Department for the Economy
www.economy-ni.gov.uk

GSNI Geological Survey of Northern Ireland
www.bgs.ac.uk/gsni

Geothermal energy potential in Northern Ireland

Summary and recommendations

for the Geothermal Advisory Committee

This report has been prepared by the Geological Survey of Northern Ireland (GSNI) for the Geothermal Advisory Committee. This paper reflects the views of GSNI, but does not necessarily reflect those of individual GAC members or their organisations.

The information contained in this publication is believed to be correct at the time of writing. Whilst care has been taken to ensure the information is accurate, GSNI can accept no responsibility for any errors and omissions.

How to cite this document. Raine, R.J. and Reay, D.M., 2021. *Geothermal energy potential in Northern Ireland: Summary and recommendations for the Geothermal Advisory Committee*. GSNI Technical Report **2021/EM/01**.

Executive Summary

On 27 June 2019 the UK set a legally binding target of achieving net zero greenhouse gas (GHG) emissions by 2050. Northern Ireland, like the rest of the UK, has made significant progress in generating electricity from renewable sources, primarily wind, leading to reduction emissions from power generation. Heat and transport sectors of the energy system are more difficult to decarbonise and are still largely reliant on fossil fuels.

Decarbonising heat is the biggest challenge in meeting net zero carbon energy emissions as it accounts for 50 % of our energy consumption and is almost entirely met through fossil fuels, mainly oil (54 % of total heat consumption) and natural gas (27 %)[1]. Natural gas has been available in the Greater Belfast area since 1996, and the network has been expanded in stages. Currently, there are approximately 280,000 connections[2] and, by 2022, approximately 550,000 properties will be able to connect to the grid.[3] Carbon emissions from the domestic heating sector have been slowly decreasing, primarily as a result of the increasing uptake of natural gas.[4] Despite its lower emissions compared to oil or coal, natural gas will eventually need to be replaced with renewable heat source to achieve net zero.

With decreasing reliance on fossil fuels, geothermal energy has the potential to form part of the solution, both through its direct use as a low-carbon energy source and the role it can play in optimizing the electrification of heating and cooling.

In many countries throughout Europe, geothermal energy forms a growing part of the energy supply, particularly in the area of low-carbon heating and cooling. The UK Government believes that geothermal energy has an important role in the United Kingdom's transition towards net-zero, particularly in the decarbonisation of heat[5].

Geothermal energy is characterised by its continuous availability, in contrast to other low-carbon energy sources such as wind, solar and tidal energy, which are intermittent and fluctuating. Although capital expenditure costs are relatively high, operating costs are competitive and a vibrant deep geothermal energy sector is developing in many European states.

Shallow geothermal accessed via Ground Source Heat Pump (GSHP) systems can be used for heating and cooling of individual dwellings or, with larger multiple loop systems for small-scale heat networks. GSHP systems are particularly useful in decarbonising space heating and may be particularly important in areas not connected to the gas grid. Deep geothermal energy systems have larger capacities, greater efficiencies and are suitable for direct use via large heat networks, or depending on temperature, power generation.

Geothermal energy potential in Northern Ireland includes widespread shallow groundsource heat in unconsolidated

---

[1] NISRA, Total sub-national final energy consumption, 2018
[2] Utility Regulator, 2020. Retail Market Monitoring. Quarterly Transparency Report. Quarter 3: July to September 2020.
[3] Utility Regulator, 2016. Price Control for Northern Ireland's Gas Distribution Networks GD17. Final Determination 15 September 2016.
[4] NI annual housing stock statistics 2020 - 808,000 homes in 2020
[5] UK Parliament – Written questions, answers and statements. UIN 24272, 29 June 2021.

sediment and rocks that have high thermal conductivity. High permeability sandstone reservoirs under Greater Belfast and several other towns across Northern Ireland have potential for shallow geothermal resources to be accessed by open-loop geothermal technology for larger scale heating, cooling and storage requirements. There exists some potential for mine water heat and heat storage in parts of east Co. Tyrone and deep geothermal prospectivity occurs in deeply buried hot saline aquifers that would be suitable for industrial, horticultural and district heating use. Limited potential for engineered geothermal systems exist in granite rocks in Northern Ireland.

The purpose of this paper is to outline the geothermal resources of Northern Ireland, identify their potential role in the development of a sustainable low-carbon energy system, and outline measures that would help to stimulate the development and use of geothermal energy in Northern Ireland.

Much progress can be made by optimising the use of existing geoscientific data, research programmes and the targeted gathering new exploration data and demonstration of working systems. Additionally, it has been recognised[6,7,8] that future development of deep geothermal energy in Northern Ireland will require greater certainty regarding regulation, including clarification of the legal ownership of resources, licensing, planning and permitting regimes, and consistent policy including support mechanisms.

Key recommendations include:

- Public awareness/engagement on geothermal energy.
- Development of a strategic approach.
- A programme of geothermal exploration & research.
    - Open access geothermal data, with Geothermal Database/Viewer.
    - Research programme to identify deep geothermal prospects.
    - Exploration programme involving drilling/surveying.
- Trials and demonstrators.
- Mapping of resource potential vs heat demand for heating/cooling.
- A Geothermal energy policy & roadmap.
- Development of resource licensing & regulations.
- Consideration of geothermal within environmental policy/regulation(s).
- Consideration of geothermal in future planning policy/regulation(s). Provision of spatial data and information for councils.
- Explore suitable market maturity based fiscal regime.
- Identify key requirements for skills development & supply chain.

[6] CSA, 2008. Report on the Potential for Deep Geothermal Energy in Northern Ireland.
[7] GTR-H, 2009 Final Publishable Report. GTRH Project, GeoThermal Regulation – Heat.
[8] Goodman et al., 2010. GTR-H - Geothermal Legislation in Europe. Proceedings World Geothermal Congress 2010 Bali, Indonesia, 25-29 April 2010.

1 Introduction

Geothermal energy is energy stored in the form of heat beneath the Earth's surface. The Earth contains huge amounts of thermal energy that were generated during its formation. The temperature of the Earth decreases from the core to the surface as heat flows upwards by convection and conduction (Figure 1). Heat is also generated in the Earth's crust as a result of the decay of radioactive elements, particularly isotopes of uranium, thorium and potassium. Additionally the local intrusion and extrusion of igneous rocks can significantly increase heat flow, and in volcanic areas of the world (e.g. Iceland, Italy, Turkey, and Indonesia) very high temperatures, hot enough to be able to produce electricity, are found at shallow depths of a few hundred metres.

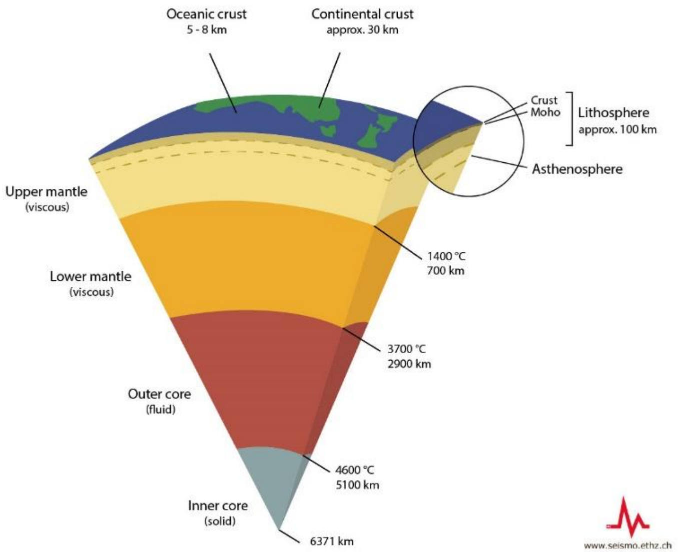


Figure 1 Variation of temperature with depth in the Earth shown as a cross section from the core to the crust.[9]

However, even in non-volcanic regions such as Northern Ireland, the lower temperature crust still retains significant geothermal energy, and rocks at a few kilometres depth can contain hot water, which can be pumped to the surface and used to provide direct heating or for district heat networks. Where there is a suitable geothermal gradient hotter resources at greater depth may be accessible and have the potential to be used for small-scale power generation (Table 1), but the cost of deep drilling is often prohibitive.

Temperature range	**Application**
Deep Geothermal (>~500 m depth)	
Above ~100 ℃	Combined heat and power (CHP), electricit generation (> 2.5 km depth)
65 ℃ - 120 ℃	Direct heating/heat networks (2–3 km)
30 ℃ - 50 ℃	Thermal spas, horticulture, heating/cooling farms (1–1.5 km)
Shallow Geothermal (2–~500 m depth)	
10 ℃ - 20 ℃	Heating and cooling, using heat pumps

Table 1 Deep and shallow geothermal energy resources, temperatures and use, in non-volcanic regions.

At very shallow depths (< 10 m) the lower temperatures are influenced by ambient air temperature at the ground surface and energy is replenished by solar radiation and the movement of groundwater. In countries with temperate climates such as Northern Ireland there may be considerable seasonal variation in air temperature, with monthly average temperatures ranging from about 3 ℃ in January to 16 ℃ in July and daily maxima and minima

[9] SED | Geothermal Energy in brief (ethz.ch)

showing an even greater range. Because of the ability of soil and rock to absorb and store heat, the subsurface temperatures do not fluctuate to the same degree and become relatively stable at depths of a few metres (Figure 2). In Northern Ireland the subsurface temperature at about 10 metres depth is usually in line with the mean annual soil temperature which has the range 10.5–11.4 ℃[10]. Irrespective of depth and temperature, geothermal energy is characterised by its low carbon intensity, sustainability, reliability, and deliverability. Geothermal systems deliver energy 24 hours a day and 365 days a year in contrast to the variability in supply from other renewable energy sources such as wind, solar and tidal energy.

Depending on the temperature and size of the resource the end use for geothermal energy can be very varied as illustrated by Table 1 and Figure 3.

The amount of energy that can be extracted from deep geothermal resources can be increased through the use of cascaded applications whereby the output temperature from one system can be used in another lower temperature application.

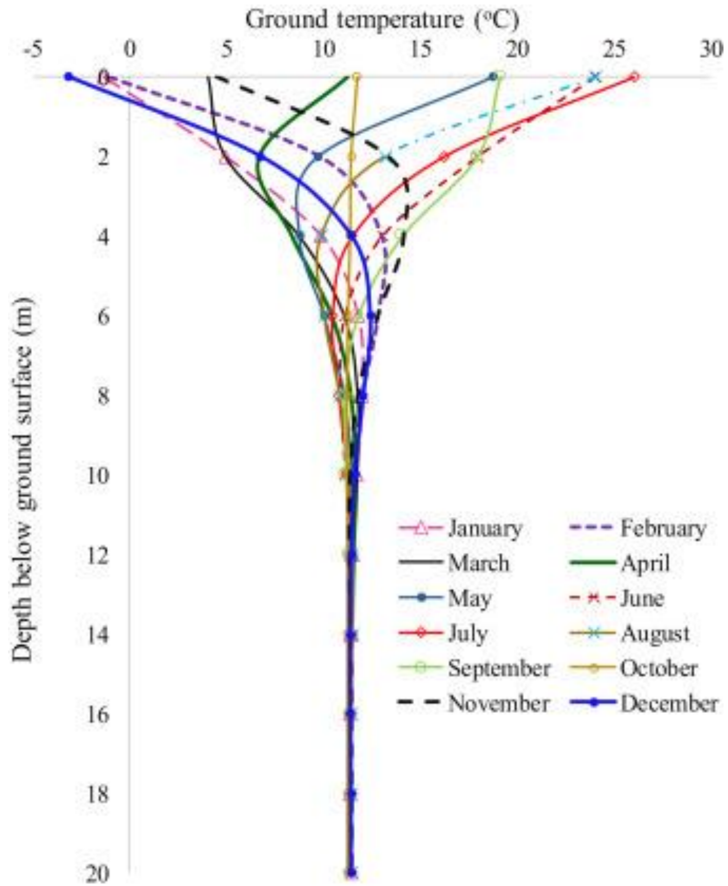


Figure 2. Seasonal variation in average monthly subsurface temperatures with depth for the south of England.[11]

[10] Busby, 2015. UK shallow ground temperatures for ground coupled heat exchangers. Quarterly Journal of Engineering Geology and Hydrogeology, 48, 248-260.
[11] Sani et al., 2019. A review on the performance of geothermal energy pile foundation, its design process and applications. Renewable and Sustainable Energy Reviews, 106, 54–78.

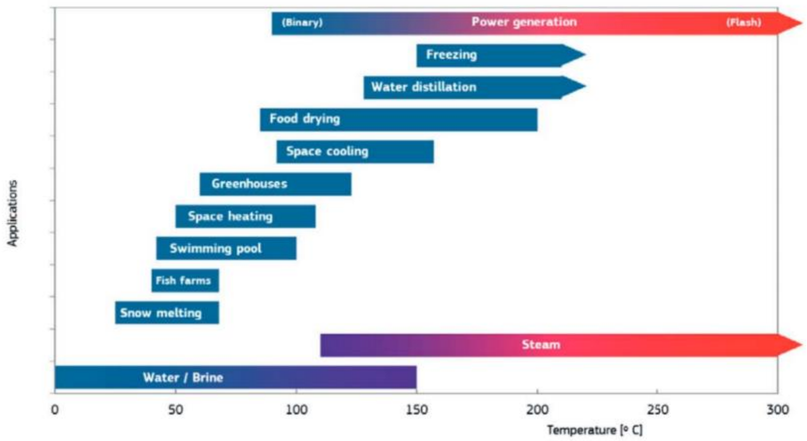


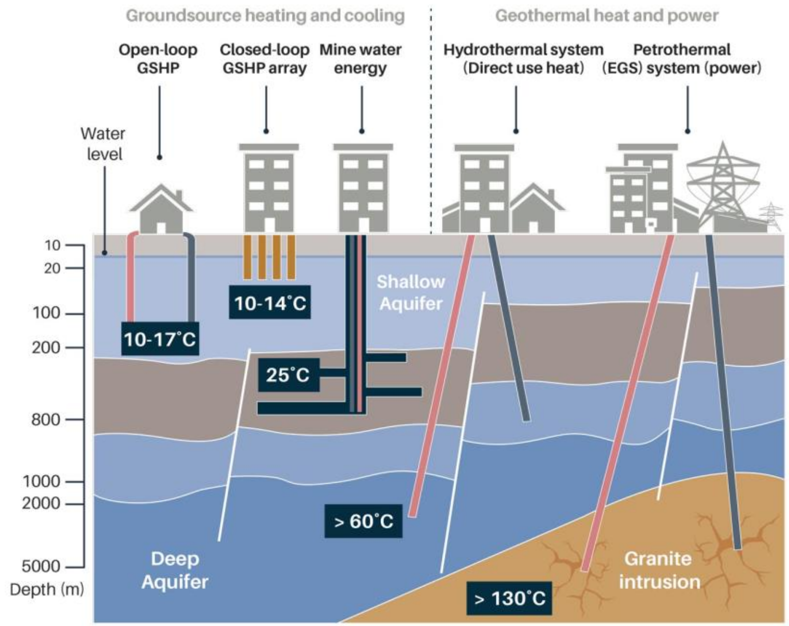
Figure 3. A Lindal diagram of temperature of geothermal water and steam suitable for various applications. Power generation can comprise binary cycle power plants (transferring heat to another liquid) and flash steam plants.[12]

2. Geothermal Systems

Geothermal energy resources in Northern Ireland can be divided into five categories based on a combination of factors such as depth, temperature, geological setting, geographical distribution, cost and complexity of the enabling technology and end use applications (Figure 4).

- Horizontal and vertical closed-loop Ground Source Heat Pump (GSHP) systems (low temperatures, heat pumps)
- Shallow aquifer open-loop heating and cooling (low temperature, heat pumps)
- Mine water energy (low temperature, heat pumps);
- Hot Sedimentary Aquifers (mid to relatively high temperature, direct heat); and
- Hot Dry Rocks / Engineered Geothermal Systems (high temperature, electricity and Combined Heat and Power).

The first three categories may be termed shallow geothermal whereas the second two are sources of deeper geothermal energy (Figure 4). There is no widely accepted single depth or temperature that defines where 'shallow' ends and 'deep' begins but this may be between 200 to 500



metres depth, depending on local geology.

Figure 4. Geothermal energy resource types and settings.[13]

[12] Carrara et al., 2020. Geothermal Energy Technology Development Report 2020, EUR 30508 EN, Publications Office of the European Union, Luxembourg.
[13] Abesser et al., 2020. Unlocking the potential of geothermal energy in the UK. Nottingham, UK, BGS, 22pp. (OR/20/049) (Unpublished).

3. Geothermal Technologies

There are a number of technologies available to access geothermal energy at different depths and in different settings. Technologies employed in the direct use of geothermal (e.g district heating, geothermal heat pumps, greenhouses) are widely used and can also be considered mature. These are particularly applicable in Northern Ireland, based on the temperature of the geothermal resource.

3.1 Closed-loop GSHPs

Closed-loop systems involve the circulation of a fluid through a closed pipe network, installed in either a horizontal or a vertical arrangement. The heat energy extracted from the ground is raised to the required temperature by the heat pump. The heat pump system can be reversed during the summer to provide cooling when the subsurface temperature is cooler than the air temperature.

Although shallow subsurface temperatures are much lower than those required for domestic space heating, GSHPs are an efficient means of upgrading this low heat to achieve the required temperature and are a proven and reliable technology when correctly installed. These geothermal resources are local and can be used at source below or beside the buildings for which they provide heating and cooling (Figure 5).

Horizontal closed-loop systems are buried at depths of 1.5–2 metres, whereas vertical loop systems may be installed in boreholes 70–200 metres deep or even in underground infrastructure such as concrete piling (Figure 5). Horizontal systems need a larger space whereas vertical systems can be drilled in relatively confined areas and occupy a very small footprint. While the heat pump itself may require maintenance and eventual replacement, as with oil or gas boilers, the collector system buried in the ground requires little maintenance and has a much longer life-span.

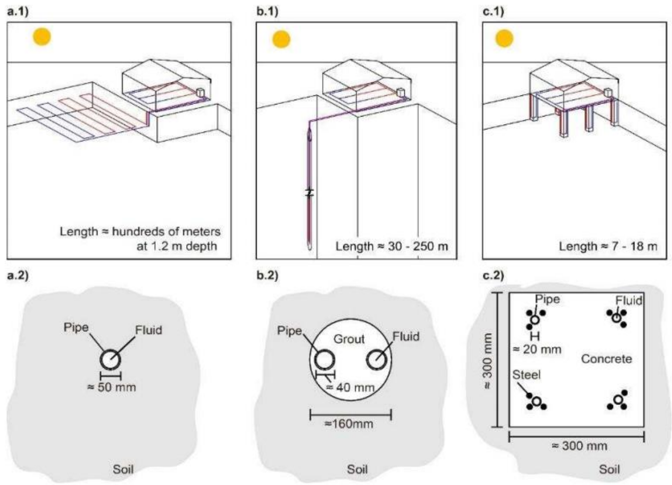


Figure 5. Closed-loop ground source heat pump systems. A) Systems based on horizontal heat exchangers. B) GSHP system based on vertical borehole heat exchangers. C) GSHP systems based on pile heat exchangers. Cross sections of the heat exchanger pipes are shown beneath.[14]

Closed-loop systems can be used for single dwellings, groups of buildings or can be used in an array for larger heat requirements of larger commercial premises. Borehole heat exchangers allow the boreholes to be used for both heating and cooling via a heat pump. This is a process sometimes called Borehole Thermal Energy Storage (BTES) and the liquid, carrying thermal energy from

[14] Alberdi-Pagola, et al., 2018. Comparing heat flow models for interpretation of precast quadratic pile heat exchanger thermal response tests. Energy, 145, 721 –733.

sources including the ambient air, solar energy and process waste heat, can either store or discharge thermal energy into or out of the bedrock.

A good example of a large closed-loop installations are the network of boreholes installed in 2008 beneath the carpark at the 32,000 m^2 Dublin IKEA store, which at the time, was the largest closed loop system in Europe. Another example of is the horizontal collector installed at the Cliffs of Moher Visitors Centre which provides simultaneous heating and cooling through 5,850 m of pipe in 39 trenches below the car park. A closed-loop, forty borehole array is, at the time of writing, being installed at Riddel Hall, Queen's University Belfast.

The underground elements of shallow geothermal systems can be expected to last up to 50 years while the other parts of the system have a reasonable life expectancy of 15–25 years[15]. GSHP systems can provide an efficient way of decarbonising heat in individual dwellings, large buildings and small housing developments. GSHPs typically have Seasonal Performance Factors (SPF) of 3.5 or higher, therefore, they can play a role in reducing the GHG emissions from heating and cooling systems. The SPF means that they output 3.5 units of heat energy for every 1 unit of electrical energy input, and when the electricity input is produced from renewable sources, GSHP systems become a very low carbon option for heating and cooling purposes as this SPF does not vary seasonally unlike other heat pumps.

3.2 Open-loop Heating, Cooling and Thermal Storage

Open-loop geothermal technology uses groundwater in shallow aquifers or within the flooded voids of disused mines along with heat pumps and heat exchanger to provide heating or cooling needs or to store heat or cold. A form of this technology, called Aquifer Thermal Energy Storage (ATES) utilises a groundwater heat pump and the aquifer to store warmth or cold in the groundwater (Figure 6). There are around 3000 ATES systems worldwide, with most systems (2500) located in the Netherlands[16]

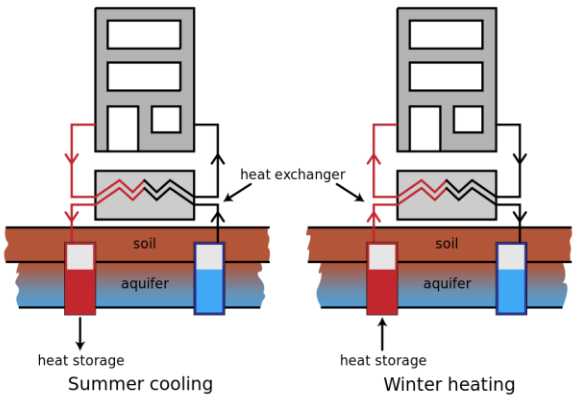


Figure 6. ATES for cooling and heating during summer and winter, respectively.[17]

Water in flooded mine workings can be used in a similar way for heating, cooling and thermal storage. The

[15] Ground source heat pump (energyagency.org.uk)
[16] Fleuchaus et al., 2018. Worldwide application of aquifer thermal energy storage – a review. Renewable and Sustainable Energy Reviews, 94, 861–876.
[17] https://commons.wikimedia.org/wiki/File:HeatAndColdStorageWithHeatPump.svg

advantage of using heat from flooded mine workings being that although the water is relatively cool, large amounts of water are readily available – making it easy to extract heat using heat pumps (Figure 7) – and therefore the efficiency of these systems is potentially higher (reported COP of 5–7[18]) and the costs lower.

The potential to use mine water for heating and cooling has been well demonstrated in Heerlen in the Netherlands, where in 2015, the scheme had CO_2 emission reductions of 65 % for heating and cooling of buildings covering 500,000 square metres.[21] Further emissions savings in the project can be achieved by increasing the renewable contribution of the electricity used in the heat pumps.

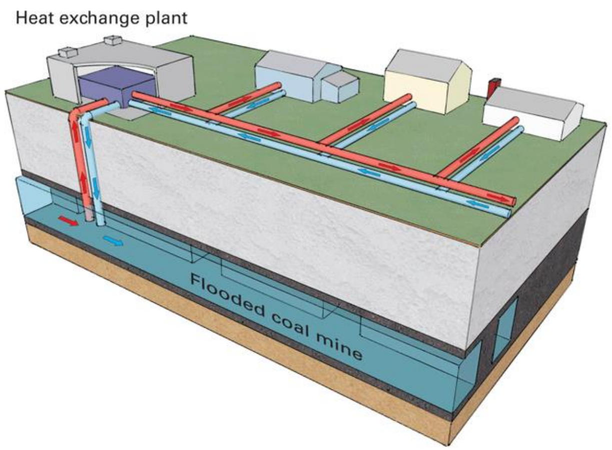


Figure 7. Diagram showing the use of water from a flooded coal mine to heat and cool a district. The heat pump cycle uses refrigerant to extract heat from the mine water, which goes to the exchange plant to provide heat to buildings. The system works in reverse to provide cooling.[19]

3.3 Geothermal doublets and heat plants

Deep geothermal resources in porous and permeable rocks in the order of 1 to 3 km depth (depending on the geothermal gradient), generally contain fluids that can be accessed via drilling a pair of wells (doublet) to provide heat for horticulture and district heat networks. This uses a heat exchanger in a geothermal heat plant to extract the heat from the geothermal fluid before it is returned to the reservoir (Figure 8) this extracted heat is distributed through a heat network.

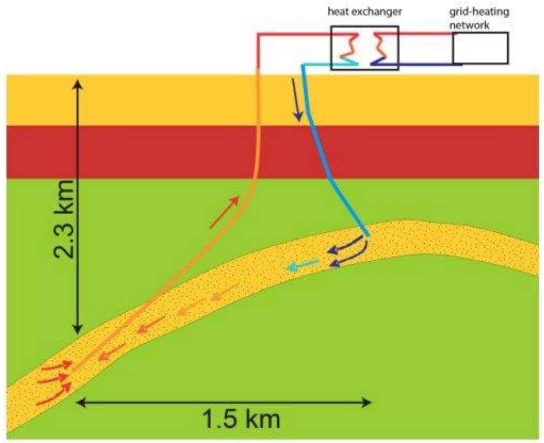


Figure 8. Schematic view of a geothermal doublet for production of geothermal energy. A deviated well is used to produce water with a temperature of 65-75 °C from the aquifer. At the surface heat is extracted by a heat exchanger to a local grid to sustainably heat buildings and greenhouses. A second well reinjects the cooled-down aquifer water into the same reservoir away from the production point.[20]

[18] Verhoeven et al., 2014. Minewater 2.0 project in Heerlen the Netherlands: transformation of a geothermal mine water pilot project into a full scale hybrid sustainable energy infrastructure for heating and cooling. Energy Procedia, 46, 58–67.
[19] https://www.solar.sheffield.ac.uk
[20] Donseaar et al., 2015. Reservoir Geology and Geothermal Potential of the Delft Sandstone Member in the West

These geothermal heat plants and heat networks are mature and widespread technologies and used extensively in the Netherlands for greenhouses and in France and Germany for urban heat networks. Munich, a city more than twice the size of Belfast, intends to meet all of its heat demand from geothermal heat networks by 2040[21].

The operational life span of deep geothermal systems is more variable than for shallow installations, but typically, geothermal heat plants operate for many decades. The Southampton geothermal plant has been producing heat since 1987[22] and a deep geothermal doublet in Paris has been producing heat for over 30 years, with plans for a new well that will be exploited for a minimum time period of 70 years[23].

3.4 Geothermal power plants

For areas that have high geothermal temperatures near the surface (volcanic regions), the technology for electricity generation from these hydrothermal reservoirs is mature and reliable, having been utilised commercially since 1913[24]. Many geothermal power plants in operation today are dry steam plants or flash plants (Figure 9) harnessing temperatures of more than 180 °C.

Medium temperature geothermal resources are becoming increasingly accessible for electricity generation or for combined heat and power due to the development of binary cycle technology, in which geothermal fluid is used via heat exchangers to heat a process fluid in a closed-loop (Figure 9).

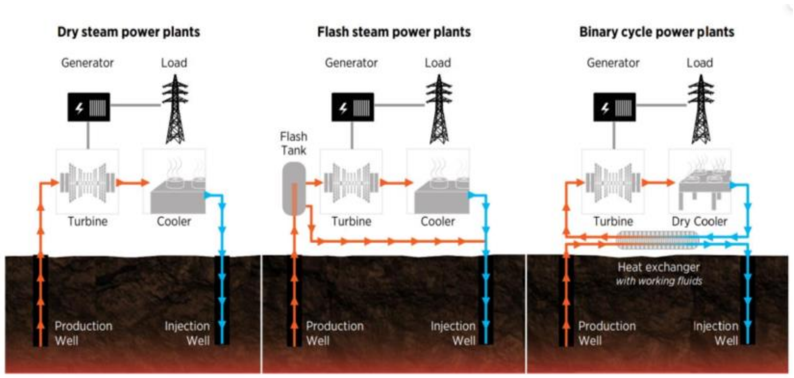


Figure 9. Dry steam, flash steam and binary cycle power plants[25]

3.5 Engineered Geothermal Systems

New technologies are being developed like Enhanced Geothermal Systems (EGS), which currently are at the demonstration stage.

The heat energy can be extracted by means of Engineered Geothermal Systems (EGS) whereby cold water is pumped down one borehole and hot water extracted from another borehole (Figure 10). The water can move from the injection hole towards the extraction hole through a network of connected open fractures. The injection of water under high

Netherlands Basin. Proceedings World Geothermal Congress, Melbourne.
[21] Aiming for Climate Targets, Germany Taps Its Geothermal Potential - Yale E360
[22] gt-southampton-uk-uk1.PDF (geothermalcommunities.eu)
[23] Hofmeister and Baastrup Holm, 2014. Geo-DH: D4.2 Business models on Geothermal DH systems.
[24] Lund 2005. 100 Years of geothermal power product. Proceedings, Thirtieth Workshop on Geothermal Reservoir Engineering. Stanford University.
[25] U.S. Department of Energy 2019. GeoVision.

pressure is often used to enhance the connectivity of a pre-existing natural fracture network. At depths of 4–5 kilometres these EGS could typically yield water at temperatures between 100 to 200 ℃, and at these temperatures, electricity can be produced.

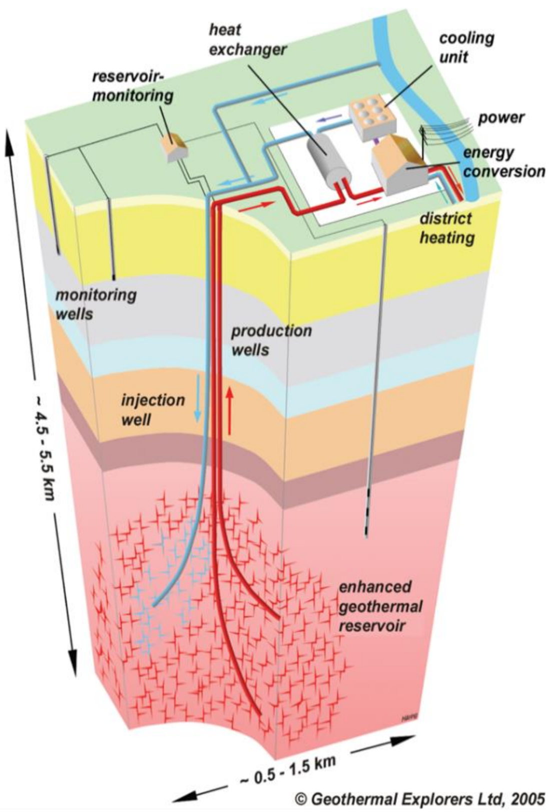


Figure 10 Diagram illustrating the EGS concept.[26]

EGS projects have been developed in several countries but, as yet, none can be considered to be fully commercial. In Cornwall, where the highest geothermal gradients in the UK have been measured and the EGS potential of the granites were evaluated in the 1980s, there are two active projects at United Downs and the Eden Project. The former has drilled two boreholes into a near vertical water-bearing fracture system, with a production (abstraction) well down to about 5.2 kilometres and an injection well to 2.4 km depth. Hot water will be pumped up the production well to the surface and used to generate electricity before the cooled water is reinjected into the shallower hole.

This returned water will be heated up as it percolates down through the fracture zone towards the production area so that the resource can sustain production for many years. Pumping tests at United Downs carried out in September–November 2020 produced geothermal steam at 175 ℃ and waters from the deepest well at approximately 180 ℃ will be pumped to generate approximately 3 MW(e) of power to the National Grid by 2022. There are plans for utilisation of an additional 12.5 MW(t) of heat.

[26] Geothermal Explorers Ltd. 2005. Schematic representation of the classical UGS design.

4 Shallow Geothermal Resource Potential in Northern Ireland

Shallow geothermal systems use heat pump technology to provide heating or cooling requirements by extracting heat from or transferring heat to the shallow subsurface. Heat pump technology is well established, and it has been widely applied in shallow geothermal energy systems in many European countries. In 2020 there were about 2.1 million Ground Source Heat Pump (GSHP) systems in operation in Europe, with an installed heating capacity of about 27 GW(th)[27]. Other heat pump systems, using ambient conditions (air pumps, water pumps etc.), are more common, largely because of cost and ease of installation, but have significantly lower SPFs (Seasonal Performance Factors) which reduce their carbon emission savings when compared to GSHPs.

The shallow geothermal heat resource beneath Northern Ireland can be considered in terms of three main geological settings and types of deployment (outlined below):

- closed-loop GSHP systems (either horizontal or vertical), (heating and/or cooling).
- shallow aquifer open-loop systems (heating and/or cooling, aquifer thermal energy storage).
- mine water energy (heating and/or cooling, thermal energy storage).

4.1 Closed-loop Ground Source Heat Pumps

Horizontal closed-loop systems are usually installed in the shallow subsoil (unconsolidated sediment) due to the ease of excavation. These sediments have been mapped in detail across Northern Ireland by the Geological Survey of Northern Ireland (GSNI). There are relatively few empirical thermal conductivity measurements and so an assessment of the potential across NI is currently limited to deriving likely thermal conductivity values from the mapped distribution of sediment types and published thermal conductivity values (Figure 11).

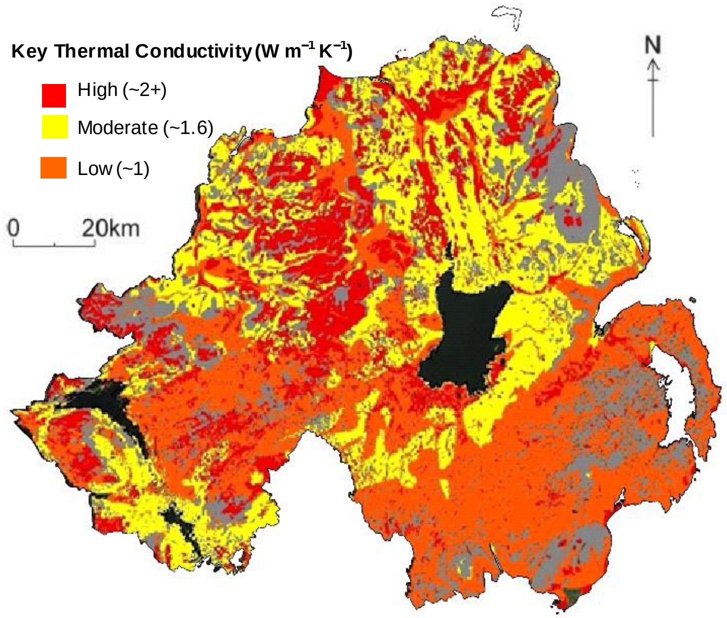


Figure 11. Predicted average thermal conductivity of superficial sediments based on GSNI superficial geology map at 1:250,000 scale. Grey colour marks rock mapped at or near surface. Produced by M Kerr.

[27] EGEC, 2021. 2020 EGEC Geothermal Market Report – Key Findings.

Vertical systems at times may pass through both the superficial sediments and into the underlying bedrock and so require geological data on both.

The simplified bedrock geology of Northern Ireland (Figure 12) can be divided into four regions. Two areas (1 and 2 on Figure 12) comprise many rock types that have very low permeability and act as very low productivity aquifers (except in the vicinity of local fracture zones) and underlie much of the northwest and southeast of NI.

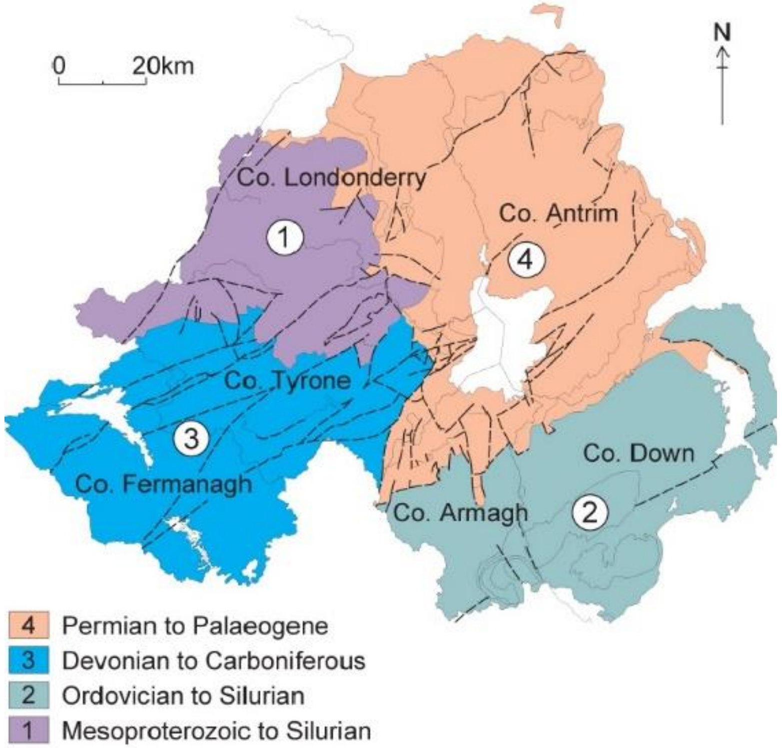


Figure 12. Major geological regions of Northern Ireland – the older rocks in areas 1 and 2 contain mostly low productivity aquifers whereas areas 3 and 4 contain some high productivity aquifers.

Whilst the rocks in these areas may be less favourable for open-loop-systems, they commonly offer good potential for closed loop systems due to their high thermal conductivity and so, at most locations shallow geothermal of some kind can be accessed.

4.2 Shallow Aquifer Open-loop Systems

Aquifers are bodies of permeable rock or sediment that may contain significant quantities of groundwater and this water can be used as the conductive fluid in a GSHP system. In Northern Ireland shallow aquifers are primarily located in the near surface sediments (glacial sands and gravels) or in bedrock (sandstones, limestones etc.).

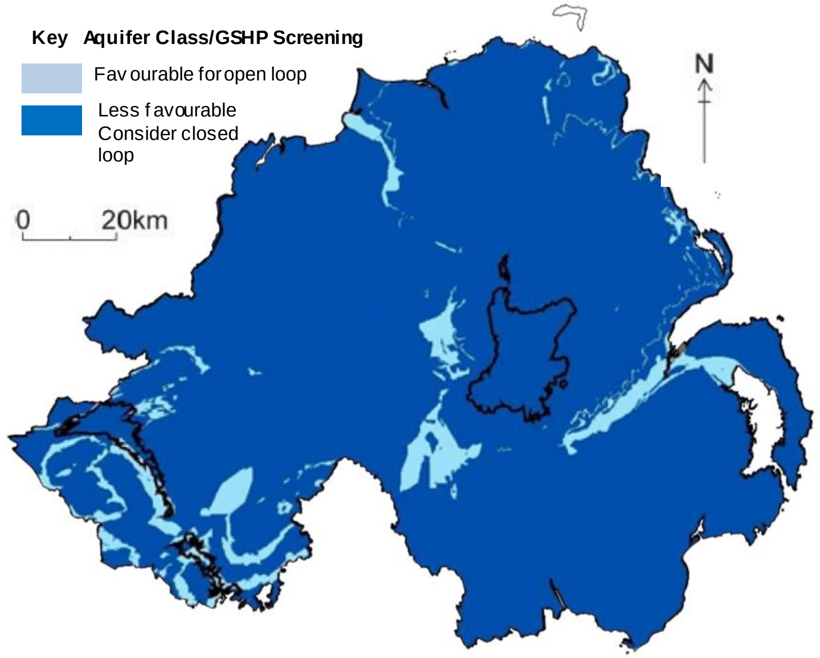


Figure 13. Aquifer class/GSHP screening map (heating and cooling output >100kW). Produced by M Kerr using GSNI Data.

The sandstones and limestones that form the bedrock in parts of the northeast and southwest of Northern Ireland (3 and 4 on Figure 12) often act as high productivity aquifers and would be suitable for the operation of open-loop GSHP systems for heating, cooling or as aquifer thermal energy storage (ATES) (Figure 13). It should be noted that the map displays only the surface extent of permeable rock units and many of these aquifers are present below other rock units at relatively shallow depth, thus extending the area available significantly.

The Sherwood Sandstone Group (SSG) is the most productive bedrock aquifer in much of the Lisburn, Greater Belfast and Newtownards areas (Figure 14) (population of ~354,000 in 2011). The same sandstones also underlies Carrickfergus, Newtownabbey, Craigavon, Lurgan, Portadown, Coalisland, Magherafelt, Maghera and Coleraine (combined population of ~197,000 in 2011) at depths to the top that are modelled to be less than 500 m making those towns prospective for shallow open-loop geothermal.

Figure 14 shows the area of SSG outcrop in the Lagan Valley and the area of SSG where the top of the unit is expected to be no more than 500 metres below surface. It can be seen from this map that the SSG underlies much of Belfast and Lisburn. In this area groundwater has been extracted from the SSG both historically (e.g. for mineral water production, distilleries, laundries, textile manufacture, flour mills and Lisburn public water supply) and more recently (e.g. Coca Cola, craft breweries and distilleries, mineral waters). In the last ten years several local hospitals (Royal Victoria, City, Ulster) have abstracted water and installed GSHP systems for heating and cooling. Other notable open-loop systems have been installed at the Lyric Theatre and the new School of Biological Sciences, Queen's University Belfast.

There is potential for much greater use to be made of the SSG for heating, cooling and energy storage using GSHP open-loop systems across Belfast and in other towns and cities across Northern Ireland. The optimum use of the subsurface for geothermal in urban areas will require planning and effective licencing.

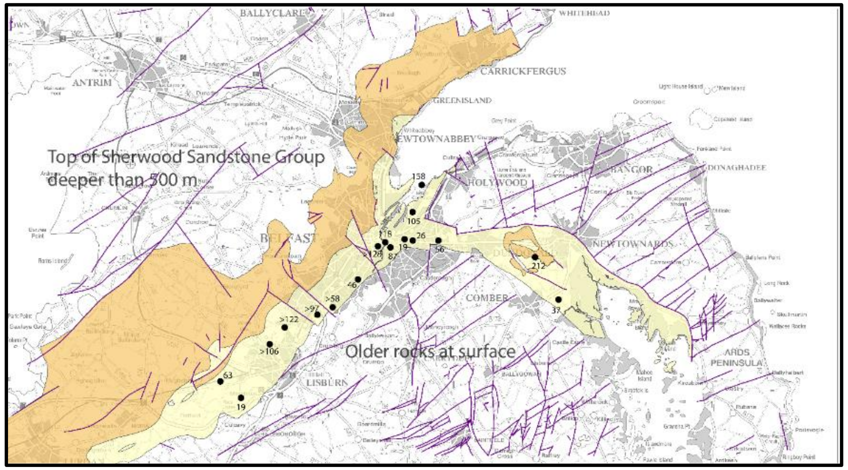


Figure 14. Geological map showing Sherwood Sandstone group in the Lisburn, Greater Belfast and Newtownards areas. Surface extent is marked by light yellow colour, with orange shading showing where the top of the SSG is predicted to lie below younger rocks at depths less than 500 metres. Faults are represented by purple lines. Black dots mark locations of boreholes, with the numbers representing known thickness. Many of the boreholes have not penetrated the full thickness of the sandstone, which is known from nearby boreholes at Kilroot to be ~485 m thick.

4.3 Mine Water Energy

Abandoned mines typically contain voids (mined-out beds or seams) which are often partially or completely flooded with water. One quarter of the UK's population live above abandoned coal mines and these abandoned coal mines in the UK present an enormous opportunity to the UK as a source of geothermal energy.

In the Midland Valley of Scotland, Midlands and north of England, and in South Wales, where there are very extensive disused coal mine workings, the potential to tap the heat energy in the water has been recognised and is currently being evaluated.[28] There are a number of projects currently at the funding or inception stage that seek to utilise this source of geothermal energy for heat. In GB, coal mines are managed by the Coal Authority, however, in Northern Ireland, The Department for the Economy owns and monitors all abandoned mines, including coal mines. Historical mine plans can be accessed online. [29]

In Northern Ireland there are a number of historic mining districts where minerals have been extracted (Figure 15). Although there has been no detailed assessment of the potential for abstraction of heat from flooded disused mine workings in Northern Ireland some preliminary observations can be made from the available information.

There are two historic coal mining districts in Northern Ireland, at Ballycastle and in East Tyrone (Dungannon–Coalisland) (Figure 15), where disused workings are likely to contain flooded voids. Many of the coal seams in Tyrone are found at the surface and were worked at surface and in underground mines at depths of about 50–330 metres.

The coal seams varied in thickness and, in some places, old workings are likely to have been backfilled with mining waste such that the extent and volume of any remaining flooded mine voids is unknown. However, flooded voids are to be expected because, for example, there are a number of historic coal mines in the Dungannon coalfield that are recorded as being abandoned after the influx of water.

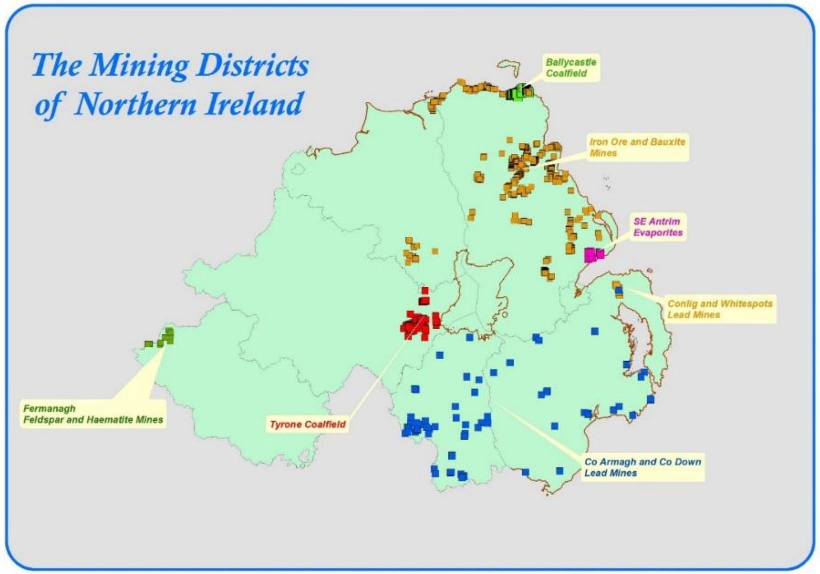


Figure 15. Historic mining districts in Northern Ireland (GSNI).

In the Ballycastle coalfield much of the mining was carried out by means of adits (sub-horizontal tunnels) driven in along the main coal seam from the coast where they

[28] Farr et al., 2020. The temperature of Britain's coalfields. QJEGH, 54.
[29] http://www.geologicalmaps.net/irishhistmaps/mine_plans.cfm

terminated against a major geological fault. Such workings, although known to contain water, are unlikely to have much geothermal energy potential because of their shallow depth. A short distance inland, at Ballyvoy, some mining was carried out by means of vertical shafts sunk into the coals and these workings may contain horizontal water-filled voids at greater depth, with more potential.

For mine water energy projects to be successful they require a sufficient heat demand and the heat extracted does not transport. It is therefore clear that Northern Ireland does not have the same potential for the extraction of heat from abandoned coal mines as areas in northern England and Scotland because the coalfield areas are not underlying major urban populations. In comparison, the workings are smaller, with thinner coal seams that were worked, many of which may have been backfilled. Nonetheless, from the available information (geological records, abandoned mine plans etc.) it can be concluded that there are some areas – particularly in the East Tyrone coalfield - that merit further investigation. Low-cost geophysical surveys, followed by a small number of targeted boreholes would allow an assessment of the resource to be made. Test drilling would help to determine areas that are backfilled vs those containing water-filled voids and to understand the temperature and chemistry of the water in these workings.

Many of the other historic mining districts in Northern Ireland are small in scale (e.g. lead mining) or involve very near-surface workings (e.g. Antrim iron ore and bauxite). The exception to this is the salt mining district of south County Antrim (Carrickfergus area) where there are known to be a number of water-filled voids at depths of 100–300 metres. However, there are practical difficulties with extracting heat from these flooded mines as the areas above these mines are liable to subsidence and the mines are flooded with brines which can be highly corrosive to metal pipework.

5 Deep Geothermal Energy Resource Potential in Northern Ireland

5.1 Hot Sedimentary Aquifers (Hydrothermal Resources)

The largest and most conductive aquifers generally occur in accumulations of sedimentary rocks, and many of these that are hot enough, and with sufficient productivity to constitute a potential geothermal resource, can be termed a Hot Sedimentary Aquifer (HSA). HSA resources are likely to exist, in general, down to depths of around 4 km, and most will yield water in the temperature range 30 to 120 ℃.

The hot water can be used for heating, either directly or indirectly (by heat exchange). Depending on the temperature of the resource, additional temperature requirements can be met through renewable fuel boilers in Combined Heat and Power Plants (for district heating) or boosted by heat pumps for smaller scale heat networks where the reservoir temperature is not hot enough. The use of the water can be cascaded, thereby increasing the efficiency of the system.

Much of Northern Ireland is underlain by relatively impermeable rocks, which have no HSA potential. However, there are two areas – the southwest and the northeast (areas 3 and 4 in Figure 12) – where sedimentary aquifers are thought to have HSA potential.

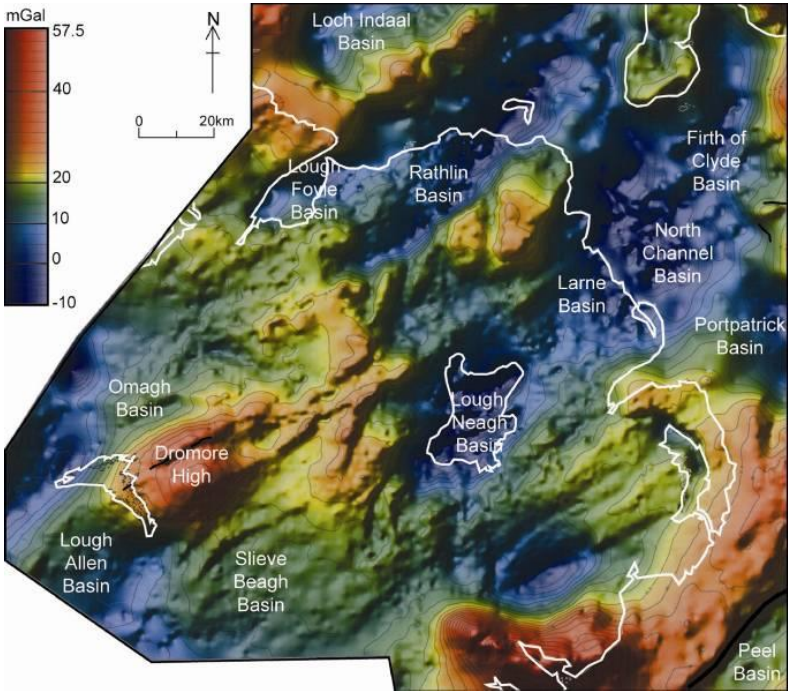


Figure 16. Sedimentary basins in Northern Ireland containing potential geothermal aquifers – the Rathlin, Lough Neagh and Larne basins in the northeast and the Lough Allen and Slieve Beagh basins in the southwest. Areas of thick low density sedimentary rocks are generally picked out by blue colours on this gravity anomaly map.[30]

In County Fermanagh, the Lough Allen sedimentary basin (Figure 16) contains both limestones and sandstones. Although the sandstones are usually characterised by low permeabilities, the limestones are locally highly productive aquifers in areas where karstic weathering has produced a well-developed network of open fractures. There are two main limestone units, the Dartry Limestone (upper) and the Ballyshannon Limestone (lower). Historical exploration boreholes have proven that the Dartry Limestone can be as deep as 500 metres at its base (although it is usually much shallower than this) and the Ballyshannon Limestone can reach depths of 1200 m (top) to 1500 m (base). At these depths formation water may be approximately 20 ℃ in the Dartry Limestone and 40–50 ℃ in the Ballyshannon Limestone (extrapolated from borehole temperature measurements at greater depths). The limestone aquifers in Co. Fermanagh may therefore have some potential for low-temperature direct use applications (e.g. agri-food sector, such as dairies, brewing, distilling and food processing) or for space heating and cooling using heat pumps. However, further investigations would be needed to enable modelling of this potential and of the effects of geothermal systems on the aquifers. Most karst systems are characterised by sinks, where surface water infiltrates down through the rocks and springs where water emerges from the rocks. In between, the groundwater can flow rapidly through karstic cave and fracture systems. This underground drainage system responds rapidly to periods of rainfall and it can be difficult to pump water out of the aquifer at the consistent rates needed for either water supplies or open-loop GSHP systems. At greater depths, where the limestones may be saturated with groundwater, this is unlikely to be a problem but it is not yet known whether karstic features are well-developed at these depths.

In the northeast (Figure 12, area 4) the bedrock geology is dominated by basalts of the Antrim Lava Group (ALG) which form a surface layer ranging from 100 metres to over

[30] Carruthers, et al, 1997. Regional Interpretation of Gravity and Aeromagnetic Data from Northern Ireland. BGS Technical Report WK/96/05/C.

750 metres thick across a wide area. Basalt is generally impermeable but the ALG is faulted and fractured in places, and these fractures provide both storage space and conduits for water to flow through so that, in places, the basalts are locally important aquifers which could be used for shallow geothermal systems in places. The Cretaceous Ulster White Limestone (chalk) forms a thin layer beneath the basalts and it is typically classified as a highly productive aquifer, again characterised by fracture flow.

More prospective older sedimentary rocks form a fringe around the margins of the basalt outcrop and these rocks are known to fill deep sedimentary basins (Figure 16 – Rathlin, Lough Neagh and Larne basins)[31]. Ranging in age from early Jurassic to Permo-Triassic, there are thick sequences of mudstones and sandstones, with salt beds in the Larne–Carrickfergus area. Older Carboniferous rocks, including sandstones, are preserved beneath the Permo-Triassic in some places, particularly in the Rathlin Basin. The main bedrock aquifers are, in order of increasing age and depth, the Triassic Sherwood Sandstone Group, Upper Permian sandstones, Lower Permian sandstones and Carboniferous sandstones[31].

The Sherwood Sandstone Group is a regionally important aquifer which extends from NI to England, the southern North Sea and the Netherlands. In the Netherlands it is used as a geothermal aquifer in open-loop direct heating systems to provide heat for large-scale horticulture and space (building) heating. In Northern Ireland the Sherwood Sandstone Group aquifer lies at shallow depths directly below the superficial sediments in central Belfast and the Lagan Valley but deepens to the north and west. Based on interpretation of geological and geophysical data the Sherwood Sandstone Group may be around 1000 metres deep in the area north of Belfast, a depth which would equate to temperatures of about 45 °C (Figure 17).

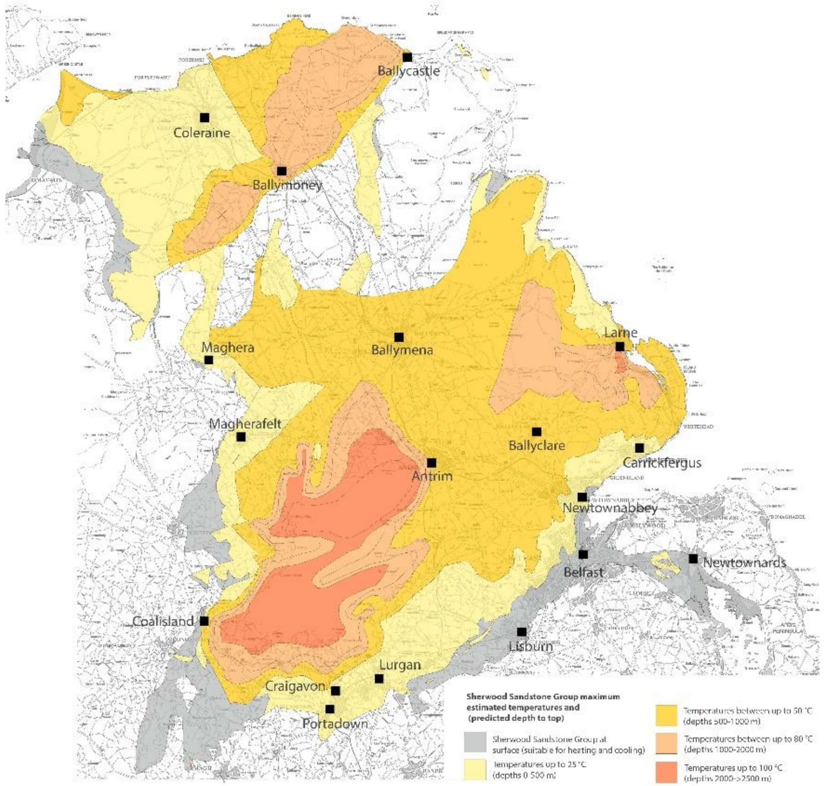


Figure 17. Predicted depth to top Sherwood Sandstone colour coded to show indicative temperature estimates based on the geothermal gradient[32]. Full-size map is included in Annex 1.

[31] Raine and Reay, 2019. A review of geothermal reservoir properties of Triassic, Permian and Carboniferous sandstones in Northern Ireland. Belfast, UK, Geological Survey of Northern Ireland, 59pp. (INTERNAL REPORT 19/EM/01) (Unpublished).
[32] Raine et al., 2020. The Sherwood Sandstone Group as a potential geothermal aquifer across Northern Ireland. Irish Geological Research Meeting (IGRM) 2020. (Unpublished).

The Sherwood Sandstone reaches depths of more than 1800 metres in boreholes drilled further into the sedimentary basins and modelling of geophysical data indicates that it should extend down to beyond 2000 metres in the deepest parts of these basins (Figure 17). Underlying this lie Permian and Carboniferous rocks at greater depth and at greater temperatures. Distribution of these sediments is more uncertain than that of the Sherwood Sandstone and the internal distribution of permeable sandstones within the successions is not well known in the subsurface due to the limited number of well penetrations. The good reservoir quality of these sediments has been documented.[31]

5.2 Hot Dry Rock (Engineered Geothermal Systems)

The term Hot Dry Rocks (HDR) was originally coined to describe crystalline rocks (e.g. granites) that would not normally be thought of as water-bearing rocks, but exhibit higher than usual temperatures at depth because they contain relatively high concentrations of radioactive elements such as uranium and thorium. The natural decay of these elements releases heat into the rocks and raises their temperatures. The development of EGS technology is opening up new geothermal resources and areas.

In Northern Ireland the granites of the Mourne Mountains are known to contain anomalously high amounts of radioactive uranium and thorium and can be classed as High Heat Production (HHP) granites (Figure 18). As such, the Mournes might be an attractive EGS target although its EGS potential is compromised by the difficulty of developing an EGS facility in a relatively remote area and an Area of Outstanding Natural Beauty. From a scientific viewpoint, geophysical evidence indicates that the granite is underlain by denser, less radiogenic rocks and the volume of the granite intrusion may not be sufficient to produce an adequate heat source for a sustainable EGS.

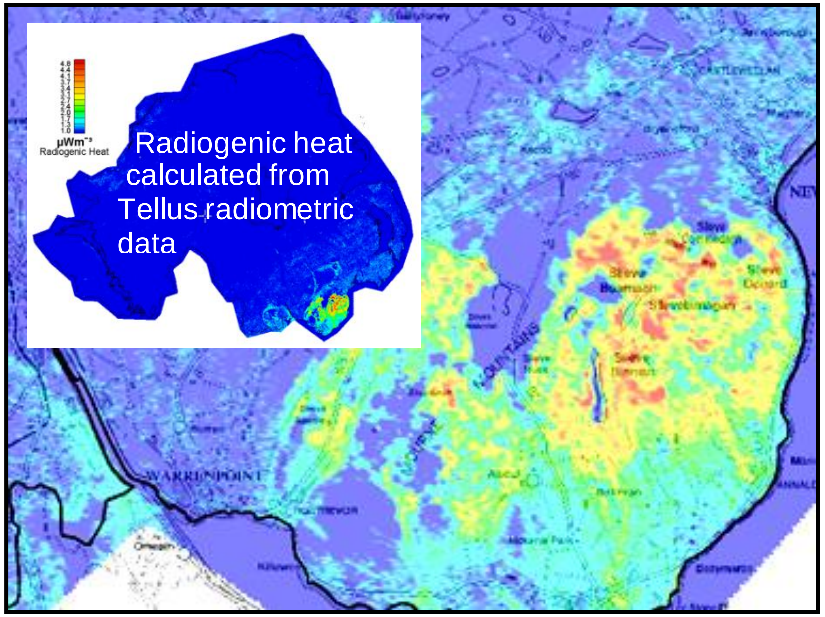


Figure 18. Map showing elevated radiogenic heat production calculated from airborne radiometric surveys flown over the Mourne Mountains. Inset map shows that the Mournes are anomalous within Northern Ireland[33]

The Tellus airborne geophysical surveys show that the Mourne granites are unique in Northern Ireland in exhibiting a high radiometric signature. However, the Tellus

[33] Ture et al., 2016. Geothermal potential of granitic rocks of the Mourne Mountains. In: M.E. Young (ed.), Unearthed: impacts of the Tellus surveys of the north of Ireland. Dublin. Royal Irish Academy.

radiometric signal is derived from rocks at the ground surface or from shallow depths. It is possible that, elsewhere in Northern Ireland, HHP granite intrusions are buried beneath a thick cover of younger sedimentary rocks. In this setting, heat generated within the granites may be trapped beneath the sedimentary rocks. Buried intrusions are, by their nature, only discovered by drilling into them although geophysics – particularly gravity anomalies – may provide indirect evidence of their presence. Gravity anomaly data suggest that there may be a granite buried beneath a structural high to the north west of Larne.

At this stage of technological development and, with inadequate data for the Mournes granites and other possible buried intrusions, the EGS potential in Northern Ireland remains poorly understood. However, should the EGS projects in Cornwall prove successful then further geological and geophysical assessment of HHP granites in Northern Ireland may be worth considering.

6 Next Steps to Realise the Geothermal Potential of Northern Ireland

Based on current understanding of the potential for geothermal across Northern Ireland as outlined in the previous section of this report, a number of recommendations can be made that would further quantify and de-risk the subsurface risk.

6.1 Programme of Geothermal Exploration and Research

Many of the barriers to development of the geothermal sector in NI centre on our current knowledge level of the resource. In particular, the geothermal gradients and heat flow is poorly understood and there is a poor understanding of potential Hot Sedimentary Aquifers (HSA) and High Heat Production (HHP) granites ('HDR') at depth. This has been compounded by the scarcity of suitable deep onshore borehole data. To advance the development of deeper geothermal resources in Northern Ireland, a Regional Geothermal Exploration Programme is recommended, comprising:

- Creation of a Geothermal Database and viewer (similar to those of Germany[34] or Denmark[35])
- Research programme for deeper prospects including lab analysis and modelling studies; and
- Physical exploration programme involving exploration drilling and surveying.

6.2 Geothermal Trials and Demonstrators

In order to increase confidence in the geothermal resources and technologies, it is recommended that any initial geothermal trials, demonstrators and evaluation projects are developed and installed as soon as feasibly possible. This would ideally be a full-scale working scheme, supplying heat to an identified demand. The demonstrator should be a heat-only project most likely utilising Triassic Sherwood Sandstone at depths of a few hundred metres or mine water energy as the geothermal resource.

Following the implementation of a National Geothermal Exploration Programme (see above), it is anticipated that deeper geothermal demonstrator projects be implemented (HSA and HDR). This is due to the high level of risk associated with such deep drilling.

6.3 Mapping of Geothermal Potential

To understand the distribution of geothermal resources in relation to heat demand across Northern Ireland maps should be made that compare the potential for different geothermal resources to the spatial distribution of heat demand. This mapping could be hosted on an online viewer, or specific maps created at a range of scales to aid planning authorities and decision makers.

[34] GeotIS Information System for geothermal energy
[35] Deep geothermal energy portal (geus.dk)

7 Other Considerations

At present, the geothermal energy sector in Northern Ireland can be described as either nascent (shallow GSHPs) or non-existent (deep). However, in other European countries with similar geology, geothermal energy deployment is much further advanced.

This section draws on the experience from other countries to outline policy options and other key actions that could encourage the development of geothermal energy, in order that it might play a role in the decarbonisation of heating and cooling in Northern Ireland. There will, inevitably, be differences in the approaches needed for shallow and deep geothermal energy, because of their different scale, capital costs, complexity and sector maturity, but there are also many commonalities.

Development of the geothermal energy sector in Northern Ireland will require strong partnerships between the Executive, Departments, agencies and stakeholders. There should be a key role for local communities, both through Council Local Development Plans (LDPs) and the participation of commercial and voluntary enterprises. It is likely that the NI Executive will need to play a significant role in the initial establishment of the deep geothermal sector and the progressive penetration of GSHPs into the heating and cooling sector.

Learning from other countries, a number of key actions have been identified within a phased and progressive approach to the development of geothermal energy in Northern Ireland. This will allow the technology to gain acceptance and the sector to grow sustainably, building capacity, reducing costs and attracting investment.

7.1 A Strategic Approach

Most European states have published energy strategies, in many cases closely aligned to climate action plans and carbon emission reduction targets. In this context, energy is often taken to be synonymous with electricity generation and such strategies have been dominated by the transition from fossil fuels to renewable sources for electricity generation. However, in terms of energy use, heating and cooling is the largest single sector, followed by electricity and transport.

Northern Ireland has already met its 2020 target of 40 % of electricity generated from renewable sources, primarily onshore wind, but it has made less progress in decarbonising the heat and transport sectors. In the heat sector this could be achieved by a combination of demand reduction (construction of ultra-low energy new buildings and energy efficiency remediation in existing buildings) and replacement of fossil fuel systems by low-carbon heat sources.

Geothermal energy can play a role in the latter via the deployment of highly efficient electricity-based heat pump systems and by the direct supply of low-carbon heating and cooling. In the UK the potential of geothermal energy has been identified and assessed in a number of reports[36,37,38,39,40] and initiatives.

The Energy Strategy for Northern Ireland has highlighted that geothermal energy potentially has an important role in the decarbonisation of heat. This, in itself, does not necessarily provide the stimulus required for the development of the sector. Key to supporting the sector will be the development of a robust geothermal energy policy.

The EU Intelligent Energy programme funded a project, GTR-H, which looked at the factors that had affected the development of geothermal energy in exemplar member States (Germany, France and the Netherlands) and produced recommendations for a regulatory framework to promote such a development[7]. The main factors identified by GTR-H, and in subsequent reviews, and suggestions for how they might be addressed in a geothermal energy strategy and roadmap include:

- Awareness: create awareness of what geothermal energy is and its potential uses, across the stakeholder community; government, industry and energy consumers.
- Information: map the heating and cooling demand; understand the distribution and nature of the geothermal resource; identify available technology to exploit the resources; disseminate information.
- Sector capacity: build a cadre of experienced personnel and equipment, with ongoing training and certification to appropriate standards, to enable sustainable sector growth.
- Legislation and regulation: establish ownership and licensing of geothermal exploration and use, regulation appropriate to size and complexity of different geothermal energy technologies.
- Financial measures: reduce regulatory costs, create a positive fiscal environment, financial incentives and availability of low-cost capital, provide technical risk guarantee schemes.
- Cross-sector participation: encourage involvement of central and local government, private and public sector, and local communities.

In countries where geothermal energy is not well-known or widely used, a separate strategy may prove useful in setting the context for the development of geothermal energy. For example, although shallow geothermal energy has been widely deployed for many years, the Netherlands has recognised the value of deep geothermal energy and formulated a national strategy which has resulted in the growth of this sector[41].

36 Downing, R. A. and Gray, D. A., 1986. Geothermal Energy: The Potential in the United Kingdom, HMSO.
37 CSA, 2005. Geothermal Energy Review of Northern Ireland – Final Report to INTERREG. CSA rept no. 3194/01.05 September 2005
38 Sinclair Knight Merz, 2012. Geothermal Energy Potential: Great Britain and Northern Ireland.
39 Atkins, 2013. Deep Geothermal Review Study Final Report. Produced for Department of Energy & Climate Change (DECC).
40 Arup, 2021. Deep Geothermal Energy: economic decarbonisation opportunities for the United Kingdom.
41 Stichting Platform Geothermie, DAGO, Stichting Warmtenertwerk and EBN 2018. Master Plan Geothermal Energy in the Netherlands: a broad foundation for sustainable heat supply.

7.2 Geothermal Energy Policy

Directly linked to the NI Energy Strategy, the Department for the Economy should develop a specific geothermal policy, including a vision for the sector as well as a roadmap to achieve that vision. The policy should cover both shallow and deep geothermal.

The policy should set out the NI Executive's position with regards to geothermal energy and provide clarity and certainty for those seeking to invest in geothermal energy as a means of decarbonising heat and or electricity. It is anticipated that the development of the shallow and deep sectors will proceed at different rates – GSHP technology is mature and can be deployed widely throughout Northern Ireland, whereas deep geothermal systems are larger, more complex, have high capital costs and are constrained by the geographical distribution of the resource. However, the latter benefit from economies of scale and could be integrated into future heat networks which are an efficient method of distributing heat in urban and commercial settings.

A report produced for Scotland[42] recommended a phased and progressive approach to the development of geothermal resources and this type of approach is also appropriate for Northern Ireland, albeit with modifications to reflect the potential resource types:

- Short to medium term (0–10 years+) - developing the supply of heating and cooling from shallow geothermal resources (e.g. closed-loop and open-loop aquifer systems), GSHP technology and infrastructure (e.g. heat networks).
- Medium term (5–10 years+) - potential development of deeper geothermal resources for direct heat and potentially generation of baseload electricity (e.g. Hot Sedimentary Aquifers).
- Medium to longer term (5–20 years+) - potential development of deeper Hot Dry Rock resources using Enhanced Geothermal Systems (EGS) for generation of baseload electricity.

This phased development from the deployment of relatively mature technology through to progressively deeper, larger and more complex systems will allow the industry sector to grow capacity, reduce costs, and build consumer/investor confidence.

The policy will cover technical, administrative, and regulatory aspects.

7.3 Resource Ownership and Licensing

The legal ownership of geothermal resources is not currently defined under existing legislation.[43] This uncertainty of ownership of geothermal resources is a potential risk for future projects, which along with risks associated with geological uncertainty, can make it difficult to obtain sufficient finance to develop deep geothermal projects. It is recommended that the legal ownership of geothermal energy resources should be established to allow a geothermal resource licensing system to be developed by amending existing primary legislation or introducing new primary legislation, potentially in the form

[42] Aecom, 2013. Potential for deep geothermal energy in Scotland: study volume 1 & 2
[43] Abesser et al., 2018. Who owns (geothermal) heat? BGS Science Briefing Paper.

of a ‘Geothermal Energy Act‘. Consideration should be given to how any implementation would affect any existing extraction of deep geothermal heat that may be operating at the time and how the licensing system fits with existing water abstraction licensing.

It is recommended that the Northern Ireland Executive explores how to establish legal ownership (and introduction of a licensing system) and how this natural resource can be protected and managed to be sustainable in the long term.

Due to the likely timescale in drafting new legislation, interim measures are required to encourage commercial investment in the short term and medium term. It may be appropriate to have a two-stage approach, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation, to be replaced at a later date with more comprehensive and stand-alone legislation, as the industry develops and matures.

The absence of an equivalent to Section 43 of the Infrastructure Act 2015 in Northern Ireland impacts on the access rights to the subsurface for any deviated drilling or laterals of deep geothermal wells.

In the intervening period, any proposed development of deep geothermal can be considered in the normal way through the development management process by submitting a planning application to the relevant planning authority. This would include EIA if/as necessary. Consideration should be given to how the relevant authorities might work with developers to ensure all subsurface exploration data is provided so it may be made openly accessible by central government within an agreed timeframe with a view to facilitating the sharing of best practice, further enabling and increasing early-stage geothermal development.

In the interim period existing regulatory guidance for geothermal heat in NI should be compiled (e.g. Scottish example[44]).

The enactment of future geothermal resource licensing should be such so as not to inhibit the take-up of GSHP technology and it is recommended that resources shallower than an appropriate specified depth should be either exempted from future licensing or made subject to General Rules. A registration process for shallow systems should be implemented, so as to facilitate spatial planning and long-term resource management.

7.4 Environmental Regulation

Environmental legislation relating to assessment and consenting issues are based on various former EU Directives and associated UK and/or NI legislation or regulations and these are well established. The existing framework of legislation should be examined to ensure that it covers the likely types of deep geothermal projects likely to come forward in NI.

7.5 The Planning System

The future uptake of geothermal will benefit from a supportive planning framework. The reformed two-tier planning system became operational on 1 April 2015, with the Department for Infrastructure being responsible for planning legislation, strategic planning policy and regionally

[44] Geothermal+heat+in+Scotland+-+regulatory+guidance.pdf (www.gov.scot)

significant development applications. There are a number of factors which will contribute to supporting the deployment of geothermal development here and consideration should be given as to how geothermal energy might appropriately be reflected at strategic planning policy level. Indeed following on from the development of the energy strategy, wider government policy could have a role in helping to incentivise, encourage and/or compel the use of sustainable heat systems (for example district heating) and renewable heat sources which would facilitate greater uptake of geothermal energy solutions.

The aim of regional planning policy for renewable energy as set out in the Strategic Planning Policy Statement (SPPS) is "to facilitate the siting of renewable energy generating facilities in appropriate locations within the built and natural environment in order to achieve Northern Ireland's renewable energy targets and to realise the benefits of renewable energy without compromising other environmental assets of acknowledged importance". This includes geothermal development and existing planning policy sets out a presumption in favour of appropriate renewable energy development. The SPPS states "Development that generates energy from renewable resources will be permitted where the proposal and any associated buildings and infrastructure, will not result in an unacceptable adverse impact"…on several planning considerations.

In relation to policy development, DfI is currently carrying out a review of the implementation of the Planning Act (NI) 2011, which may identify potential areas for legislative change to help to improve the planning system. In addition, on 21st April 2021 Minister Mallon announced a review of strategic planning policy for renewable and low carbon energy to ensure the Department's planning policy remains up to date, robust and fit for purpose. The outcome of the review could result in amendments to the SPPS.

The 11 councils in Northern Ireland, in their role as planning authorities, are responsible for bringing forward Local Development Plans (LDPs) for their areas. This will provide a great opportunity to reflect the community plan for an area in a spatial way and meet the aspirations of the local community. As it is a plan-led system, the plan will provide certainty and clarity to communities, developers, investors and the public alike. The council's LDP will include policies, tailored to their local circumstances for a range of land use matters, including renewable energy development. In preparing their LDPs, councils must take account of the Regional Development Strategy 2035 and any other advice in guidance issued by DfI, including the SPPS. The LDP will encompass a Plan Strategy (PS) and a Local Policies Plan (LPP).

It is recommended that consideration be given as to how development utilising geothermal energy should be appropriately provided for through the review of strategic planning policy for renewable energy

Engagement with councils to raise awareness of the spatial distribution of shallow geothermal resources for exploitation with Ground Source Heat Pumps, and deep geothermal resources that could be combined with heat demand (identified from heat mapping). This could comprise a set of bespoke maps and/or digital shapefiles on Spatial NI.

Support for and engagement with councils as they develop local policies for renewable energy through their Local

Development Plan documents (Plan Strategy and Local Policies Plan) so that the potential for geothermal is fully considered and included.

7.6 Costs, Financing and Risk Mitigation

There is a significant difference in technological, risk and costs uncertainty between shallow geothermal heat-only developments and deep geothermal developments. It is anticipated that experience gained from the demonstrator project(s), and progressively deeper schemes will increase developer and investor confidence, reduce costs and thereby encourage development.

For heat-only developments, an incentive scheme could support developments. Additional support is likely to be required to attract and encourage deep geothermal developments for electricity generation. However, costs should reduce over time as confidence increases and technology advances, and the funding gap should reduce.

It is recommended that the NI Executive investigate how it can act to support deep geothermal projects in NI, potentially setting up a deep geothermal fund to provide support. Any government funding would be subject to State Aid regulations and must comply with either the EU State aid rules or Chapter 3 of the EU-UK Trade and Cooperation Agreement and any other international subsidy commitments.

In several EU countries (e.g. France, Netherlands, Belgium) the Government operates an insurance scheme to underwrite the geological and technical risks associated with drilling deep boreholes. This should be tailored to the maturity of the market as highlighted by the research done by the GEORISK project (Figure 16).

Investment aid in the form of grants is seen more appropriate for nascent markets while public risk insurance and public-private partnerships for risk insurance are more appropriate for intermediate and near mature markets, respectively.[45]

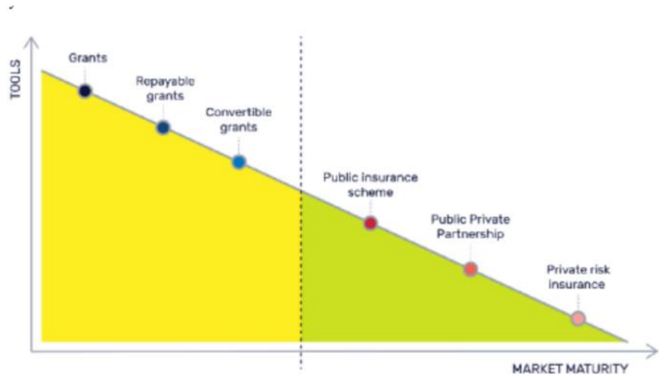


Figure 19. Transition of financial tools to mitigate the resource risk depending on the maturity of the market.[45]

[45] Dumas et al., 2019. Risk Mitigation and Insurance Schemes Adapted to Geothermal Market Maturity: The Right Scheme for my Market. European Geothermal Congress 2019 Den Haag, The Netherlands, 11–14 June 2019.

Geological Survey of Northern Ireland
Dundonald House
Upper Newtownards Road
Belfast
BT4 3SB

t: 028 9038 8462
e: gsni@economy-ni.gov.uk
www.bgs.ac.uk/gsni

@geosurveyni