Net Zero Pathways:
Building the Geothermal Energy Sector in Northern Ireland

QUEEN'S UNIVERSITY BELFAST

Abridged Version

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Report Summary

Understanding how the subsurface of Planet Earth works has been a long passionate interest and pursuit of the geologist community. Harnessing this interest and building upon the well-established geoscience knowledge base can unlock opportunities to make available geothermal heating and cooling resources that remain dormant in Northern Ireland (NI).

Geothermal energy integration provides a low-carbon alternative to current fossil fuel-dominated energy sources. Building this sector will help contribute towards commitments to the net zero target and transition Northern Ireland towards a just energy future. This report focuses on the confidence-building actions needed to build the geothermal sector in NI. The report has consulted widely and therefore reflects the experiences of those leading out on, or working with, geothermal projects.

Despite over forty years of geological evidence gathering; including well operations, sub surface data analysis and detailed geoscience report generation confirming favourable geological conditions for geothermal activity in Northern Ireland, along with over two decades of political discussion, the findings of this report show an absence of awareness and indeed visibility – showcasing – of the geothermal project activity on the ground.

For both the journey to net zero by 2050 and growth of the geothermal market sector in NI to be a success, the challenge is as much a market behavioural breakthrough activity as it is a technological breakthrough activity. In markets further afield, geothermal technologies are a proven part of the LZC energy portfolio and solution mix. Therefore, the policy challenge is one of building confidence, shifting attitudes and establishing the link between its potential and the actual working of geothermal projects on the ground. It requires a portfolio-driven policy approach of the energy market.

The geothermal sector in NI is presently in an early development niche phase. This report, therefore, invites the geothermal shaper community to build a niche strategy, while putting in place the market scaffolding and also showcasing geothermal buildability. Creating the geothermal transition must be accessible, fair and without adverse effects on peoples' jobs and quality of life. This report puts forward several considerations for building the market scaffolding and outlines a holistic perspective for showcasing flagship geothermal projects.

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1.0 INTRODUCTION

Geothermal energy is defined as "the heat generated and stored in the ground and is a source of low-carbon, renewable energy."[1] In this report, we scope out the confidence-building actions that link sector potential with actual geothermal projects on the ground across Northern Ireland. Before this, we briefly set out a brief non-technical overview of geothermal energy, as exhibited in Box A. Put simply, geothermal is a heating or cooling energy source that naturally occurs from the earth's subsurface. That energy source can be connected directly to a home or business, but can also be designed across networks with other homes and businesses. There are different designs, depths and technologies deployed to accomplish a geothermal project. Initial exploration and feasibility survey are typically undertaken to scope out and ascertain the subsurface potential and to match that assessment with the customer's heating and cooling requirements. The geothermal heat source can be designed as a standalone source, or alternatively as a complement to other energy sources. At the surface interface, ground source heat pumps are used as part and parcel of the everyday built environment mechanical, electrical and plumbing solutions.

Box A: **What is Geothermal Energy?**

Geothermal is a heating or cooling energy source that naturally occurs in the earth's subsurface.

Geothermal energy is a single energy source that connects directly to one domestic home or industrial business.

Geothermal energy is an energy source that connects across networks with multiple homes, institutes and businesses.

There are different designs (closed loop, open loop), depths (shallow, deep) and technologies deployed to accomplish a geothermal project.

Exploration and feasibility surveys are typically used to scope out and ascertain the subsurface potential and to match with the customer's heating and cooling requirements.

For both domestic and business users, geothermal energy source 'flows' can be enabled with ground source heat pumps, or through direct use systems.

For larger network deployment across homes or businesses, the geothermal heat source can be configured and integrated with existing mechanical, electrical and plumbing solutions.

The report has three main sections:

- A brief overview of the geothermal energy sector and policy developments in Northern Ireland.
- An outline of the market scaffolding for building institutional support and practice for the sector.
- Exploration from a holistic perspective on demonstrating the geothermal technology deployment.

Finally, the report concludes and outlines a set of abridged recommendations for consideration by the NI Department for the Economy (DfE).

[1] https://researchbriefings.files.parliament.uk/documents/POST-PB-0046/POST-PB-0046.pdf

1.1 Geoscientific foundations and the N.I. Diamond

The geothermal sector is underpinned by geoscience research and related applied technologies.[2] [3] Much research work has been, and continues to be done, on developing and testing the potential geothermal resources in Northern Ireland (NI).[4] In addition to this geoscience activity, the potential use of geothermal in NI has been of interest amongst elected representatives, with Assembly Hansard records indicating over two decades of political discussions on geothermal use in NI.[5] The Hansard conversations date as far back as 2001. This public engagement shows that geothermal is not a new idea or topic of conversation amongst elected representatives in the NI Assembly.

A number of geoscience reviews of the geothermal activity in NI have pointed to the significant potential of this energy resource. A recent analysis of existing borehole data, by GSNI, has shown that hot water is available at a relatively shallow depth around Belfast and in Co. Antrim and is reported extensively elsewhere.[6] Raine and Reay's (2021) GSNI report describes the geothermal energy sector in Northern Ireland as, *"either nascent (shallow GSHPs) or non-existent (deep)."*[7] That market descriptor remains accurate as of May 2022.

Previous geology research shows that one of UK's key onshore geothermal reservoirs, the Triassic Sherwood Sandstone Group (SSG) is prominently present beneath Northern Ireland, at varying depths and reservoir temperatures. Particularly in the Greater Belfast area, where the SSG is relatively shallow and heating & cooling demand is high, there is potential for this type of geothermal energy use to grow (See Appendix 1 SSG map for NI).[8] This geoenergy resource has been long recognised and researched by the geology community. Downing and Gray's (1986) study estimate the Sherwood Sandstone Group across NI, at temperatures of 20 ˚C, at approximately 523 Mtce (million tonnes coal equivalent) or equivalent to 2.5 billion barrels of oil (See table and map in Appendix 1& 2).[9] Building the geothermal sector from this Sherwood resource, we believe, can in part transition Northern Ireland towards more affordable, clean and secure energy. Our consultation suggests that geothermal feasibility surveys are undertaken, but comparatively few opportunities would seem to be realized from this activity.

We find that the existing reports on the NI geothermal sector are mostly geology-centred and tied to geological foci — e.g. borehole test output analysis, samples, geological mapping and analysis. In markets further afield, geothermal technologies are a proven part of the LZC energy solution mix. Therefore, we believe that the policy challenge is one of building confidence, shifting attitudes and effectively 'linking in' to the transitional community pathways.

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[2] Pasquali, R., O'Neill, N., Reay, D., Waugh, T., (2010), The geothermal potential of Northern Ireland. Proceedings World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010

[3] Jackson, T., (2012), Geothermal potential in Great Britain and Northern Ireland, SKM, London

[4] 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.

[5] As far as this research is aware, the first citation of geothermal use is in 2001 Committee for Enterprise, Trade, and Investment, Report on the Energy Inquiry (Vol. 1).

[6] 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.

[7] Ibid.

[8] 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.

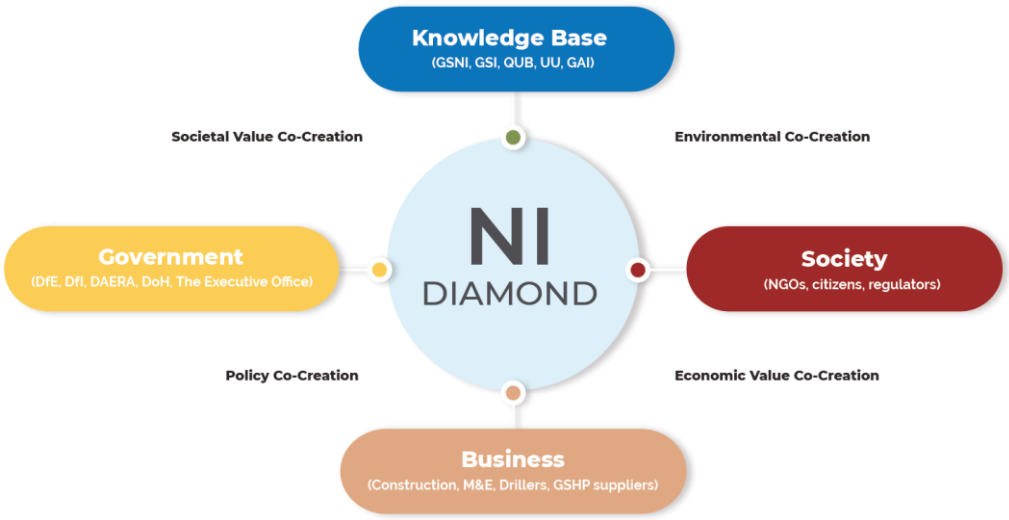
[9] https://pubs.geoscienceworld.org/jgs/article-abstract/143/3/499/92878/Geothermal-resources-of-the-United-Kingdom?redirectedFrom=fulltext

1.2 Strategically important policy pathways

We believe that there is an opportunity for building the geothermal sector NI by transitioning it and 'linking in' with the net zero pathways and the journey of travel. The NI Executive's Green Growth strategy[10] provides a transitional framework for the operational delivery of net zero in NI. It also points the geothermal shaper community in the direction of engagement with what is referred to as the N.I. Diamond.[11] Effectively, the N.I. Diamond seeks to create an ecosystem in which the NI government can work together with business, society and knowledge bases to deliver a market-focused approach for net zero energy futures.

Figure 1.0: Geothermal and the NI Diamond

Source: Adapted from Independent Strategic Review of NI Agri-Food – Final Report.PDF (daera-ni.gov.uk)



Net zero targets. The strategic importance of building a geothermal sector can be seen in terms of the scale of the deliverables to achieve the legally binding net zero emission targets by 2050. The NI Executive has committed to these targets and produced primary legislation.

NI Strategic Energy Framework. The Northern Ireland Executive published Strategic Energy Frameworks (SEF) in 2004 and 2010 respectively, strategically setting out four key energy goals. SEF goals therefore provide provision for the work in building the geothermal sector in NI.

The Energy Strategy. The DfE Energy Strategy for Northern Ireland Consultation on Policy Options was published in March 2021 and highlighted that geothermal energy could make an important contribution to the decarbonisation of heat.

[10] https://www.daera-ni.gov.uk/sites/default/files/consultations/daera/Green%20Growth_Brochure%20V8.pdf

[11] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/Independent%20Strategic%20Review%20of%20NI%20Agri-Food%20-%20Final%20Report.PDF

The Path to Net Zero Energy 22-point Action Plan. Geothermal provision is explicitly presented in the action points 15 and 16 in the publication of DfE's Energy Strategy for Northern Ireland - The Path to Net Zero Energy Action Plan 2022.

The role of Geothermal in the decarbonisation of heat. The UK Climate Change Committee (CCC) report identified low-carbon heating sources for reducing emissions from heating buildings including; *"waste heat, large-scale (e.g. water-source) heat pumps and geothermal heat."* This report sets out the key technologies for decarbonising heating and states how geothermal can play an alternative role.[12]

UK energy security. Recent global events and energy price volatility put energy stability and the dependence of the UK on international sources as a pressing issue for all communities. In the British Energy Security Strategy published in April 2022, the Prime Minister makes clear that *"…we need a flow of energy that is affordable, clean and above all, secure."*[13]

The next part of this report focuses on how the institutional market-building measures might support the growth of the geothermal sector in NI.

2.0. BUILDING GEOTHERMAL MARKET INSTITUTIONS IN NI

2.1 Exploration R&D activity

Many areas of geothermal activity still remain poorly understood. This requires further understanding from multi disciplinary teams of expertise in geoscience, geophysics data and geomechanics innovation in a wide range of fields. Alongside this, we believe it also requires social science expertise in market building, public engagement, georisk, social policy practice and development in understanding the workings of institutions that deliver on a *just and equitable energy transition for all communities.*

2.2 Protective niche scaffolding

A baseline finding is that the NI geothermal sector is presently in an early development niche phase. Our findings indicate a small patchwork of geothermal projects in NI that are mostly of an early niche stage nature and hard to find. These require inchoate stitching work for a coherent picture to emerge and we believe that there has been a missed data sharing opportunity to build sector confidence from this early work. For instance, the newly built McKay Library at Queen's University Belfast, has had a geothermal heating scheme installed since 2009. Similarly, the Lyric Theatre in Belfast has had a geothermal cooling system installed since 2009. There is, therefore, a need for 'data stewards' to showcase data and experience to help the sector grow.

Table 2.1 sets out stages of the niche trajectory of the geothermal niche development and how that normally evolves. We find evidence from the interviewees that the geothermal option in buyer decision-making is fully open to the glare and scrutiny of the existing mainstream market regimes across all categories of evaluation and assessment. That finding suggests shielding policy intervention is required for NI geothermal projects, as has been afforded in the other renewable technology sectors previously.

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[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1036227/E02666137_CP_388_Heat_and_Buildings_Elay.pdf p.64.

[13] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067841/british-energy-security-strategy-print.pdf

Table 2.1: Geothermal niche building strategies

Geothermal niche building strategies	Shielding	Nurturing	Stretching and transitioning
Decision-making measures	Measures presented as temporary (Subsidies are only necessary until levelling up parity is reached)	Measures presented as targeting performance improvements. (Learning curves are identified and going down 'rapidly' with regional cluster events – scalability readiness).	Shielding is not removed but institutionalized and extended to nurturing. Larger deep geothermal increased and 'hybridized' /sector coupling with the repertoire of geothermal solutions with, for example waste water, pilots have undertaken.

Source: Adapted from Geels and Raven (2007).[14]

2.3. Multiple narratives and energy value systems

Making Northern Ireland geothermal ready, according to the interviewees, requires more conversation and clarity around how government can create confidence by encouraging and supporting the many voices and dialogues that can participate and co-create in the building the sector. Those narrative approaches must open up and span beyond the geothermal technical community and with broader market-spanning stakeholder and community engagement.[15] This, in turn, will ensure a transition to a wider group of actors, including public authorities, think tanks, engineers, consultants, journalists, private investors, climate agencies, environment agencies, regulators, NGOs, citizens and civil society organizations, and involving them in their opinions commercialisation of the technology.

2.4 Sector priorities and mobilizing partners

At this early stage in niche- building, prioritizing the sectors and partners is warranted through building and sheltering technology competition and showcasing a range of flagship activities within;

- Shallow deployment projects. Pertaining to near-surface exploitation of subterranean heat and/or cooling by means of closed-looped systems with ground source pumps.
- Deep deployment projects. Relying on drilling technologies that allow deeper access to the subsurface, with a range of open-looped systems and undertaken with multi-stakeholder demands. [16] [17] A fulsome outline of both systems has been recently published as a UK POST policy briefing in April 2022.[18]

Multi-sector prioritization approaches, with illustrative sector examples, could include, but are not limited to;

[14] Geels, F.W., Raven, R.P.J.M., (2007), Socio-cognitive evolution and co-evolution in competing technical trajectories: biogas development in Denmark (1970-2002). International Journal of Sustainable Development & World Ecology. 14, 63-77.

[15] Didonet, S. Simmons, G. Díaz-Villavicencio, G., and Palmer, M (2016), Market orientation's

boundary-spanning role to support innovation in SMEs, Journal of Small Business Management. 54, p. 216-233

[16] https://www.r-e-a.net/wp-content/uploads/2021/05/Deep-Geothermal-Energy-Opportunities-for-the-UK.pdf

[17] https://www.bgs.ac.uk/download/science-briefing-note-deep-geothermal

[18]https://researchbriefings.files.parliament.uk/documents/POST-PB-0046/POST-PB-0046.pdf

- Key public infrastructures that have **twenty-four-hour heat or cooling demands** such as hospitals, airports, transport hubs, university laboratories, prisons and other similar activities across Northern Ireland.
- Key infrastructures such as laboratories in **temperature controlled environments in the life sciences** including all pharmaceutical industry firms, medicines manufacturing and healthcare activity across Northern Ireland.[19]
- Other research points towards the fit of geothermal with **industrial manufacturing sites**, the overwhelming majority of which only require medium to low temperature range for their processes. Medium to low temperature process emissions include:
  a) The production of nitric acid its oxidation process requires cooling at 38 degrees, the nitric oxide formation requires temperatures between 30-50 degrees whilst the boiling point for nitric acid is 120 degrees.
  b) The production of bulk organic chemicals requires temperatures below 70 degrees with the use of enzymes and biocatalysts requires temperatures between 4-60 degrees.
  c) The production of adipic acid requires temperatures between 60-80 degrees. [20]

Agriculture and horticulture: international cases showcase greenhouse environments, distilleries, fish farming and agriculture stock buildings.[21] An illustrative case is the Dutch horticulture sector which has become a pioneer in terms of geothermal systems operating projects and which represents an installed capacity of over 100 MWth, contributing significantly to lower energy costs.

Key infrastructures in leisure such as swimming pools, hotel settings, spa and recreational playing pitches, visitor destinations in Northern Ireland.

All new buildings, net zero *carbon in build* and *carbon in use* targets.

Strong NI public sector leading out. The public sector is the largest aggregate energy consumer and has a large estate of buildings, primarily in Health, Infrastructure, Education, Justice and Economy.[22] Some 96% of the annual energy consumption is split across five departments: Department of Health (DoH) 39%; Department for Infrastructure (DfI) 25%; Department of Education (DE) 21%; Department of Justice (DoJ) 8%; Department for the Economy (DfE) 3%.[23] We believe there is an opportunity for the government to lead within existing Asset Management Plans to present key heat data and ensure alignment with operational investment initiatives at both regional (8 departments) and local (11 councils).

2.5 Maintaining temporary sector clusters

The vibrancy of any business sector can be ascertained from the frequency of, and attendance at, temporary sector clustering events. Temporary sector clusters are critical for forming the sector, effectively building the knowledge, the social networks and confidence.[i] These temporary sector events allow market actors to share experiences, find and open conversations, build positive expressions of interest, hatch plans and actions and consider

[19] https://www.abpi.org.uk/media/news/2022/january/pharmaceutical-industry-sets-out-manifesto-for-the-next-northern-ireland-assembly/

[20] https://www.egec.org/wp-content/uploads/2020/04/Smart-Sectoral-Integration.pdfp.16.

[21] https://www.thinkgeoenergy.com/plans-for-pioneering-gbp4m-geothermal-research-centre-in-cornwall-uk/

[22] https://sibni.org/app/uploads/2019/03/Energy-Management-Strategy-March-2019.pdf

[23] Ibid.

the latent buyer demands, interest and sector potentiality and doability.[24] Trade associations usually lead out on this activity when the sector is more organised, and structured, and rules are established. However, when a sector is at an early stage, support from government partners and other local, national and international agencies is required to nudge the sector organising along and instil confidence.

2.6 Evaluation and stakeholder engagement

Our initial showcase sector analyses led us to seek to understand the role and potential contribution of geothermal technology towards the pathways in the decarbonisation of heat within Northern Ireland. The actual source document for the decarbonisation of heat targets was difficult to find and the targets would appear not to be published in Northern Ireland. This finding is a bit surprising given the previous scrutiny of renewables in Northern Ireland and the establishment of cross-departmental committees in related areas. This finding also suggests that cross-departmental committees might not be a long-term solution for monitoring key performance targets and indicators, or in supporting a portfolio-driven approach to renewable technology solutions.

A Whole Systems Networking funded project called "Zero-in on NI heat project", investigated the major barriers and opportunities towards heat decarbonisation in Northern Ireland.[25] This research usefully mapped out the stakeholders for heat decarbonisation for Northern Ireland along with the technological pathways but surprisingly omits geothermal as a source of heat decarbonisation and does not shed light on the heat decarbonisation metrics.[ii] There are useful geothermal risk tools available online that could be adopted and adapted to provide support for decision-making and wayfinding. [26]

2.7 Market-making with government partners

This section might seem that we are pushing at the boundaries of our brief remit but in the context of the previous RHI scheme and in the consultation with the interviewees on confidence building, the role of the government is raised; our main point might seem obvious, but it is worthwhile restating that governments are builders and also custodians for markets.[27] [28]

In November 2018 the Secretary of State outlined four principles for the UK's power sector, in response to a 2017 Cost of Energy review by Professor Dieter Helm on energy reform (see Box B). We suggest that the saliency of these principles is discussed when considering the policy role of the NI government in building the geothermal sector.

Box B: Bringing government's principles to the geothermal sector

- **The market principle:** wherever possible, use market mechanisms that take full advantage of innovation and competition.

- **The insurance principle:** given intrinsic uncertainty about the future, the government must be prepared to intervene to provide insurance and preserve optionality.

[24] Palmer, M. Medway, D. Warnaby, G. (2017), Theorising temporary spatial clusters and institutional boundary-work in industrial marketing, Industrial Marketing Management. 61, p.104–113.

[25] https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/07/Final_Report_UU_Zero_in_on_NI_heat-2.pdf

[26] See https://www.georisk-project.eu/georisk-tool/

[27] Mazzucato, M., (2018). Mission-oriented innovation policies: challenges and opportunities. Ind. Corp. Change 27, 803–815

[28] Chandrashekeran, S. (2022). Re-stating power: How states make, tame, and shape markets. Geographical Research, 60(1), 138-151.

· **The agility principle**: energy regulation must be agile and responsive if it is to reap the great opportunities of the smart, digital economy.

· **The "no free-riding principle":** consumers of all types should pay a fair share of system costs.

Committee on Climate Change. Net Zero – Technical report Committee on Climate Change May 2019. London. P.57

The role of evaluation will be critical in building legitimacy of the geothermal sector. To generate data for insight, wayfinding and decision-making, managers need tools. Box C provides an illustrative EU approach to tool wayfinding, while Figure 2 provides the overall roadmap cycle vision for this data creation, application, storage and retrieval system. Together, these can create sector readiness and build confidence.

Box C: Managing renewable data reporting The EU Taxonomy represents an important tool for understanding managing renewable data reporting. The benefits of the EU taxonomy can be summarized as follows:

1. 'Inventory Tool': allows the definition of what is a sustainable asset and process. Provides a reliable certification for investors on the environmental impact;

2. 'Reporting Tool': allows the unequivocal assessment of the degree of sustainability of an investment or product;

3. 'Transition Tool': combining its inventory and reporting utility, the EU taxonomy allows firms and investors to navigate and benchmark their economic transition to net-zero.

https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

Figure 2: Building the knowledge links and creating data governance

Source: Adapted from Goulding et al. (2007)[29]

2.8 Ensuring high standards

Standards are an essential part of driving technology trajectories and are an important factor in the process of creating a new path for those firms following projects to enable catch-up.[30iii] Effectively, geothermal sector standards build confidence and accelerate technology wayfinding and acceptance. These standards could be developed in a consensus-driven approach and through an open, neutral, and inclusive environment, by experts from many disciplines, representing geologists, drilling utilities, manufacturers, end-users, academe, governmental and regulatory bodies, and other stakeholders.

2.9 Legislation, regulatory framework and procedurality

Northern Ireland has no specific legislation, regulatory framework or procedures covering geothermal energy. The law in Northern Ireland is almost completely silent on geothermal, with the exception of references in specific guidelines, and finding more definitions would provide confidence in the sector insofar as policy out workings could be assessed and evaluated. Almost all of the interviewees call for more market scaffolding around the legal, regulatory framework and procedures in the building the geothermal sector. How this is enhanced requires further exploration, stakeholder consultation and evaluation of the impact of any proposed reforms. Specifically the definition and legal ownership status of the energy produced from technically different forms natural resources hydrothermal petrothermal and the related minerals are questions which are acknowledged by the geology and other academic communities[31] [32] We believe this will require primary legislation and in accordance with UK Regulatory Policy Committee guidance.[33]

2.10 Social licence

Building an inclusive social licence for geothermal projects will be another critical cornerstone of building confidence in the geothermal sector in Northern Ireland. The journey to net zero greenhouse gas emissions will rely on building confidence with LZC technology, institutions and people. A market transition depends on people living in communities where the ownership of the issues can be understood, particularly where concepts seem alien or far removed from end user day-to-day activities. We find interesting case evidence from Iceland in terms of a zoning resolution policy and demarcation between areas of industrial activity and areas of natural outstanding beauty. Iceland has one of the most beautiful natural landscapes and it is able to find the balance between safeguarding its natural environments, some of which are visited by millions of tourists each year, and also accommodating its growing and important geothermal energy activity.[34] A lesson drawn from the Iceland case is the importance of having a clear zonal resolution geothermal map of

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[29] Goulding, J., Sexton, M., Zhang, X., Kagioglou, M., Aouad, G.F. Barrett, P. (2007), Technology adoption: breaking down barriers using a virtual reality design support tool for hybrid concrete, Construction Management and Economics, 25:12, 1239-1250.

[30]Kim, D-h., Lee, H., Kwak, J., (2017), Standards as a driving force that influences emerging technological trajectories in the converging world of the Internet and things: An investigation of the M2M/IoT patent network. Research Policy, 46, 7, 1234-1254.

[31] https://www.bgs.ac.uk/download/science-briefing-paper-who-owns-geothermal-heat

[32] file:///C:/Users/Mark%20Palmer/Downloads/SSRN-id3942391.pdf

[33]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/827907/RPC_case_histories_-_Primary_legislation__August_2019.pdf

[34] https://geothermalcommunities.geonardo.com/assets/elearning/10.14.S12Paper069.pdf

Northern Ireland's areas of natural outstanding beauty. We believe that this could be considered to provide clarification for geothermal project developers and prevent unnecessary costs.

3.0. SHOWCASING GEOTHERMAL BUILDABILITY

An important activity for building the geothermal sector in Northern Ireland is in showcasing buildability practices through flagship projects and this part of the report now outlines those experiences. Our findings indicate a small patchwork of geothermal projects in Northern Ireland that are mostly of an early-stage nature and difficult for the "show and do" institutional stitching activities. Some projects are at an early feasibility stage, some at planning, some awaiting connection, while others are simply hard to find.

The fact that showcase examples exist outside Northern Ireland and elsewhere in the UK and in the EU where the technology is mature shows that the challenge is one of bringing about institutional change, building out and showcasing working cases in Northern Ireland. That visible public leadership is clearly signalled by Her Majesty The Queen at the Buckingham Palace estate, the NATO headquarters in Belgium, the European Parliament and the Bundestag in Germany.

3.1 Strategic importance of flagship visibility and experiences

Visibility is an enduring characteristic of any business flagship activity. In searching for the deployment of geothermal technology in Northern Ireland, this activity could be analogously described as *'a lonely secret'*, with limited end-user awareness outside technical geoscientists and geo-consulting specialists. The geologist community are the first to acknowledge this as the interviews attest and this is not a criticism of that community. We believe that strategic geothermal technology showcasing could be undertaken in a holistic way.

3.2 Build assessment and reporting

We find that decisions to adopt/disadopt are not made arbitrarily and our research provides insights into the broader decision practice and process. A noticeable feature of that demonstrating process is the imprinting role of the construction and financial sector institutions.

The Royal Institute of British Architects (RIBA) operate standards and challenges design teams to design with a focus on sustainable outcomes from the outset of the project, with a defined set of stages when interacting with clients.[35] Stage 4 provides a Low/Zero Carbon Energy Report. As part of the overall RIBA Stage 4 submission, architects and building consultants produce a final report on the LCZ Technologies that are available for new proposed building works and provide recommendations for the technologies that best suit the proposed building type and its functions.

Additional assessment tools are used including, but not limited to, Low Carbon Energy Assessor (LCEA) with CIBSE Chartered Institution of Building Services Engineers (CIBSE).[36] In addition, the *Building Research Establishment (BRE)* has also established a number of tools for the measurement of the sustainability of a building, through both design, construction and operation and these are covered by the BREEAM suite of manuals with the current version being the 2018 New Construction Manual, specifically tailored to Northern Ireland.

[35] https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-plan-of-work

[36] https://www.cibsecertification.co.uk/About-Us

We also find that geothermal projects must endure financial regimes and imprinted immediacy of short-term productivity outputs. The *Institute of Management Accountants (IMA) and Association of Chartered Certified Accountants (ACCA)* operate prescribed standards on budgetary requirements, financial models and metrics with a focus on forms of risk models and outcomes. We find that demonstrating geothermal technology is not aligned with the long-term geothermal technology lifecycles, long-run savings and productivity models.

3.3 Governments as demonstrators

Geothermal use has been successfully demonstrated by governments throughout the UK and European Union.[37] [38] It is clear that governments elsewhere are a demonstrator of LZC technologies in use. Effectively, the government is employed as the flagship for others to follow its lead.

NI Assembly government. To build confidence, interviewees are calling for visible government geothermal demonstrators at the Stormont estate and at key government infrastructure builds (e.g. hospitals, healthcare, transport hubs, schools). Interviews suggest that plans are afoot on working with other government departments (e.g. DAERA, Department for the Economy, Department for Health, Department for Infrastructure) as well as with local councils to create public geothermal demonstration leadership. To build sector confidence, the findings also suggest that InvestNI could lead out on their programme of capital investment across all sectors and build programmes in Northern Ireland and not exclusively within the division of energy per se.

Local councils. An important aspect of building confidence and providing the local councils with the scope and responsibility in the development of renewable energy actions outlined in their Local Plans and which can connect and 'link in' with the NI 22-point Action Plan in relation to the decarbonisation of heat of council estate and economic development.

Case 1: Belfast City Council, Belfast Destination Hub Building, a flagship project

Belfast Destination Hub Building

Location: Former Bank of Ireland Building, 92 Royal Ave, Belfast BT1 2GU

Flagship pioneer: Belfast City Council

Sector: Leisure

Type: Shallow, single loop, exploratory, heat

Boreholes: Design

Status: Feasibility stage

The Belfast Destination Hub Building is planned to be a redevelopment of the former site of the Bank of Ireland building on Royal Avenue. The Belfast Destination Hub Building is at an early-stage of development, with the Belfast City Council seeking to consider the feasibility of geothermal heating. This project is an important flagship opportunity not only for showcasing Belfast City and Northern Ireland more generally but specifically showcasing the role of LZC technology such as geothermal heating in the Northern Ireland context. This form of showcasing is evident in cities throughout the EU. This project also shows the early-stage nature of geothermal and the strides necessary for realising the potential for the widespread deployment of this important renewable resource.

[37] http://geodh.eu/project/southampton/

[38] https://www.bridgend.gov.uk/residents/housing/caerau-heat-scheme

3.4 Strategic market framework

The interview findings highlight the need for a strategic market approach toward building out the early-stage niche development. Effectively this is a holistic approach to sector-building and is not driven by the interests of the few, but the interests of the whole sector. That form of approach aims to safeguard and build a sustainable approach to sector-building. One of the key drivers of geothermal development in countries such as France, Germany, Iceland, Sweden or the Netherlands, Sweden, was the broader mutualised approach with actors working together or incentivised to work together in the development of geothermal resources.

The derisking mitigation questions safeguard against a full failure or collapse in sector activity where there is a large failure of geothermal resources. The mutualising principle runs through the forming of consortiums in public and private organisations, a geofund, and across R&D activity sharing, collective standards and certification development, skills capacity-building and collaborative supply chain developments in drilling parts and fluids, heat pumps and pipe networks. We believe that this consortium-type market approach institutionally safeguards against any individual arbitrage effects or unintended market profiteering from policy or regulatory market inefficiencies at an early niche development stage.

Case 2: The Geothermal NI Project

Geothermal NI consortium with industry and academia

Location: Antrim

Pioneer: MJM Renewables - led consortia

Sector: Industrial and commercial

Type: Deep

Boreholes: Planning stage

Status: in progress

MJM Renewables, Geothermal Engineering Ltd, ARUP and Queen's University Belfast are working together as part of the 'Geothermal NI' consortia on the development of a deep geothermal project. MJM Renewables are presently exploring viable sites with the ultimate goal of developing a deep geothermal project that delivers continuous renewable heat to large commercial and industrial end users in a health care setting, as well as for local homes.

3.5 Geothermal operations capability and capacity

Early-stage niche development means that activities are ad hoc, fragmented and less organised. However, fragmentation is widely seen as one of the most challenging attributes of geothermal project activity and is very marked in the application process and on the drilling side where it is limited to a small sample on the island of Ireland (work appears to be cross-border in nature), and where a high proportion of small and micro-businesses operate in informal networks, satisfying local market demands mostly on water wells. The interview evidence also suggests that there is a close-knit community of experienced consultants with geology and hydrogeology expertise who are collaborative, supportive and are proactively reaching out to end users and the government partners.

To build and showcase the geothermal sector, having a supply chain capability and capacity to support the geothermal build opportunities will be critical. This supply chain ranges from the specialist design and consultancy services, rig drilling and equipment, materials, the ground source heat pump equipment, distributors and reselling agents of equipment,

installation and maintenance, project and site management, data management and ongoing data and network project governance.

3.6. Mobile Geoenergy Observatory

To help build confidence in the sector a **Mobile *Geoenergy Observatory*** has been called for. Effectively the **Mobile *Geoenergy Observatory*** is an underground research science laboratory that seeks to create a controlled environment for geoscience ideas to be explored, tested and examined. The UK Geoenergy Observatories (UKGEOS) project has been led by the Natural Environment Research Council (NERC) – UKRI – and the first UK observatory, the Geoenergy Observatory in Glasgow opened in December 2020. Respondents raised the question: how does the geothermal sector undertake R&D project activity and scientific research on the ground in Northern Ireland? Respondents highlight the critical need for and importance of acquiring data in a controlled laboratory environment to build confidence in developing geothermal opportunities. We believe that given the size of Northern Ireland, a more flexible dual-purpose and Mobile Geoenergy Observatory might be better suited and could add additional sector R&D capacity, while also leaving a positive social value hallmark on communities across Northern Ireland in the Net Zero energy transition.

East-West geothermal capacity building. The interviews called for policy support through East-West institutional arrangements, perhaps with a digital corridor with an existing centre close to UK North Sea oil and gas field operations. One possible consideration that might support NI geothermal capacity-building is the recently rebranded Net Zero Technology Centre in Aberdeen, Scotland (formerly the Oil and Gas Technology Centre (OGTC).[39] This type of arrangement could provide an East-West institutional corridor with the offshore drilling community, with some geothermal-related elements investigated in Northern Ireland, particularly with the recognised advanced manufacturing excellence in Northern Ireland (AMIC) at the Global Point Business Park, Newtownabbey.

North-South geothermal capacity building. The interviews called for policy support through North-South institutional arrangements, perhaps through an institutional digital corridor with iCRAG centre which is hosted by University College Dublin (UCD). iCRAG comprises 150 researchers across eight universities and institutions and is supported by Science Foundation Ireland, Geological Survey Ireland and industry partners.

Both the North-South and East-West institutional arrangements could supplement a Mobile Geoenergy Observatory to further leading-edge scientific research for benchmarking and inter-comparison of all geothermal activity in Northern Ireland.

3.7 Low and Zero Carbon (LZC) Technology Centre NI

Respondents are calling for the Department for the Economy to consider taking a strategic management approach and tie together the various LZC technology agendas on road to net zero. Bringing together in close proximity a range of groups, centres, institutes and offices located under one umbrella for end users might help transition the road to net zero and make this road more accessible to end users across Northern Ireland. To help level up the institutional market scaffolding conditions, a *LZC Technology Centre in Northern Ireland* has been called for in the interviews.

Low and Zero Carbon Technology Centre. Interviewees raise the issue of a LZC Technology Centre within the context of geothermal capacity-building support. Our research clearly shows that, in parallel to a Mobile Geothermal Observatory, the respondents raised the question: How do you deliver net zero targets on the ground in Northern Ireland? How do you consolidate all of the different centres, institutes and NGOs in the decarbonisation

[39] https://www.netzerotc.com/about-us/our-purpose

agenda to deliver net zero targets on the ground in Northern Ireland? Addressing these questions, we believe, can build confidence in the geothermal sector in Northern Ireland.

Northern Ireland has one centre - The Centre for Advanced Sustainable Energy (CASE) which is operated from within Queen's University Belfast. The @Economy_NI 22-point Action Plan in 2022 for the Path to Net Zero outlines a provision for the establishment of LZC technology offices such as hydrogen and institutionally linking this activity could help to transition the energy market, including geothermal activities. Interviewees suggest a more industry-led and policy-led LZC Technology Centre could be the institutional vehicle to allow government departments to align LZC technology project-building with the pathways towards the international standard environmental categories: climate change mitigation, climate change adaptation, natural resource conservation, biodiversity conservation, and pollution prevention and control[40] It could also support the distribution of subventions for Net Zero transitions projects – similar to the provision made in the Environment Act (1990) and afforded to projects elsewhere in the UK. [41] One possible consideration that might support NI geothermal capacity-building is to institutionally decouple The Centre for Advanced Sustainable Energy (CASE) from Queen's University Belfast[42] and rebrand this centre as the LZC Technology Centre of Northern Ireland and to boost this centre.

3.8 Geothermal heating flagship project demonstration

Our findings indicate a small patchwork of geothermal heating case projects in NI. Queen's University Belfast is an institutional pioneer using geothermal across their estate. Interestingly, the early stage cases are not only based on built environment heating solutions, but also address increasing energy loads from 'big data centres' as well as other heating applications for 24/7 agriculture and healthcare solutions.

Case 3: Queen's University Belfast, Management School flagship project

QUB Management School

Location: Riddel Hall, Stranmillis, Belfast

Pioneer: Queen's University Belfast

Sector: Education

Type: Shallow, closed-loop

Boreholes: 40 wells drilled

Status: To connect and complete by 2023

The QMS building is within the overall Riddel Hall site on the Stranmillis Road in south Belfast. The Management School has been expanding and the university developed plans to build a 6500 sq metre building. The Riddel Hall project adopted geothermal technology for heating the building. The Low Carbon Report was critical in the adoption as part of the RIBI stage 3 process. Renewable energy systems were presented as part of a range of LZC technologies, including wind turbines, photovoltaic panels (electricity generation), solar Thermal Panels (Water Heating), and Biomass/Waste Wood Boilers and Geothermal (Ground Source Heat Pump) Heating Systems. Economic models and cost calculations that drive resource allocations of costs were not the primary drivers, as the longer-term growth and expansion prospects, coupled with taking long term perspectivising on the

[40] https://www.icmagroup.org/assets/documents/Sustainable-finance/2021-updates/Green-Bond-Principles-June-2021-140621.pdf.

[41] https://www.legislation.gov.uk/ukpga/1990

[42] https://www.case-research.net

life-cycle of the building, as the Estates Manager and the University Director of Operations experiences below highlight.

We find evidence from the interviewees of local start-up entrants entering the nascent market. These geoscience technology-led firms are engaged in pioneering work on deep geothermal activity with heat exchangers, enabling and testing the techno-economics for energy systems, thermal dynamics and heat pumps systems.

Case 4: Case Project, Ulster University partnership with industry

CASE project

Location: Various across NI

Pioneer: Ulster University in partnership with CausewayGT, Enisca and Atlantic Hub

Sector: Industrial and commercial

Type: Shallow and Deep, closed loop

Boreholes: Planning stage

Status: In progress

This InvestNI funded project focuses on the decarbonisation of industry using geothermal energy with high temperature geothermal heat pumps as the key focus area for advancing R&D development practice on closed-loop systems in deep wells. This project is led by Professor Neil Hewitt, Ulster University and in partnership with industrial partners, including CausewayGT, Enisca and Atlantic Hub. Both deep and shallow boreholes are being explored across multiple industry sectors.

3.9 Geothermal cooling demonstrator solutions

There is evidence of two flagship projects deploying geothermal technologies for cooling in Northern Ireland. With Net Zero carbon new build agenda, it is suggested that there is a clear opportunity for the role of geothermal in cooling within a repertoire of energy solutions and within a hybrid system. The Lyric Theatre have tens of thousands of local as well as tourist visitors going through its doors and this shows the City of Belfast in a positive environmental light.

Case 5: Lyric Theatre, Belfast, geothermal cooling in control environments

Lyric Theatre, Belfast

Location: Stranmillis, Belfast

Flagship pioneer: Lyric

Sector: Leisure

Type: Shallow Geothermal Energy systems in the Sherwood Sandstone

Boreholes: 1 well drilled

Status: Completed, 2010

The Lyric theatre utilises Shallow Geothermal Energy in the form of a single ground source borehole drilled into the SWS aquifer for cooling purposes within the building. The main

auditorium and studio theatre spaces are cooled in a heat exchange process using a plate heat exchanger. The resulting 'warm' water plume is then discharged to the Lagan River. The building is 12 years old and there are no visible evidence of the geothermal technology installed.

Another case demonstrator can be seen working at Queen's University Belfast's The School of Biological Sciences (SoBS). Here, the geothermal technology is working in the demands of high controlled and precision temperature environments for cooling purposes. We believe there are technology deployment opportunities in similar high controlled temperature environments in the pharmaceutical and horticultural sectors across Northern Ireland, including in the Health & Social Care Trusts, NI Water, Randox and Norbrook Laboratories to cite but a few.

Case 6: QUB The School of Biological Sciences (SoBS)

QUB The School of Biological Sciences (SoBS)

Location: Stranmillis, Belfast

Pioneer: Queen's University Belfast

Sector: Education

Type: Shallow, single loop

Boreholes:

Status: completed

Science laboratory spaces are cooled in a heat exchange process in the installation at the QUB School of Biological Sciences. The geothermal technology is a doublet well open loop borehole style system, with the two wells drilled to 100m depth. The water at this depth ranges from 12-15^{o}C seasonally. The doublet system is used to cool 14 laboratory rooms. The School of Biological Sciences (SoBS) has a Shallow Geothermal duplet well open-loop ground source cooling system in place. The system switches on at nighttime to provide cooling to 14 laboratory rooms. Water is abstracted from one well via a pump system to a plate heat exchanger where the water is warmed in a heat exchange process. The 'warm' water plume is then discharged to a second well back into the aquifer. The wells are 120m deep into the SWS aquifer.

3.10 Demonstrating heat networks

There are presently no consumer or industrial demonstration projects in Northern Ireland for heat networks. However, elsewhere in the U.K and across the EU, there are examples of successful heat networks. The heat networks are normally installed and operated by a specialist management company known as an Energy Services Company which also maintains the system and runs the metering and billing service. One interviewee concluded that a contest or community competition for heat network acceptance installation might encourage willing consumer and industrial communities. Academic evidence suggests that contests effectively solicit innovation. Elsewhere in the UK, heat networks have been linked with disused mines and developed in conjunction with authorities responsible for those mines, with 5th generation heat networks now being considered or installed.[43] We believe there is an opportunity for geothermal heat networks to be established in Northern Ireland, working in conjunction with the Department for Communities and Department for

[43] https://researchbriefings.files.parliament.uk/documents/POST-PB-0046/POST-PB-0046.pdf p.26.

Infrastructure, the Northern Ireland Housing Executive, Northern Ireland Federation of Housing Associations (NIFHA) in relation Social Housing Projects, along with the UK Cities Climate Investment Commission (UKCCIC), City Deals and High Street regeneration schemes. Consideration of network heating systems in the regeneration of city centre zones for shared community living, meeting social, affordable and private housing needs.

3.11 Geothermal technology hybridization and sector coupling

Some of the interviewees called for market-based incentives for organising energy sector-coupling, and energy 'hybridised collaborations' which are not exclusively tied to one technology application. We believe that there is a continuum of geoenergy solution opportunities, but careful consideration should be given before proceeding with exploratory projects to ensure that they should not detract from the early-stage collective sector building in Northern Ireland. Internationally, it is well recognised that the use and management of the subsurface can play an important role not only as a natural energy heat source, but also in electrical, and material storage for natural gas, methane, hydrogen, carbon dioxide, and wastewater. In addition, geothermal can be used to produce green hydrogen when there is an oversupply of electricity on the grid. Despite these promising developments, we believe that confidence-building in the development of the sector in Northern Ireland should be the policy priority. This will ensure stability and institute geoenergy as part of the community norm in Northern Ireland.[44]

3.12 Narrowing and closing execution and evaluation gaps

Our research shows that, with the experience of the geothermal projects, there are two gaps.

- The first gap is in execution, which relates to the difference between the intended actions and how well the geothermal institutional scaffolding supports or allows the sector to execute actions.
- The second gap is in the process of evaluation, or the degree of ease or difficulty in assessing the geothermal environment and application.

Narrowing and closing execution gaps. There was an awareness of managing the geothermal project and learning how to do things with the geothermal unknowns. In effect, early flagship pioneers had to take on a more intense evaluation role as well as an issue-selling role to convince others of the geothermal merit. There was a basic fear of owning a project that became a market outlier.

Narrowing and closing evaluation gaps. There was an aspiration and willingness to assess the role of geothermal as part of a flagship project build. The flagship project leaders were asking for assistance and support with finding the secondary desktop information and for that to be a standard. The geothermal terms of reference was difficult to understand. It was evident that accessing information was typically burdensome. Some interviewees were agitated by this burden. Interviewees' called for plans to build more awareness of geothermal heating and cooling systems as well as addressing the image misperceptions on the subsurface.

4.0. CONCLUSIONS

The present report outlines the confidence-building actions needed to build the geothermal sector in Northern Ireland. Unlocking Northern Ireland's geothermal resources will help contribute toward commitments to Net Zero targets and those actions mandated within the

[44] Hargadon, A. B., & Douglas, Y. (2001). When innovations meet institutions: Edison and the design of the electric light. Administrative Science Quarterly, 46, 476–501.

Climate Acts for NI. Operationally, building the geothermal sector can help contribute toward the NI Executive's Green Growth Strategy and, in particular, the Energy Strategy and two of the 22-point action plan.

This report underlines the importance of building a range of market scaffolds for harvesting both shallow and deep geothermal resources in Northern Ireland. When taken together, it seems clear to us that, as a minimum, these market scaffolds are required to build the confidence to unlock Northern Ireland's geothermal resource.

Approaching the demonstration of geothermal in a holistic way as well as closing the execution and evaluation gaps will help unlock Northern Ireland's geothermal resource. Downstream end-users are mainly evaluating the experience of heat or cooling in terms of the front-facing development and maintenance capacities. By contrast, upstream market actors are evaluating buildability and also drawing on existing regimes on how to evaluate geothermal projects. The existing templates can harm technology innovation and market-making. Unlocking Northern Ireland's geothermal resources will require protective strategies for geothermal technology to shield from existing instituted renewable technologies, fossil fuels, business cases and legislation regimes.

5.0. PROPOSED ACTIONS

This report considers the range of confidence building actions and sub actions that we believe are needed for building the geothermal sector in Northern Ireland. The recommendations are set out below for consideration. We also recognise that some of the proposed actions are outside the remit of the Department for the Economy and the GSNI and will require collaboration and support.

5.1. Recommendations: Scaffolding for building geothermal sector confidence

Based on this research, we have identified a set of recommendations in relation to building confidence in the geothermal market sector and these are set out in Table 4.0:

Table 4.0: Scaffolding for building geothermal sector confidence

Geothermal sector-building issues	Recommended actions for consideration
Exploration R&D activity	(1) DfE to bring forward a business case for developing a programme of investment in R&D geoenergy infrastructure in Northern Ireland. (2) DfE to resource and institutionally support geothermal R&D activity in places where individuals can undertake this research activity. (3) DfE to establish a Geothermal R&D organising committee to consult with NERC, the UK Geoenergy Observatories (UKGEOS) and the NI universities to establish a dual-purpose-design mobile R&D facility for deployment within communities.
Protective niche strategy	(4) DfE to build and resource a protective niche strategy for strengthening the geothermal sector, with specific shielding and nurturing policy.
Sector priorities	(5) Geothermal heating and cooling activities to be prioritised in building out the geothermal sector in Northern Ireland.

Multiple narratives	(6) DfE to capture and elicit community voices to ensure that geothermal resources in Northern Ireland are recognised, unlocked and harnessed to benefit all consumers, businesses and communities in a just energy transition.
Evaluation and stakeholder engagement	(7) DfE as custodian of the subsurface resources to create a safeguarding strategic-level oversight evaluation process with governance.
Maintaining temporary sector clusters	(8) Steer and unite sector visions and growth by creating and maintaining temporary sector clusters.
Sector building with government partners	(9) Set the strategic direction with market-making activities while also balancing its responsibly to safeguard the sector and the subsurface resources. (10) Review and draw upon national and international experiences on finding appropriate policy balance of where, when and how to intervene in building the geothermal sector on an interim basis until 2030 and then incrementally to 2050 with bi-yearly reviews. (11) Develop a geothermal energy roadmap for the geothermal sector in Northern Ireland, which reflects, develops and outlines a vision for the sector. (12) Design an interim set of actions that ensure the geothermal niche commercial development is strategic, portfolio-driven within the energy mix.
Standards	(13) Consider how the early stage niche development of the geothermal sector can follow national and international standards. (14) Consider developing one website with universal resource links for the geothermal legislation, regulatory guidelines and procedurality. (15) Consider how to link any geofund or start-up subvention awards with sector-promoting and-growing activities.
Legislation, regulatory framework and procedurality	(16) It is necessary to make legislation, the regulatory framework and procedurality clearer than it is at present. (17) Ascertain which statutory authority prescribes standards of performance in connection to geothermal activity. (18) Northern Ireland geothermal regulatory provisions to consider UK government's 'Levelling up the UK' White paper principles for a successful policy framework as outlined in this report. (19) Undertake a review of policies and regulatory impacts solicited from other jurisdictions, with similar geologies, including but not limited to Sweden, Germany, France, the Netherlands and Denmark and with benchmarks on how NI policy, legislation and regulation can be designed to facilitate development of these resources and to mitigate risk for developer, consumers, the environment and communities. (20) Enhance the clarity given on project steps, procedures and guidelines.
Social licence	(21) Ensure that the geothermal transition is accessible, fair, and without adverse effects on peoples' 'sense of place', their jobs and quality of life. (22) Link geothermal subventions and/or incentives with community social value in developing geothermal projects and beyond procurement social metrics. (23) Link to primary legislation and the statutory authority that sets out consultation and standards performance of geothermal activity. (24) Outline an integrated communication actions plan for community engagement and with social justice groups.

5.2.Recommendations: Showcasing geothermal buildability and visibility

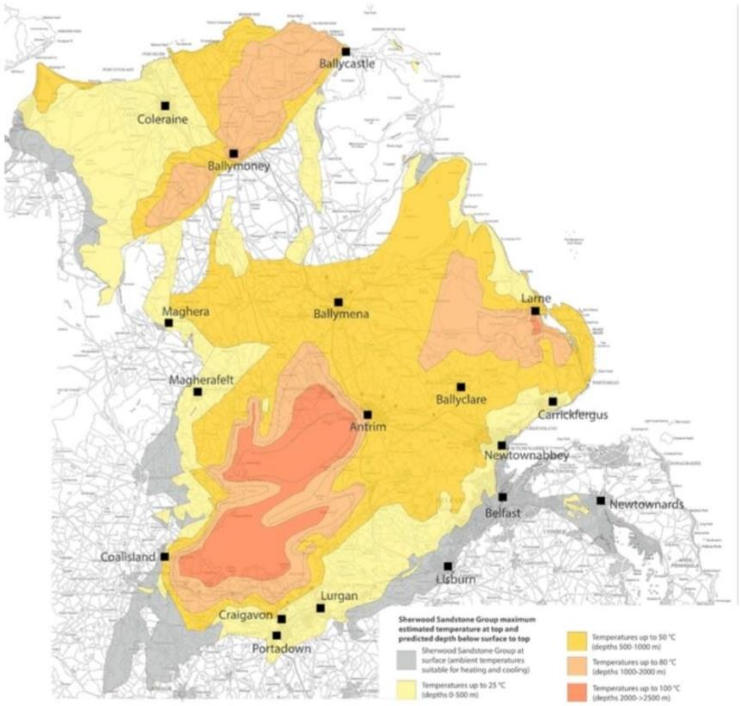
Based on the interviews, we have identified a set of recommendations in relation to demonstrating the buildability of geothermal projects and these are set out in Table 4.1:

Table 4.1: Showcasing geothermal buildability and visibility

Geothermal project issues	Recommended actions for consideration
Flagship visibility	(1) The geothermal shaper community to become more visible in their efforts in demonstrating the scope of geothermal technology applications.
Build assessment and reporting	(2) Develop activities that shed light on geothermal practice and solutions in the presentation of building assessment and reporting process.
Government as demonstrators	(3) Showcase geothermal buildability through visible flagship geothermal demonstrators within the NI Assembly and local council estates.
Strategic market-focused	(4) Showcase geothermal buildability through a strategic market-focused approach that mitigates risks. (5) Enable a strategic market-focused approach not only for delivery purposes but also in the designing, testing, drilling, installing, connecting and monitoring of geothermal sector development. (6) Ensure that deep geothermal projects are multi-stakeholder in nature and mutualised across a range of heating demands and contexts.
Operations capability and capacity	(7) Organise and financially support a workshop to consult and elicit drilling operators' views and experiences. (8) DfE to undertake a skills gap diagnosis and prognosis and to set out a series of actions to build geothermal operations skills to support the development of the sector.
Mobile geoenergy observatory and exploration capacity	(9) Consider the business case for building a Mobile Geoenergy Observatory, scoping out a dual-purpose science-led facility and industry R&D exploration capacity.
LZC Technology Centre for Northern Ireland	(10) DfE to consider building a business case for an industry-solution and-policy led LZC Technology Centre that focuses on a portfolio-driven energy transition with low zero carbon technology advocacy in Northern Ireland. (11) DfE to consider and/or to review with Queen's University Belfast whether The Centre for Advanced Sustainable Energy (CASE) which is operated from within Queen's University Belfast, can be reconfigured/rebranded into industry-solution and-policy led LZC Technology Centre for Northern Ireland and its activities boosted. (12) DfE to harmonise a range of LZC technologies in the implementation of 22-point energy action plan through the vehicle of the proposed LZC Technology Centre. (13) DfE to establish a Geothermal Technologies Office (GTO) within the LZC Technology Centre and to scope out its core activities which could include, but is not limited to, information requests from end users, assist with policy compliance, help integrate decision-making within and across projects, build skills initiatives, licencing of resources, permits for activity (exploration and production), planning and control authorization.

	(14) DfE to consider supporting an East-West and North-South capacity and capability institutional corridors.
Geothermal cooling demonstrator solutions	(15) DfE to organise and financially support a sector workshop to promote cooling geothermal solutions for firms operating within high controlled and precision temperature environments.
Heat networks	(16) DfE to incentivise and promote four closed loop geothermal heat network deployments in new build environments and one open loop geothermal heat network deployment with multi-stakeholder energy demands.
Technology stretching and sector coupling	(17) Geothermal policy and resource allocation should follow the normal temporary cycling between both technology exploration and exploitation. (18) DfE Ministerial action for a hiatus to be placed on commercial fracturing applications in Northern Ireland as a matter of urgency until further research data and academic-led experiments are undertaken within the field and more is understood within the locale.
Narrowing the project gaps	(19) DfE and GSNI to work at initiatives for narrowing the evaluation gaps from the existing geothermal projects. (20) DfE and GSNI to work at narrowing the execution gaps from the existing flagship. (21) DFE and GSNI to set out a UK White paper on the feasibility, design and installation of Ground Source Heat Pumps.

Appendix 1: Triassic Sherwood Sandstone Group (SSG) Map for NI

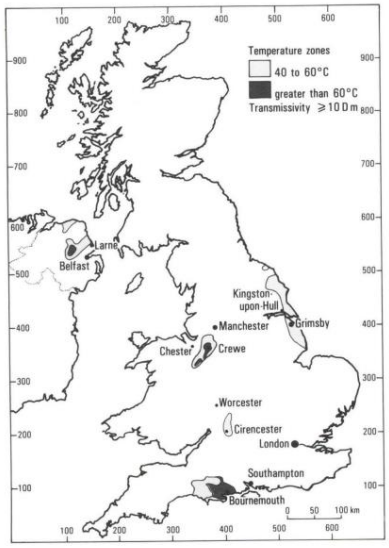


Appendix 2: Downing and Gray's UK Geothermal Resource table and map

Table 10.5 Identified Resources of the Permo-Triassic sandstones expressed in units equivalent to million tonnes of coal (Mtce)

Basin	Aquifer	Temperature °C		
		20–40*	40–60*	>60†
East Yorkshire and Lincolnshire Basin	SS	1115	922	–
	BPS	19	52	7
Wessex	SS	29	105	69
Worcester	P-T	676	112	–
Cheshire	P-T	182	331	56
West Lancashire	P-T	19	–	–
Carlisle	P-T	12	–	–
Northern Ireland	SS	226	249	48
Totals		3278	1771	180

Estimates assume development with doublets (i.e. two wells – one for abstraction and the other for reinjection).
* Use of heat pumps assumed and hence a reject temperature of 10°C.
† Assumes heat pumps would not be used and hence rejection at 30°C.
BPS Basal Permian Sands
SS Sherwood Sandstone
P-T Permo-Triassic sandstones (undifferentiated)
Total annual coal consumption in the UK is about 100 million tonnes.



10.3 Potential low enthalpy geothermal fields in the UK as defined by a transmissivity of more than 10 D m and a temperature of more than 40°C.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