users, becomes less risky, more predictable and less costly, and thus investable. Successful developments in the UK to date have relied on direct state (including EU) support, through grants to support capital expenditure and/or as revenue. Most of these mechanisms have now disappeared, yet the technology must be supported if it is to reach a point where it is economically self-sustaining and genuinely attractive to investors.

While some of the needed changes are specific to MWGH, others are common to geothermal energy in general. In particular, heat itself is not currently treated as a resource in law which can be valued, regulated and traded. Existing regulation is piecemeal, falling across mining, environmental and planning bodies, and differs between the UK's nations. There is a widespread consensus amongst stakeholders that what is needed is a single, bespoke framework to provide clarity and certainty to developers and users, and to ensure sustainable use of the resource.

Rational decision making about how best to support the development of MWGH, along with other forms of geothermal energy, is only possible as part of an overall system of energy provision and use. Policy making therefore needs to be linked with the development of heat networks[2], the most likely use for MWGH. It also needs to be associated with very wide-ranging policy decisions in the energy sector and across housing, spatial planning, industrial strategy and decarbonisation more generally.

Recent reports in the geothermal energy field show a clear concurrence in their recommendations: in particular moving on from the need for technological development and instead stressing the need for government action on policy and regulation as the primary need for the sector[3]. In a rapidly evolving field, this Policy Brief adds value through updating the North East Local Economic Partnership's 2021 Mine Energy White Paper (the White Paper from here on), sustaining its specific focus on mine water (rather than geothermal energy more broadly), and targeting its recommendations on the actions required of central government. The White Paper (along with other publications listed below) provides valuable detail on the nature of the resource and technology, which is not repeated here, beyond a brief recap.

This Brief was drawn up on the basis of a review of current policy and research publications, alongside 14 interviews with experts from universities, industry and local and regional government, with written inputs from two other academic experts. Drafts were reviewed by a smaller group of academic and regulatory specialists. Where statements in the text are not attributed to a published source, they were drawn from one or more of the interviews and checked during the review process.

1 Energy policy is reserved to the UK government in Westminster. However, the environment, land use planning and housing are devolved, as are some aspects of energy such as heat policy.

2 Also referred to as 'district heating' or 'district heating networks'. See UK Parliament POST (2020) and Millar et al. (2019).

3 Compare, for example, the changes in emphasis visible in Banks et al., 2019 and Walls et al., 2021.

The amount of energy stored in mine water is enormous

2

The resource and its uses

The basic resource is geothermally heated water from coal mines, many of which filled with water after mining ceased[4]. It is geographically widespread: a quarter of the UK's homes and businesses are sited on former coalfields. Many of these communities continue to suffer from economic deprivation, and MWGH offers the possibility of both cheaper heating and new business opportunities.

In principle, geothermal heat is an almost inexhaustible resource, stable and renewable. With proper management, mine water could provide predictable, uninterrupted and sustainable energy over the long term. Enabling this requires ensuring that the rate of extraction of energy from a given mine system does not exceed the recharge rate: a detailed understanding of the hydrogeology of the subsurface is therefore essential, particularly where there are multiple users and water extraction and return points.

The amount of energy stored in mine water is enormous. While accurate quantification is currently beyond current capability, the MRA estimates a total figure of around 2.2 million GWh. A recent calculation, extrapolating from the actual yield of one mine, suggests that around a quarter of this (0.52 million GWh) could be available on an annual basis - roughly 1.2 times the total demand for heat, and 1.4 times the domestic requirement, of England, Wales, and N Ireland.

Access to MWGH is principally either from existing mine water treatment plants or through drilling bespoke boreholes, from which water is pumped and then returned to another part of the subsurface. In both cases heat pumps are used to extract heat, which is then transferred at higher temperature to the water in a heating system and distributed to end users. The former approach is relatively low cost and low risk, since the water is already at the surface and the heat is currently an unused, 'waste' resource. The MRA operates 75 treatment plants across Britain, with a potential yield of around 100 MW of heat energy. However, economic use of the resource is limited by the location of many of these plants away from current centres of demand, though this situation could be improved by developing new users such as greenhouses and other industries[5]. In contrast, drilling bespoke boreholes entails higher upfront costs and risks (see below), but is far more flexible as it can be demand-led in terms of location and technology.

The resource is very variable in terms of its suitability for extraction, depending on the geology and layout of the mine workings and the nature of the ground water resource, which are often only approximately known. Key factors here are rates and volumes of flow of water at different temperatures, and the routes they take through the flooded voids left by mining, all of which determine how much water and heat can be sustainably removed, and where both removal and recharge can best be done. (Using mine water as a heat storage and transport medium further complicates these issues.) This is an area in which very considerable progress has been made in recent years, in terms of collating and making available existing data, improving subsurface surveying techniques, and understanding and modelling groundwater and heat flows[6]. This has enabled a more nuanced and realistic approach to assessing the potential resource. For example, the 'opportunity mapping' of ten English cities by the MRA shows that 85% of Newcastle sits above old mine workings, and nearly three quarters of this area (71%) is considered by the MRA to offer 'good' opportunities for exploiting MWGH. Towards the other end of the scale, of the 20% of Leeds located above coal mines, three quarters is 'challenging' (the worst category) in MWGH terms, as is all of the 3% of Birmingham lying on the coalfield.

The technology for extracting and distributing heat from mine water is well proven, having been used for many decades in countries across the globe[7,8]. At least three projects are now operating at megawatt-scale, each heating several hundred homes as well as public buildings. The earliest of these was at Heerlen in the Netherlands[9], initiated in 2002, followed by Barredo Colliery in Spain 2017. The largest and most recent is in North East England, where the local authority-owned Gateshead Energy Company is using a 6.2 MW plant to heat major public buildings and 350 homes. Elsewhere in the North East, different ownership models have developed: Lanchester Wines has privately developed 2.4 MW and 1.6 MW systems to heat its own industrial premises, and a partnership of public, private and not-for-profit organisations is creating a c. 6 MW system based on an existing mine water treatment plant at Dawdon, to supply 750 new affordable homes at Seaham Garden Village.

Mine water is typically at 12-20°C[10], making it suitable for 'low temperature' 4th and 5th generation district heating systems, and other concentrated demand for space heating. The consistent temperature means that the coefficient of performance will be above that of an air-source heat pump whenever air temperatures fall below mine-water temperatures (ie in cold seasons when heat demand is greatest). 4th generation systems are a straightforward development of the familiar 3rd generation systems already widespread in the UK and elsewhere, using lower temperature water (40–60°C) and thus able to make efficient use of low carbon heat sources, including mine water. Retrofitting existing systems to upgrade them is relatively straightforward.

5th generation systems are different, in that they supply heating, cooling and heat storage through an ambient-temperature water loop, typically feeding a range of users with different demands. Each of these will have its own reversible heat pump, which moves heat in and out of the network. The Heerlen Mijnwater project has been developed into a 5th generation system in the past few years and demonstrates the technology's viability and potential.

Mine water thus offers the promise of services beyond space heating: cooling, heat storage and heat transport. In a warming world, and with the imminent abrupt increase in energy-intensive data centres, cooling is an increasingly important service. The potential for 5th generation district energy systems[11] to deliver cooling and storage within the system (to balance out short term and seasonal changes in demand) is now well-established. Moreover, current research is also showing the possibility for mine water to be used as a store for excess energy, through heating water which is then available for recovery through a MWGH system, which may be at some distance, depending on the hydrogeology of the mine system. This has a number of potential uses, such as cooling high energy users, grid balancing and storing energy from variable renewable sources, thus reducing the need for expensive and wasteful 'curtailment' of wind generation in particular.

Each use and each location has a different cost-benefit profile, depending on the precise nature of the mine water resource, and the scale and nature of the intended demand, so generalisations are difficult. What is clear however, is that a) the potential heat resource is enormous; b) the emerging possibilities of using mine water for cooling and storage further enhance the potential economic and net-zero benefits; but c) in most settings development incurs high initial costs and risks, and – like other renewable energy systems – projects require a viable long term business model to recoup these costs.

4 See the resources picked out in bold text in the list of sources for introductions to the technology and its development.

5 See, for example, the proposed development of the Horden plant in Co. Durham (Durham County Council, 2023).

6 See Section 3.3.

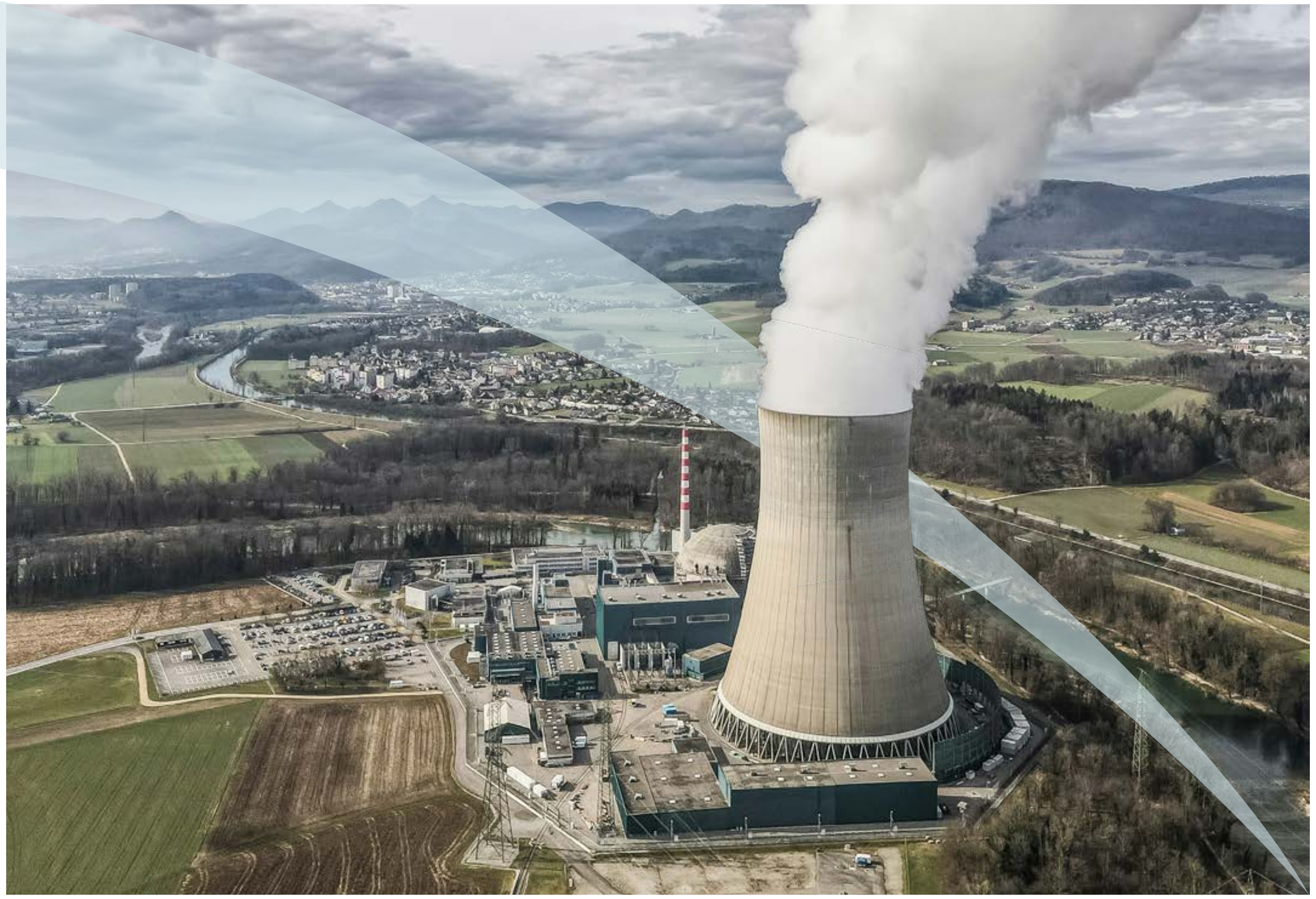
7 MWGH extraction and use lies at technology readiness levels (TRL) 8 and 9 i.e. actual technology completed and qualified through test and demonstration (TRL8) and actual technology qualified through successful operations (TRL9).

8 See Walls et al. (2021) and Banks et al. (2019) for comprehensive reviews of the history and locations of MWGH projects. The latter includes a map of the UK schemes functioning in 2019.

9 Heerlen Mijnwater is the most developed mine water energy system in Europe, and has a lot to offer in terms of learning about technical and regulatory issues for developments in the UK. It has developed over time from a 4th generation heating system to a 5th generation heating/cooling system, with multiple users of different kinds. It is also very well documented. For a brief introduction, see HeatNet NWE (n.d.). For a very extensive description, produced by the project, see Brummer and Bongers (2019). Verhoeven et al. (2014) provide a more academic description, albeit now rather dated.

10 The deepest UK mines are considerably hotter at c. 40°C. While these potentially offer substantially more energy, accessing these seams entails higher risks and costs (Farr et al., 2021).

11 Also known as 'district heating and cooling' or 'district anergy' systems (Erdle and Pröll, 2022).



3

An increasingly favourable context for MWGH development

A number of contextual factors come together to create an increasingly favourable environment for the development of MWGH, related to policy, the organisational landscape and the state of knowledge. In all of these there has been recent, rapid and positive change, with significant shifts since the publication of the Mine Water White Paper in 2021.

3.1 The policy environment

3.1.1 Decarbonising the UK's energy use

Context

The challenges posed since 2021 to the UK's energy security and cost of living by the Russia-Ukraine war, the increasing salience of the climate emergency, and the additional impetus given by a change of government in Westminster, have pushed decarbonisation of the UK's energy use up the political and policy agenda. It is now the focus of policy initiatives aimed at achieving the triple goals of energy security, sustainability and affordability, and supporting equitably distributed economic growth[12]. The UK government has a goal of achieving net zero across the whole economy and society by 2050; Scotland has independently set a target of 2045.

In 2019 space heating accounted for around 40% of all UK energy use, and a third of total greenhouse gas emissions. More recent figures are not directly comparable, but in 2021 (the most recent figures available at time of writing in 2025) domestic heating, principally from the burning of natural gas, accounted for 18% of emissions. Historically the sector has seen less policy attention and progress on decarbonisation than electricity generation, but this is changing. Overall consumption has been falling, due principally to high costs to the consumer and government policies to phase out gas boilers and to an extent by the replacement of gas and oil by heat pumps. However, the National Audit Office reports that progress needs to be greatly increased to hit the 2050 net zero target.

Heat pumps, primarily air source (ASHPs), are currently the UK government's preferred technology for decarbonising domestic heating. Achieving this would require both the complete decarbonisation of the grid (currently well under way) and substantial expansion in total electricity generation, reversing a long-term declining trend. (This might be by as much as 30%, if the entire demand was met by air source heat pumps.) There will also be up to a 40% increase needed to electrify transport, and a currently uncalculated new demand from data centres to meet the needs of the potential expansion in the artificial intelligence industry. The Clean Power 2030 Action Plan estimates that the total UK demand for electricity will double between 2025 and 2050.

12 See for example the UK Department for Energy Security and Net Zero's stated responsibilities at *https://www.gov.uk/government/organisations/department-for-energy-security-and-net-zero/about*: "UK energy security, protecting billpayers, supporting economic growth for the UK and protecting jobs, reducing the UK's emissions" (DESNZ, 2025a).

Advantages of MWGH

Although ASHPs are the preferred technology, and the most advanced in terms of roll-out, there is also central government policy support for heat networks fuelled by a range of low-carbon sources including mine water, hydrogen, and carbon capture, usage and storage (CCUS). Among this set of candidate technologies, MWGH has some distinct advantages, which make it supportive of the broader grid decarbonisation agenda.

- As a direct source of heating based on efficient heat pumps, MWGH can substitute for electricity demand and so the need for new generation/transmission infrastructure, at a time when demand is likely to rise steeply. Although the heat pumps used to extract energy from the mine water use electricity, they typically have 'coefficients of performance' (COP) of 3-4 i.e. they deliver 3-4 times as much heat energy output as electricity input. (This is comparable to or better than the best modern ASHPs, installed and operating under ideal conditions.)
- Mine water systems are also complementary to a decarbonised, renewables-dominated grid. As noted above (Section 2), their ability to store and then release energy as heat can be used to balance the grid, and to store excess generation by renewable sources.

By reducing overall emissions, MWGH complements the UK government's strategy on Carbon Capture, Use and Storage (CCUS). Whereas CCUS aims to dispose of collected CO_2, MWGH prevents its emissions in the first place, reducing our reliance on CCUS overall. Even if this is deployed widely, there are contexts in which it will not be suitable, either because there is not a critical mass of CO_2 being emitted locally or a suitable receptor nearby.

Finally, in the context of the drive to energy security, MWGH is based on relatively simple technology, which is not reliant on imported 'critical' minerals. Its use as a replacement for direct heating (through gas or electricity) and as an energy (heat) store could thus reduce the demand of the current principal battery technology for imported lithium, and of wind turbines for the rare earths (mainly of Chinese origin) used in their electricity generators.

Integrated energy planning and heat networks

New policies on strategic energy planning and heat networks have come into force since the 2021 White Paper, and are particularly propitious for the development of MWGH. The introduction of decentralised and integrated local authority-level energy planning through Local Area Energy Plans (LAEPs) (in England and Wales) and Local Heat and Energy Efficiency Strategies (LHEESs) (in Scotland) explicitly recognises heating as a service, and devolves decision making to a governance level which allows coalfield areas to push forward with MWGH[13]. Integrated planning, looking across all energy sources and demand within a local authority's area[14], encourages the consideration of a whole range of candidate technologies, from which combinations can be chosen comprising the most suitable in terms of local supply and demand.

In tandem with integrated planning for heat, low-carbon heat networks have been given an increasingly prominent role in government policy, and, as noted above (Section 2), MWGH is particularly well-suited as an energy source for them. Heat networks have the potential to deliver half of the country's heating needs, and provide a large opportunity for private sector investment. State guidance and financial support are available through the Heat Network Delivery Unit, the Green Heat Network Fund, and the BHIVE dynamic purchasing system, and policy is being developed to designate areas as Heat Network Zones (HNZs) in which networks will be expected to be the lowest cost solution for decarbonising heating. In Scotland and Wales it is already mandatory for local authorities to identify HNZs; while not yet the case in England, the Energy Act 2023 set the same direction of travel, with HNZs and a requirement for some buildings in HNZs to connect to a network, likely within a few years[15]. Building Regulations already set an upper limit on the working temperature of central heating systems which make them compatible with low-temperature (4th generation) heat networks.

3.1.2 The wider policy context

The development of MWGH has the potential to contribute to important policy fields alongside energy.

Economic growth

Energy in general is seen as important to the government's overarching economic growth agenda, both as an enabler of growth in other sectors, and as a creator of jobs and growth in own right. MWGH expansion will create a large number of new jobs, across a wide range of sectors and ranging from manual employment through to highly specialised research and consultancy work[16].

UK government has a goal of achieving net zero across the whole economy and society by 2050

13 Note that LHEESs are mandatory in Scotland, as are LAEPs in Wales but not in England.

14 "The LAEP scope addresses electricity, heat, and gas networks, future potential for hydrogen, the built environment (industrial, domestic and commercial) its fabric and systems, flexibility, energy generation and storage, and providing energy to decarbonised transport e.g. electricity to electric vehicles and charging infrastructure" (Energy Systems Catapult, 2025).

15 Mandatory connection in order to give investors 'connection assurance' (Jones et al., 2024) is seen as an important factor in promoting the widespread use of heat networks (Brown, Hampton et. al, 2024). See also Gorroño-Albizu and de Godoy (2021) for evidence from Denmark.

16 Numbers are hard to estimate. The 2021 White Paper suggested nearly 4500 direct jobs, with around 10000 more in the supply chain, would be created if all the projects they were then aware of were implemented.

Socio-economic regeneration of disadvantaged areas

MWGH is unique amongst low-carbon energy sources in that its location corresponds to some of the country's most deprived communities. While in terms of crude numbers of jobs and unemployment levels the ex-coalfields have largely recovered from the closure of the mines, they still remain blighted by low economic output, low quality employment, and a local 'brain drain' as better-qualified young people move out[17]. MWGH could contribute to tackling all of those challenges through creation of high-quality jobs, along with reducing heating costs for a population with high poverty levels.

Housing

The proposed large-scale expansion of housing across the country creates an enormous opportunity for MWGH-powered heat networks in appropriate areas. This will require close cooperation (facilitated by integrated energy planning) over the location and design of new settlements, with housing officials, developers and land use planners working together, with advice from the Mining Remediation Authority and BGS to maximise the extent to which heat networks can be designed-in. This will be particularly relevant in the new generation of new towns, intended to be 'sustainable' settlements of more than 10,000 homes.

3.2 Institutional/ organisational development

Developing MWGH resources is increasingly supported by an expanding ecosystem of organisations, collectively able to tackle many of the regulatory, coordination and data challenges identified in previous reports, including the 2021 White Paper. Key participants in this ecosystem noted how it forms a supportive community, characterised by a collaborative rather than competitive ethos. With the exception of the National Geothermal Centre, these are not new organisations, but since the White Paper they have expanded their capacities. One notable change is that names and activities reflect to some extent the increasing salience of geothermal energy in general in energy policy. While arguably this raises the visibility of MWGH, and is thus to be welcomed, the counter-argument was also made by interviewees that attention to mine water specifically will be diluted by its inclusion along with other sources of geothermal energy.

The most prominent members of the ecosystem (not including the handful of experienced private sector consultancies now active in the field) include:

- The Mining Remediation Authority (MRA; previously Coal Authority), with an expanded (but not centrally-funded) capacity in its Heat and By-Product Innovation Team to support enquiries and licensing applications, and a 'living lab' at Gateshead in the NE of England which provides the only location in the world where thermal and hydrogeological interactions between operational mine water heat schemes can be studied
- The National Geothermal Centre, established to push forward policy, regulation and investment frameworks and maximise the impact of research and innovation in real-world developments
- British Geological Survey's Geothermal Energy team, which conducts research, provides datasets and mapping products, tools and information, and has a key role in providing information and expertise to inform the development of policy and regulation
- The UK Geoenergy Observatory in Glasgow, funded through the UK government's academic research programme and delivered by BGS to support and deliver research into MWGH, creating publicly accessible data
- The expanded Mine Energy Taskforce, renamed and with a wider remit as the (UK) Geothermal Taskforce, operating as a networking group across government at local, regional and national level, and including private as well as public sector stakeholders; and
- International Energy Agency Geothermal, part of the IEA's Technology Collaboration Programme, which facilitates international collaboration and networking to advance research, development, commercialisation and deployment of geothermal energy; associated with this is the Mine Water Energy Expert Group coordinated by the BGS.

There is also an increasingly strong research base in the university sector, including Durham, Edinburgh, Glasgow, Leeds and Strathclyde Universities.

3.3 Expansion in knowledge

Expanding the accessible knowledge base for MWGH development is ongoing, across many organisations and fields. This is driven both by research and by the experience of developing working projects, and also learning from those which have not been successful. A significant development is a nuanced and detailed understanding of the resource, with an evidence base and advances in sensing and modelling which allow better assessment of potential for exploitation in different places.

3.3.1 Real world experience

Since the White Paper was published, the country's two largest schemes have been completed successfully: the 6 MW Gateshead Energy Company project and Lanchester Wines' two pumps (1.4 and 2.6 MW), which are now running at full capacity. The Seaham Garden Village project is under construction; proposed projects at Caerau and South Tyneside have been abandoned. All of these have generated a great deal of practical knowledge, contributing to growing expertise at the MRA in particular, in the handful of private consultancies which have been involved in the projects, and in the public sector in North East England. This knowledge and expertise is both technical (for example, the MRA's expertise in the successful drilling of new boreholes into abandoned mines) and institutional (for example, the detailed understanding of the licensing process now held by successful developers.)

A great deal of this experience-based knowledge has been made available for future developments in the Toolkit[18] commissioned by Bridgend County Borough Council in S Wales. This draws on the design and development stages of the Caerau project to deliver heat to housing and a school, using a private wire power supply from a local windfarm.

17 In England, 44% of coalfield neighbourhoods are in the most deprived 30 per cent in the country (Fothergill et al., 2024); in Scotland 31% are in the most deprived 20% (CRT, 2020).

18 The Toolkit includes guidance on: Mine Energy and Heat Networks, Licenses and Permissions, Hydrogeology, Boreholes and Drilling, Private Wire, Procurement, Project Management, and Techno-Economic Modelling (Bridgend CBC, 2025). It also includes the MRA's detailed 5-stage Indicative Mine Energy Consultancy Timeline.

3.3.2 Resource maps and data

Much progress has been made on mapping potential supply and demand for MWGH. There are now interactive maps of the resource for Great Britain, Wales, Scotland and ten English cities.

As part of this 'opportunity mapping', areas in Wales and the ten English cities have been categorised by the MRA as 'good', 'possible' or 'challenging' in terms of their suitability for development, depending on depth of workings, mine water status, presence of multiple mine workings and absence of potentially unstable surface workings. The Scottish 'resource atlas' uses similar criteria to generate a simple classification of areas as 'optimal' or not. Research is under way at the Durham Energy Institute (DEI) to compare these methodologies.

Addressing stakeholders' concerns about the availability of data to support MWGH development, BGS is creating a comprehensive UK Geothermal Platform for data storing and sharing, and as a metadata catalogue for geothermal data held elsewhere.

3.3.3 Modelling and investigating the MW resource

Significant progress has been made since 2021 on obtaining detailed information about the geology and hydrogeology of the subsurface. This is crucial for expanding the use of MWGH, as some of the initial high costs and risks associated with drilling boreholes can be mitigated with better information.

A significant contribution has come from the GEMSToolbox, which models the flows of water though mine systems and the heat exchanges between water and rock, in a way which is both rapid (compared to detailed coupled-process simulations) and more site specific than purely analytical modelling. It allows calculation of the potential for sustainable heat extraction and of the uncertainties involved, which means that quantified risks can be factored into a scheme's business model. The tool is thus very useful at the feasibility stage of a project.

The complexity and variability of the subsurface is such that modelling has its limits. Advances in mapping the subsurface without drilling multiple (expensive) boreholes are thus important. Novel techniques for this are being explored, including the use of muon tomography to look 'outward' from a borehole through the subsurface to locate voids without further drilling.

3.3.4 Economic and social issues

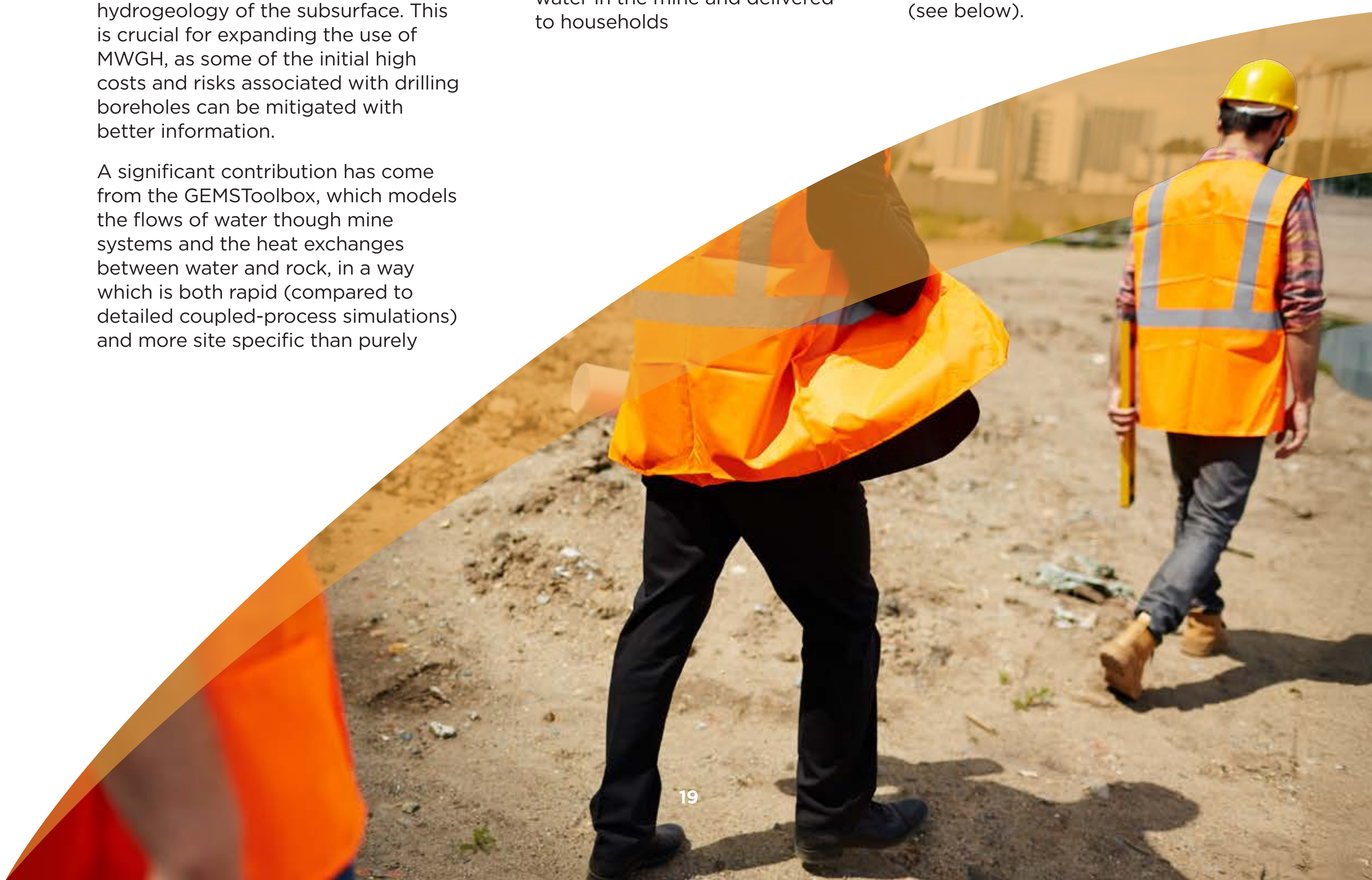
The economics of MWGH is a focus of current research. There is not yet any widely-available, peer-reviewed economic data or analysis. However, researchers based at the DEI have papers in preparation which provide:

a. the first detailed financial and carbon cost/benefit analyses of different mine water and district heating scenarios, comparing the Levelised Cost of Energy (LCOE) from MWGH with conventional gas central heating, and showing that the key factors in determining viability are the temperatures of water in the mine and delivered to households

b. insights into the public's 'willingness to pay' for different low carbon heating technologies, based on research in the NE of England. These suggest that household choices are motivated more by perceived cost and longevity of the technology than by social concerns with CO_2 reduction and job creation.

Research funded by the UK government (DESNZ) is under way (in early 2025) to establish accurate LCOE figures for different types of geothermal systems and their use in heat networks. It will also establish the technological requirements to achieve cost reductions, estimate GHG emissions and wider 'system' costs and benefits, including analysis of different funding mechanisms.

Stakeholder awareness and perceptions of MWGH are important factors in its acceptance (see Section 4.3 below). Deeming et al. (2024) show that the level of awareness of MWGH among Scottish stakeholders who either require heat for developments or would be involved in scheme delivery is fairly high. They largely share the views of the experts involved in the 2021 White Paper and this Brief: that mine water technology is attractive, for storage as well as heating, and that co-locating exploitation with heat demand makes sense, but suffers from high capital costs and pre-construction risks (see below).



4

Enduring challenges for MWGH development

Although many factors are increasingly supportive of MWGH, most of the principal challenges identified in the White Paper and echoed in other reports endure: primarily that unlocking mine water's potential is held back by the upfront costs of developing new extraction boreholes, and the risks associated with these. Stakeholders concur that the technical challenges are receding in importance, as more experience is gained and shared.

4.1 The most important factor: competitiveness

At present, the upfront costs of new boreholes and distribution networks are high compared to other heating technologies, in particular air source heat pumps installed for individual households - the principle current 'competitor' with mine water heat in policy terms. However, running costs (principally the cost of electricity) are low, making the overall cost comparable to other renewable sources over time, albeit with long payback periods. The latter are believed by some to be a significant disincentive to private sector investment at scale in MWGH – investors wish to see quicker returns and avoid being locked into very long term contracts.

Under current policy, the situation is compounded by the competitiveness of gas: despite the far higher efficiency of heat pumps, the unfavourable electricity-to-gas price ratio make running costs comparable between household gas boilers and MWGH. Initial analysis by the GEMS project suggests that in terms of the levelised cost of energy delivered, the latter can be competitive in situations where water temperatures and volume of demand are relatively high[19]. Clearly a change in policy – whether decoupling the price of electricity from that of natural gas, or the removal of gas from the market - would significantly and immediately make the economics of MWGH much more favourable[20].

The challenge posed by high upfront costs is compounded by the link to district heating as the most likely consumer of MWGH. Heat networks have the same issues of high capital costs (but low running costs), and uncertainties – in this case imposed by the complexity and immaturity of the market, problems with ensuring residential demand (without mandatory connections)[21], and technical issues concerned with responding to and balancing demand. As with MWGH, it can be expected that increased development of district heating will resolve the market issues. Experience from Heerlen in particular points to the desirability of networks being anchored by reliable, non-residential baseload demand centres such as hospitals or large industrial users, and to incorporate cooling and storage services, as ways to balance and stabilise the network.

Current policy has also removed some of the state support which previously mitigated the unfavourable cost situation, and which was used by all the successful projects in the UK to date. These included support for capital costs from a range of funds (including from the EU, now no longer accessible in the UK), and long term (20 year) support through the UK government's Renewable Heat Incentive (RHI), based on the amount of heat generated. Two of the three large projects – Gateshead Energy Company and the incomplete Seaham Garden Village – also reduced capital costs through, respectively, using existing district heating infrastructure

19 There are no up-to-date, comprehensive and quantitative comparisons of the different technologies. The comments here reflect a general consensus of stakeholders, and the little quantitative analysis that exists.

20 The Climate Change Committee's Sixth Carbon Budget (CCC, 2020a) advocates exactly this decoupling, a view shared by many stakeholders interviewed for this Brief.

21 See the final report on the Caerau scheme (Bridgend, 2024) for an example where expected demand failed to materialise, in part causing the demise of a project.

The government's role in unlocking MWGH's potential is crucial

and accessing surface mine water from a treatment plant. There is thus not yet a UK example at megawatt scale of a fully self-funded MWGH system, using newly drilled extraction boreholes.

4.2 Compounding factors

4.2.1 Risks

Extracting energy from the subsurface carries risks additional to those affecting other low-carbon technologies, which translate into additional costs and – sometimes – into project failure.

The principal risks are about reaching an economically sustainable geothermal resource – whether this will be found at all after drilling, and whether in the long term depletion will make exploitation no longer viable. The former is partly due to the variable quality and availability of maps and other data on the subsurface, the need for very precise drilling in the traditional room-and-pillar mines to ensure that voids (rather than pillars) are pierced, and changes in the subsurface (particularly collapses) since working was stopped. There are also risks of subsidence and collapse caused by the drilling itself and explosions from mine gas. Even where water is reached, it may not be suitable in terms of temperature, flow rates and chemistry to provide a viable and long-term sustainable resource.

The consequences are generally increased costs, typically from the need for additional boreholes to be drilled, and from the likelihood of this being factored into investment plans. At worst, unforeseen problems with drilling can cause a project to become unviable, as happened at the Hebburn scheme in South Tyneside.

To an extent these risks can be mitigated technically: much of the progress noted above (Section 3.3) is directed at better understanding of the subsurface, by hydrogeological modelling, remote sensing of geology, making existing data and maps more accessible etc., as well as the developing expertise in the sector. At any site, pilot boreholes can also de-risk the process to an extent, being considerably cheaper than full extraction boreholes. Removing these risks completely is impossible. Direct state funding or state-supported risk insurance for initial drilling are therefore important as ways to mitigate the risks financially - at least eight European countries have risk insurance schemes, but these have not been developed in the UK[22].

There are also possible demand-side risks, though these are less well-documented in practice. Predicted demand may not materialise, potentially due to reluctance of residents to engage with a district heating system. There is also a risk of losing demand due to changing land uses, driven by state planning or market forces. Once drilled, MWGH developments are fixed, and since mine water is not cost-effectively portable over significant distances (unlike electricity) local demand is essential. These risks will probably reduce over time, as district heating becomes more familiar and accepted, and also as HNZs increasingly require connections by some types of building. The development of 5th generation networks, with multiple users of different types, including large 'anchors' (see above), should also buffer schemes against the loss of individual users.

A subsequent risk area lies in the realm of public support for infrastructure development. Current government approaches to this is to frame it as a problem of 'public acceptance', or to over-ride opportunities for legitimate objections to be aired in the planning process. This risks exacerbating public discontent and lack of trust in authority, and enabling conspiracy-theorists to spread disinformation. Instead, consistent and thorough community involvement in project design and development, and the inclusion of guarantees of collective local benefit (eg through access to affordable heat or other collective benefit) is recommended.

4.2.2 Regulatory and policy constraints

The government's role in unlocking MWGH's potential is crucial, as competitiveness and risks can both be made more favourable through changes in regulation and policy. There is a general consensus[23] in the mine water community that the current regulatory system is not fit for purpose, constrains the development of mine water systems, and needs to be replaced by a bespoke and holistic regulatory system for licensing, ownership and management. The technology also lacks visibility in central government policy, which further limits its uptake.

22 For example, the Dutch government insures 85% of the initial drilling cost for geothermal projects against complete failure (Boissavy, 2019). At least one private scheme is also in operation: MunichRe operates a 100% risk cover for geothermal drilling in Germany (see MunichRe, 2025). For more detail, see the outputs from the EU-funded Developing geothermal and renewable energy projects by mitigating their risks (GEOrisk) project at (https://cordis.europa.eu/project/id/818232/results).

23 See the Mine Water White Paper, the Deep Geothermal White Paper (Abesser et al., 2023), the Future of the Subsurface report (Government Office for Science, 2024) etc.. McClean and Pedersen's (2023) review is a recent, thorough exploration of the issues, which can only be briefly summarised here.

Heat is not regulated

The central issue is that heat is not in itself regulated: it is not recognised legally as a resource, but rather as a waste product or threat to the environment, with no legal ownership structure. This precludes effective planning to prevent both over- and under-exploitation, and has deterred investment in the technology. (This contrasts with, for instance, Germany, where geothermal heat is defined as a natural resource, on a par with minerals and fossil fuels.) Instead, regulation is piecemeal, based on existing regulations developed for other resources, and requires developers to obtain separate permissions from the MRA and Environment Agency (or Scottish Environmental Protection Agency) prior to drilling. Developers' experience to date suggests that this is time consuming and unnecessarily complex, imposing unnecessary additional costs and uncertainties on the process. A lack of clarity over how to engage in the process is reported, potentially off-putting to external investors and requiring specific expertise in negotiating the system. This last problem is being tackled by the MRA and EA/SEPA[24], and experience is being shared through, for example, the Bridgend Toolkit, but the underlying problem remains.

Mine water heat has low visibility in policy

Addressing the core regulatory issue requires central government attention to MWGH as a significant potential contributor to decarbonisation. However, mine water (and geothermal energy more generally) has very little visibility in national policy, even in the new context promoting district heating. The ministerial Forward to the Mine Water White Paper is very positive, and the 2021 Heat and Buildings Strategy includes "geothermal sources (such as ambient air, the ground, rivers, the sea, and water in abandoned mines)" as potential heat sources for networks. In contrast, it is absent from BEIS's 2018 review of evidence on decarbonisation heating.

Geothermal energy is still hardly visible in key energy policy statements: the 2024 Clean Power 2030 Action Plan is oriented towards decarbonisation of heat through electrification with domestic heat pumps, rather than heat networks and geothermal sources. While the previous government's Energy Security Plan sets out a significant role for heat networks, geothermal energy is not associated with this. Similarly, most central government information and guidance on heat networks also omits mine water and geothermal heat in general[25].

Land use planning policy differs between the constituent nations. The English National Planning Policy Framework (NPPF) lists geothermal energy as a renewable source, but without specific policy implications or any mention of mine water. The Welsh equivalent, Planning Policy Wales, instructs planning authorities to develop policies to "maximise the use of… other heat sources such as former mine workings" while in Scotland the National Planning Framework 4 (NPF4) supports heat network development, and contains a presumption in favour of energy infrastructure development which repurposes "former fossil fuel infrastructure for the production or handling of low carbon energy".

Energy policy is in a state of flux

Energy policy is a rapidly changing field, in part because of the change in UK government in July 2024, but also in response to continuous technology development and the fluid politics of achieving net zero[26]. However, with very substantial upfront capital expenditure, MWGH (and also heat networks) needs policy stability over several decades to make investment attractive. There is clearly a tension here with the need, described above, for regulatory reform: stakeholders would like to see reform quickly, and then a stable policy environment. Some also perceive a 'chicken and egg' problem, with investors needing a new regulatory system, but government unwilling to develop this until it is apparent that the sector will be sufficiently large to justify the administrative resources involved.

4.3 Awareness and attitudes

Achieving widespread uptake of MWGH requires, as a minimum, knowledge and positive attitudes towards the technology, along with the resources to effect change. These requirements appear to be lacking with many relevant stakeholders, though the situation is uneven and not very well-evidenced through formal research.

The state

The point made above that MWGH and geothermal energy are not as visible as one might expect in national policies suggests a need to raise awareness amongst critical groups within central government, including politicians and civil servants. There are notable political champions in Parliament[27], but there does not seem to be a sufficient grouping capable of mobilising policy change[28].

At regional and local authority level the situation is variable. While in North East England there appears to be a critical mass of support from local and combined authorities, and significant support in Scotland from Scottish Enterprise, this is less evident in the South Wales coalfield, which might be expected to view MWGH similarly to the North East. The relevant Local Area Energy Plans (LAEPs)[29], and Cardiff City Region policies, either do not mention MWGH or treat it as a less immediately viable alternative to ASHPs, meriting investigation and/or pilot projects but not a central role in deployment. The reasons for this are unclear: one key proponent of MWGH has suggested it results from

24 See the MRA's Mine water heat access agreement application process timeline for schemes in England (MRA, 2024), which is clear and transparent, though does not combine the MRA and Environmental Agency processes.

25 Salient examples are the Energy Systems Catapult guide to the decarbonisation of heat (Energy Systems Catapult, 2025b), the 2024 report by the National Audit Office for DESNZ on decarbonising home heating (NAO, 2024), and the Scottish government's Heat Network Zone (HNZ) guidance (Scottish Government, 2023a).

26 See, for example, the flagging up of the potential for hydrogen as a heating fuel in the previous government's 2021 Heat and Buildings Strategy, but with a five-year evidence gathering timeline. The phase out of gas boilers has become politicised, with English and Welsh policy no longer stipulating an end date for installation in new homes, while Scotland's separate New Build Heat Standard bans them in new homes from 2025, and altogether from 2045.

27 See for example, Kieran Mullan MP's report (Mullan, 2023). There is also an All Party Parliamentary Group (APPG) on Deep Geothermal (whose membership includes some significant proponents of mine water energy) but no dedicated Shallow Geothermal APPG.

28 There are also well-organised lobbies for alternative policies. See Lowes et al. (2020) on the cross-sector group arguing for a gas-based approach to decarbonising heating (i.e. using hydrogen to replace natural gas, as opposed to either electrification or heat networks.)

29 Completed LAEPs are for Bridgend, Merthyr Tydfil, Newport, Rhondda Cynon Taf and Torfaen.

the comparative strength of MWGH professional networks in the North East, and the lack of connections from those to the Welsh coalfield.

Non-state organisations

While there is no comprehensive research base to draw on, it appears that outside specialist communities MWGH has little salience, contributing to its low profile in public discourse, with negative effects on political and policy maker interest and motivation for change. So, for example, despite their obvious commitment to the energy transition, none of the large environmental NGOs show explicit interest in MWGH. Informally they express interest and support, but resource limitations mean that they focus their attention elsewhere in energy policy. This is also true of the Confederation of British Industry (CBI), as a major representative of the private sector, which follows much of government policy in highlighting the potential of heat pumps, hydrogen or "even district heating…supplied through industrial waste heat and combined heat and power plants" but not referring to MWGH.

A key stakeholder group is the volume housebuilders, given the potential for MWGH-powered heat networks to supply heat to new settlements created under the government's building programme. Historically, housebuilders have been generally conservative when it comes to innovation for sustainable building – the prioritisation of immediate financial viability means that uptake of new technology typically only happens where it is either enforced through regulation or increases sale prices. They also need certainty, or at least stability, in policy and legislative terms before making long-term investments in new technologies. There is limited evidence, but a reasonable supposition, that this economically rational caution extends to MWGH, even in relatively favourable (i.e. relatively low cost, low risk) circumstances. Thus at Seaham Garden Village, a heat network using mine water from an existing treatment plant is being installed for 750 affordable houses; the open-market homes on the same site have been fitted by their mainstream developers with gas central heating.

Public attitudes

There is also a growing evidence base around public attitudes to decarbonisation of heat, but again with very little specifically about MWGH. The general picture is one of a relatively high level of awareness of the overall need for decarbonisation and the available technologies, but little detailed knowledge, some distrust of both government and private sector organisations, and an overall ambivalence towards adopting the new technologies. People appear to be discouraged by cost and disruption, as well as unfamiliarity, and while heat pumps are viewed fairly positively, the slow uptake of these suggests that public attitudes may well be a constraint on the acceptance of MWGH.

While there is evidence to support the assumption (widespread and promoted by MWGH proponents) that some coalfield communities welcome a green repurposing of the mines, there are also reports of widespread lack of awareness or interest. Attitudes to MWGH are assumed to be compounded by generally negative

The lack of skilled personnel and supply chain industries remains an obstacle

attitudes to district heating in the UK[30]. Intensive community engagement by developers is seen by some as the key to acceptance: this was the case at Caerau, and is supported by early, positive, results from the retrofitting of existing homes for connection to the Gateshead Energy Company's heat network. Recent publications also highlight the potential positive response among ex-mining communities to the prospect of local benefit from mining resources.

The overall picture is unclear, but the impact of the public's negative response to fracking on the viability of that technology shows both the importance of cultivating a positive narrative around energy innovations, and also of explicitly distancing geothermal technologies (with their reliance on drilling) from shale gas extraction. This reinforces the need to pursue genuine and extended community participatory procedures throughout the development of schemes, and to secure real local benefits for MWGH developments. Building community support, albeit time-consuming and iterative, is shown to ease the path to infrastructure development and result in projects that are best suited to the local context, and suitable guidance is readily available[31].

4.4 Distribution of the resource

Important constraints remain which are imposed by the spatial distribution of the resource at both the project and strategic planning scales. While significant progress has been made in improving both actual and predictive knowledge of the resource, the variability of geology, hydrogeology and thermal properties of rock and groundwater, and the fact that these can only be approximately modelled or mapped remotely, remain significant challenges. These impose both costs and some ineradicable uncertainty from extraction involving new boreholes. This impacts on project viability, and also creates issues around determining sustainable yields, particularly in future situations with multiple users of the same subsurface system[32]. The uncertainty also poses challenges for developing appropriate regulation and licensing of heat extraction.

Aligning supply and demand at the strategic planning level remains challenging, given the fixed nature of the resource. The limitations are greatest for the cheapest, lowest-risk option of accessing mine water through existing treatment plants, many of which are in rural areas, distant from extensive urban demand. The issue is a general one, however, and emphasises the importance of developing viable and socially acceptable retrofitting of existing housing. In the longer term, strategic planning for heat will also help, but will be most effective if heat and mine water exploitation are explicitly written into national planning guidance, so that future housing and industrial development can be linked to heat resources. Developing novel rural uses such as horticulture may also be an option to maximise the use of the resource[33].

4.5 Human resources

The lack of skilled personnel and supply chain industries remains an obstacle. The situation has improved since the 2021 White Paper was produced, with increased relevant expertise at the MRA in particular, and at a small number of engineering consultancies. There is also an increasing number of specialised geothermal and related MSc programmes at UK universities. However, the problem endures, and has been manifested in poor performance by inadequately skilled companies meeting the demand for new projects. The UK's regulatory complexity, amongst other wider factors, is reported also to make the country unattractive for experienced foreign engineering consultancies.

This constraint is increased by the complexity of MWGH projects, which are inherently highly interdisciplinary because of the nature of the subsurface resource and the integration with end users through heat networks. (This contrasts with, for example, wind energy, which is comparatively straightforward.) The ability to manage MWGH projects is thus in itself a scarce but essential skill, as is the capacity to negotiate the current institutional complexity of the field.

30 For a counterexample to the UK, demonstrating the importance of histories and national cultures, see Johansen (2022).

31 Eg *https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/eu-valorisation-policy/knowledge-valorisation-platform/guiding-principles-knowledge-valorisation-and-implementing-codes-practice/code-practice-citizen-engagement_en*

32 The new (early 2025) MRA research facility in Gateshead and the UK Geoenergy Observatory will help address this issue. However, the challenge posed by the uniqueness of every mine system will remain.

33 The Netherlands is already using geothermal energy in greenhouses (Cariaga, 2023). Horticulture accounts for 2.5% of UK agriculture's carbon emissions (AMC Online, 2022). The Horden mine water treatment plant development is intended to be the UK's first involving greenhouse heating (Durham County Council, 2023).

5 Development principles

Drawing together the issues described above concerning

- the nature of the resource
- the increasingly positive environment for MWGH exploitation; and
- the challenges which nevertheless persist, and constrain realising the resource's potential contribution to UK decarbonisation and other important policy agendas

leads to a set of development principles which should inform policy support for MWGH exploitation. They are intended to provide a set of cross-cutting guidelines for all policy and regulatory development going forward. In particular, the specific actions recommended for central government set out in Section 6 below should be executed with these principles in mind.

Integration

MWGH should always be considered as a candidate technology in coalfield areas, as part of an integrated, demand-led approach to heat and energy planning. Physical integration of MWGH into multi-source district heating systems may also be appropriate. The location of potential mine water resources should also be integrated into economic and spatial planning at every scale in relevant places, and into skills development strategies.

Evidence-driven focus

Improved knowledge should be used to focus development in areas assessed as having a high quality, accessible resource and high demand (actual or potential). Attention should also be paid to reducing costs through capitalising on either/both existing infrastructure such as mine water treatment plants and heat networks, and incorporating MWGH from the start into new housing and industrial development.

Diversity of uses and power sources

Uses of MWGH beyond space heating should be considered, for thermal storage, grid balancing, heat transport etc. In some circumstances multi-purpose, multi-user '5th generation' energy networks may be appropriate, based on the model developed at Heerlen in the Netherlands. So long as electricity costs remain high, decoupling MWGH systems from the national grid through private wire connections to renewable sources of electricity should be considered.

Stakeholder support

The support of stakeholders across government, industry and the public is essential to expanding the use of MWGH, both at policy and project level. Community support is also essential for the effective development of infrastructure projects of this type. It cannot be taken for granted, however: significant resistances and low awareness are enduring challenges. Developing stakeholder support will require specialist input and champions within stakeholder groups.

Equity

Maximising MWGH's potential benefits from high quality employment and lower energy costs in deprived coalfield communities requires explicit attention in project planning and implementation of the whole system, from drilling and heat extraction to end use in people's homes. Equally, attention must be paid to avoiding disadvantages from disruption and higher energy costs, and the potential for exclusion from MWGH's and district heating's benefits because of the costs involved.

6

Unlocking the resource: actions for national government

The principal barriers to a step change in MWGH exploitation are interrelated financial and risk-related factors. The technical challenges are secondary and manageable once the economic and regulatory framework is favourable. Consequently government, and particularly national governments (the UK government in Westminster, and the devolved administrations where relevant) have a crucial role. DESNZ will have a leading position, but will need to coordinate its policy development in particular with the Treasury, DEFRA (and the Environment Agency), MHCLG and the Holyrood and Cardiff governments.

An overarching policy stance, which informs the detailed recommendations below, comprises three parts:

a. MWGH should be recognised as a potential major contributor to decarbonising the UK's energy needs in a secure and sustainable way, and should therefore be supported, as other renewable resources were at a similar stage in their development[34]. Many of constraining factors noted above – related to knowledge, capacity, expertise, local supply chains – will reduce over time and, while the technology is straightforward and proven, the implementation of large (i.e. megawatt) scale MWGH in the UK is still at first mover stage, and needs support while the system matures.

b. A 'roadmap' for MWGH is needed, which provides a clear and coherent approach that aligns financial, regulatory and other support, and links MWGH to broader energy, housing, planning and industrial strategies. It should provide a timeline for policy change, linked to quantified targets for projects initiated and installed heat supply capacity. The roadmap needs to allow for stability (to support investment) and be flexible enough to support innovation - this will require a rather light touch, agile approach to regulation.

c. Unlocking MWGH's potential will involve some combination of direct financial support, regulatory change to shape investment and practice, support for research, and leadership. Financial support and regulatory change can be traded off to some extent: the latter could reduce the need for the former if it improves investability. A key policy goal must be to reduce uncertainty for all stakeholders, including the public, over returns on investment and the capacity of MWGH to deliver affordable, reliable energy.

34 CCUS is currently receiving such support (UK Parliament, 2025). As a better-developed technology, MWGH should arguably receive similar treatment.

Note that some of the proposed changes (and the timing of the roadmap stages) are dependent on much wider, ongoing policy developments around energy and decarbonisation, such as the review of electricity market arrangements (REMA) (in particular the possible introduction of zonal costing, and the decoupling of low-carbon electricity prices from the gas market), the decision about the role of hydrogen, and the regulation of heat networks. MWGH's needs should be part of those discussions, to avoid inadvertently undermining the technology's potential contribution.

The overall vision is of strategic heat planning across all the coalfield areas, based on detailed evidence about the mine water resource, leading within a few years to significant (i.e. multi-megawatt) 4th and 5th generation installed district heating capacity, heating thousands of homes and industrial units, reducing CO_2 emissions by thousands of tonnes. This will be supported by state-backed insurance for initial exploration and direct funding in the form of either upfront support or payment for units of delivered heat, and regulated by a simple, transparent system which is specifically designed to support the exploitation of the resource. Delivery of the vision will be enabled by supportive energy and spatial planning policy frameworks, and will feed explicitly into the achievement of net zero, industrial and economic development and housing strategies.

6.1 Direct support

There is very widespread support amongst stakeholders for the next two points, which are seen as essential to enable the expansion of MWGH.

- Government-backed incentives such as grants, low-interest loans, and tax breaks are needed to de-risk projects and improve economic viability. Long-term financial mechanisms, including green bonds or public-private partnerships, could address concerns about long payback periods for investments. Additionally, operational subsidies (e.g. an equivalent of the previous Renewable Heat Incentive, or a Contract for Difference for heat) could provide ongoing financial support for system maintenance and energy delivery
- State-backed insurance is an additional/alternative way to de-risk the exploratory phase of borehole drilling projects. It is possible that as the market matures, private investment companies would participate.

A number of other activities would also benefit significantly from state support.

- Supply chain and technology development. This could be modelled on the public-private partnerships which support other rapidly developing net zero technologies such as offshore wind, and be channelled through the Catapults[35] in the same way
- Stakeholder engagement. This is an activity which is essential to achieving stakeholder and public acceptance of MWGH projects. Currently it is provided on an ad hoc basis within projects, and as such is largely unfunded and conducted by non-specialists. Ensuring that new projects are publicly funded to carry out effective engagement would be worth exploring (at least for the next few years), drawing on the experience of government agencies for whom this kind of work is routine (e.g. the Environment Agency)
- Demonstration projects. The development of skills, changing stakeholder attitudes, and disseminating knowledge would all be enhanced by demonstration projects, adequately funded by government. At present this role is fulfilled in a very ad hoc way by individual projects which are not designed as demonstrations, but whose management are prepared to invest in sharing their experience.

Finally, government should provide clear and readily available information about what support is available and what benefit-sharing opportunities are possible.

6.2 Regulatory and policy change

Regulatory development also needs to be clear, and clearly publicised, including likely further changes. It is clear that lack of certainty is in itself a major disincentivising factor for investors and developers.

6.2.1 Energy policy

- Heat should be treated in policy and law as a separate resource, integral to the energy system but with regulatory needs distinct from other resources and energy technologies. This is a prerequisite for the establishment of an effective regulation and licensing system for MWGH
- The privileged position of natural gas should be removed from the existing energy market, as it currently disincentivises the uptake of most low-carbon heating alternatives, including MWGH and district heating. In the short term, as part of REMA, this could be achieved by decoupling (renewable) electricity from gas prices. In the medium term, as part of decarbonisation, natural gas should be removed as much as possible from the energy mix, especially by prohibiting the installation of gas boilers

35 The Catapults are independent, not-for-profit organisations intended to support innovation through the provision of R&D infrastructure, specialist knowledge and expertise (DSIT, 2023).

Tackling the low salience of MWGH in policy making requires leadership by national governments

- Guidance and legislation on the expansion of heat networks, strategically planned through HNZs, LAEPs etc., should refer explicitly to MWGH resources for the coalfield areas, in order to avoid the resource being overlooked due to lack of awareness. The possibility of mandatory connection of homes to heat networks should be explored i.e. strengthening the provisions of the Energy Act.

6.2.2 Regulation of MWGH

Along with direct support for the initial stages of MWGH projects, the first point below is the most consistently referenced request from the MWGH community: it is seen as essential to allow the resource to be developed effectively.

- A bespoke regulatory and licensing framework should be created which creates a single, speedy and readily navigable permitting process. This could be achieved by creating (or assigning responsibility to) a single geothermal regulator or an agency that coordinates the approval process
- A key part of the licensing framework should be a transparent and equitable regulatory framework for sustainable extraction by multiple users
- A government-backed quality assurance scheme should be introduced for companies planning and executing MWGH projects, to ensure sufficient levels of experience and competence to conduct drilling safely and with high probability of success.

6.2.3 Planning and building regulation

- Coordination between DESNZ and the government bodies responsible for land use planning[36] will be essential to maximise the effective alignment of MWGH supply and demand. This coordination will need to be reflected in guidance to combined and local authorities, in particular to ensure that energy planning delivered through LAEPs, LHEESs, and HNZs is strategically linked to land use planning through development plans[37]. The twin goals are to maximise the use of the resource, and facilitate efficient development of multi-user, muti-purpose networks where appropriate.

This will entail updates to the national planning frameworks, specifically:

- Directing planning authorities to consider the potential of MWGH in strategic planning of residential and industrial development, taking into account the distribution of the resource, its estimated quality and accessibility, and the location of existing infrastructure which might reduce the cost of installing MWGH (e.g. mine water treatment works, district heating plant)
- Create a presumption in favour of development proposals for mine water extraction infrastructure and its varied uses (district heating, cooling for data centres, etc.) similar to and strengthening Scotland's NPF4 Heat and cooling Policy 19[38], and extending the scope beyond heat networks and HNZs to include supporting proposals for mine water energy service use by single large users, such as data centres, business parks or large scale greenhouse horticulture[39]
- Create a presumption in favour of proposals for the infrastructure required to establish heat networks and MWGH extraction in existing housing stock, particularly in deprived communities (rural and urban)
- Consideration should be given to amending Part L of the Building Regulations to require new buildings to be compatible with cooling (as well as heating) networks, to facilitate the development of 5th generation systems
- Rather than bypassing opportunities for objections in the planning process, consistent effort should be put into raising public awareness, including communities in project design and securing local benefit (such as access to affordable heat) in the locality of MWGH developments.

Finally, going beyond 'land use planning' in a strict sense, an analogous, comprehensive system for planning the subsurface should be developed, to enable the greater use of geothermal energy, including MWGH. This approach should draw on the recent (2024) Government Office for Science's Future of the Subsurface Foresight report.

36 Ministry of Housing, Communities and Local Government in England; Planning and Environment Decisions Wales; the Planning, Architecture and Regeneration Directorate in Scotland.

37 Development plans are adopted local plans, neighbourhood plans, spatial development strategies, and regional spatial strategies. See NPF4 and the NPPF.

38 "Local Development Plans should take into account the area's Local Heat & Energy Efficiency Strategy (LHEES). The spatial strategy should take into account areas of heat network potential and any designated Heat Network Zones (HNZ)...19e Development proposals for energy infrastructure will be supported where they:
"i. repurpose former fossil fuel infrastructure for the production or handling of low carbon energy;
"ii. are within or adjacent to a Heat Network Zone; and
"iii. can be cost-effectively linked to an existing or planned heat network." NPF4 p. 69.

39 This distinction is important: a policy with the same focus on heat networks as the existing NPF4 would not cover a development such as Lanchester Wines' successful warehouse heating project. Policy 19d only mandates support for "national and major developments that will generate waste or surplus heat" and requires a plan demonstrating how recovered energy will be used. In coalfield areas, this should be linked explicitly to a presumption that proposals from a heat generator of any size to connect to a mine water system will be approved.

6.3 Leadership

In addition to the policy and regulatory changes detailed above, tackling the low salience of MWGH in policy making requires leadership by national governments, both in 'shifting the narrative' and increasing MWGH's visibility, and empowering other organisations to play appropriate roles. Specific positive actions would be:

- to explicitly include MWGH in energy and related policies, including in particular those promoting heat networks and strategic energy planning (HNZs, LAEPs and LHEESs)
- the salience of MWGH should be 'levelled up' and made consistent across the UK's constituent nations
- unitary and combined authorities should be empowered to lead on the development of the mine water resource, through e.g. strategic planning at the regional scale, and developing skills and supply chains[40]
- policy and financial support should be provided for the key sector organisations (the MRA, NGC, BGS, GE Task Force, UK Geoenergy Observatories etc.) to progress the development of MWGH, including, inter alia
  - networking between academia, public and private sector stakeholders
  - establishing a national research borehole programme by MRA
  - supporting the development of the UK Geothermal Platform by BGS and linking this to the development of a national repository for subsurface data
  - development of a detailed research agenda backed by UKRI funding, as follows
- support should be given for research which:
  - creates/collates supply and demand maps at site planning scale for the entire UK, as a fundamental resource for the MWGH industry
  - further develops modelling and engineering approaches to assess the mine water resource and the impacts of exploitation (including in particular long-term and cumulative impacts)
  - explores the financial, carbon and wider social costs and benefits of various systems of mine water exploitation and use, in particular to identify the tipping points at which MWGH provides the most desirable energy source, and the potential for new uses
  - explores community and other stakeholders' beliefs, attitudes, perceptions and needs with respect to MWGH, including volume housebuilders and civil servants as groups about whom little is known, but who play key roles in enabling the scaling up of MWGH
- investigations should be commissioned (which would appropriately be coordinated by the NGC) into three outstanding issues which need resolution to support the policy developments listed above:
  - Determining the appropriate scale of governance for MWGH. At present responsibilities are divided between local and combined authorities (in England), with the national administrations playing significant but not entirely coordinated roles. This adds to the complexity of the regulatory landscape for developers, and perhaps obstructs coherent energy/heat policy making[41]
  - Determining exactly what the regulated resource should be and how it is best measured, and what the most appropriate ownership model would be. Heat, energy transfer (including cooling etc.) and groundwater are all candidates to be the resource recognised in law. Ownership could plausibly lie with the state, landowner, energy company, or even local communities. This is a very open question, which will have to be resolved to enable the needed bespoke regulatory system to be developed
  - Linked to both the above, there is a third issue about the appropriate role for the public and private (and possibly not-for-profit, community) sectors in extracting and distributing MWGH. Different models currently exist, and proponents argue for their merits on varying grounds: economies of scale for investors, ensuring community benefit, potential for integration into other aspects of planning etc. There are no options with clear superiority for all stakeholders, but a framework and guidance will be needed to underpin the development of a route to market for large scale MWGH

40 For instance, FE, HE, employers and local authorities could be supported and encouraged to develop a combined Renewable Heat Academy to address skills development across diverse heating and cooling technologies, which could be located in a region with skills needs (e.g. using the model of the multi-level Energy Academy at Blyth, Northumberland).

41 There are tensions inherent in the existing system. For example, while land use and spatial planning are a local authority responsibility, the cross-border nature of mine water systems and local economies may make the combined authority level appropriate for more strategic planning of energy (currently a local authority responsibility through the LAEPs) and supply chains. This kind of issue will need resolution, either though allocating leadership to one tier or the other, or by mandating coordination of policy making.

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