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

QUEEN'S UNIVERSITY BELFAST

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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.

We believe that the invisibility of geothermal technology in use is emblematic of its *'Cinderella stepchild status'* amongst other low and zero carbon (LZC) technology solutions. The recent Climate Act legislation that mandates net zero greenhouse gas emissions by 2050 in NI is therefore a critical pivoting transition pathway for bringing about a levelling up of the institutional conditions for geothermal activity and other LZC technologies more generally. Not least it is an opportunity for policy-led geothermal market-making.

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, moreover, invites the geothermal shaper community to engage in upstream nudging activity as well as downstream showcasing of heat decarbonisation in the day-to-day lives of the people and experiences of communities across NI.

This research suggests that there is a need for mutualised financial support ranging from feasibility consultation, planning and exploration to drilling, a programme of operations, research & development (R&D) activity, along with establishing capacity institutional support arrangements, data capture governance processes, and digital infrastructure, commensurate with sector building activity. This report puts forward several considerations for building the market scaffolding and outlines a holistic perspective for showcasing flagship geothermal projects.

## Key Findings

There are important findings from this research.

Northern Ireland's (NI's) geothermal resource exploration is part of the **inexorable national and international shift toward a circular economy and decentralized energy infrastructure**, where the global decarbonisation imperative has resulted in the emergence of dispersed LZC technologies and a portfolio mix of renewable energy sources such as solar, wind, hydrogen and geothermal.

We find evidence of **over four decades of comprehensive geoscientific geothermal resource assessments and two decades of political discussions** on geothermal interest amongst NI elected representatives, without policy-led action on the ground. Significantly, though, the recent NI Path to Net Zero Energy Action Plan 2022 provides provision for two key geothermal actions in points 15 and 16. Point 15 details action to develop & commence delivery of low carbon heat demonstrator projects, and point 16 details action to develop and commence delivery of a geothermal demonstrator project.

The geothermal energy sector in NI has been recently described as, "either nascent (shallow ground source heat pumps (GSHPs)) or non-existent (deep)". That **market descriptor remains accurate as of April 2022**.

The **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-stage nature. In NI, we find that **Queen's University Belfast is an institutional pioneer** in NI of geothermal technology deployment across its built estate. Building the sector will require **long term support, institutionally, politically and financially**. This transition work can be progressed by building out a niche strategy.

In building confidence in the sector, we find that investment in the **geoscientific evidence-base and R&D activity** is a critical requisite for unlocking NI's geothermal resource.

**NI finds itself still out of step with elsewhere** in the UK, EU countries, and internationally further afield, where geothermal (shallow and deep) is a mature technology and is part of the solution mix of dispersed and LZC technologies and renewable energy sources. This shows that the challenge is one of bringing about institutional change and portfolio decision-making which should be considered as much a **market breakthrough phenomenon as a technological breakthrough phenomenon.**

We find little evidence of a specific percentage contribution target for geothermal heat and also overall heat decarbonisation targets in NI. There appears to be no annual digital reporting of energy carbon in use for businesses in NI.

An assessment of the current market scaffolding of the geothermal sector in NI identifies several areas where there is buildability work yet to be done. This includes the building of; **(i), exploration R&D activity (ii), protective niche scaffolding (iii), multiple narratives and energy value system (iv), maintaining temporary sector clusters (v), evaluation and stakeholder engagement (vi), market-making with government partners (vii), ensuring high standards (viii), Legislation, regulatory framework and procedurality, and (iv), social licence.**

We find strong evidence calling for a clear definition of heat as a resource along with the provision of geothermal legislation, a regulatory framework and enhanced procedurality.

We find some preliminary **insights into the subsurface property rights question**; there is taken-for-granted and automatic entitlement (i.e. the *ad coelum* doctrine), while others emphasise the 'vicinity control' question and the ability of one geothermal project activities to influence the subsurface conditions of surrounding geothermal projects. We believe that it is necessary to try to make the subsurface property rights question clearer than it is at present. In this regard, there is **strong evidence of a science-led and informed approach from the Department for the Economy (DfE), supported by the Geological Survey of Northern Ireland (GSNI),** and also preparatory reviews of common UK geothermal policy frameworks being assessed,

benchmarked and created. We believe this informed approach would also open the opportunity to explore the subsurface property rights question in a more holistic manner to include other subsurface resources such as groundwater and lithium for example.

We find that there is **no industry voice or a single platform** for managing multiple voices and the means for accommodating interests, groups and opinions within NI. A clear sector voice and articulation of the geothermal project governance and related steps might help to mobilise and support professional certification activity. We find that temporary sector cluster activity helps to organise the sector at the nascency stage.

Our findings indicate a small patchwork of existing geothermal projects with **a remarkable lack of visibility and absence of awareness of geothermal technology** in Northern Ireland. Previous geology research shows that one of the UK's largest Triassic Sherwood Sandstone Group (SSG) formations is predominant across Northern Ireland, particularly in the Greater Belfast area, where it is relatively shallow and there is potential for this type of geothermal energy use to grow (See Appendix 3). This is arguably **Northern Ireland's lonely secret,** with little, or any, public and end-user awareness outside technical geoscientists and geo-consulting specialists. On balance, we find that opportunities for R&D data collection have been missed on early-stage geothermal projects which, hitherto, could have helped showcase the technology deployment and the resources more generally.

We find surprising omissions in stakeholder-evidenced workshops recently held on heat decarbonisation in Northern Ireland where **the role of the geothermal resource has been ostensibly treated as a Cinderella stepchild technology**. In short, we find technology selection bias in the levelling up of the net zero energy solution mix.

There is no visibility of geothermal deployment in the pioneering sites after connection and completion. Where geothermal technology is installed, it is not visibly mentioned at the entrance of the building, foyer, or website in terms of environmental efforts to decarbonise heat. This is a bit surprising given mandatory environmental reporting in built environments, but also the extent of efforts undertaken in showcasing corporate social responsibility (CSR) and sustainability efforts in other mediums of communication.

**We find that NI presently does not have a geoenergy observatory**. Both Scotland and England do. We find evidence calling for a **dual-purpose Mobile Geoenergy Observatory** to ensure that geoscience and R&D activity is built and is commensurate with sector developments. We find that a key sector confidence-building outcome of having **a geoenergy observatory is that it helps to bridge the vicious cycle of no data/no project and vice versa**. This is viewed as important for investors. Additionally, we find complementary R&D activities and capacity bases that could be availed of with **East-West and North-South institutionally supported arrangements.**

We find an opportunity to institutionally bring together geothermal activities within a **LZC technologies centre** that captures the operational activities of the Path to Net Zero Energy Action Plan 2022 and that which is both industry-led and policy-led.

Amongst the interviewees, there was a palpable awareness of the integral role of the government in the buildability of the geothermal sector, in effect, as the market-maker and market-custodian. There are calls that the government both at the NI Assembly level and at the local council level, should lead out and demonstrate geothermal projects. Government is the largest aggregate energy consumer and has a large estate of buildings, primarily in Health, Infrastructure, and Education, but it is difficult to ascertain the level of heat decarbonisation from existing and new developments of the estate, with limited key performance indicators (KPIs) present.

We find some evidence from the sampled **local councils** in NI, notably Antrim and Newtownabbey Borough Council, Belfast City Council (BCC), Derry City & Strabane District Council, an interest **in pursuing geothermal project prospects,** but that the councils are calling

for more institutional niche shielding protection. We find a willingness, but also a need for more information, support, understanding and knowledge transfer in relation to geothermal activity.

There is some evidence of innovative council network collaboration on net zero projects, working for the benefit of all citizens across NI. **Harnessing this council 'super additivity' will be critical in developing, mutualising and accruing the social benefits for all communities** from geothermal projects across NI.

Despite the flagship showcasing opportunities, we **find little evidence in the recent announcements on capital works in NI,** including for major public school building work programmes, provision of residential home/hotel and spa developments, or in retail horticulture and how such capital projects could unlock geothermal resources.

If NI is to build, grow and maintain a geothermal industry, it initially needs a geothermal niche strategy with a broad **market-focused framework that builds** policy, standards, certification programmes for utility providers, standardisation protocols, skills development and training programmes. This strategy will need to be carefully designed with mandated responsibility.

Recommended actions for consideration are outlined at the end of the report, along with future research. We believe that the information contained within the report will bring much needed attention to areas for discussion at **#NIgeothermalweek.**

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# 1.0 INTRODUCTION

This report was commissioned by and compiled for the Department for the Economy (DfE), with support from the Geothermal Advisory Committee (GAC) in Northern Ireland (NI). The purpose of the GAC is to inform the development of the geothermal sector as a strategic low-carbon source of both heating and cooling, while also creating jobs in Northern Ireland.

The methodology of this report followed the Department for Environment, Food and Rural Affairs (DEFRA)/Natural Environment Research Council (NERC) guide entitled, *'The production of quick scoping reviews and Rapid Evidence Assessments: A how-to guide*', and is outlined in Appendix 1, along with a glossary of abbreviations.

Geothermal energy is defined as "the heat generated and stored in the ground and is a source of low-carbon, renewable energy."[1] The building of the geothermal sector in Northern Ireland is set within the broader circular economy and distributed energy resource context. The idea of the circular economy combined with Distributed Energy Resources (DER) is emerging across the UK, EU and internationally further afield.[i] The emphasis is now on showcasing circular energy transitions, with a more decentralized energy infrastructure, where a mix or portfolio of dispersed and Low & Zero Carbon technologies (LZC) sources such as solar, wind, geothermal, hydrogen fuel cell, and battery installations sit alongside and/or are integrated with the larger power grids, storage and circular energy systems.[2] Understanding the location and potential of renewable energy resources is a crucial pre-requisite to their utilization, and the building of the geothermal sector in Northern Ireland. The geothermal potential of the geology of Northern Ireland and the subsequent mapping of that activity as a geothermal heating and cooling resource has been reported elsewhere and is not within the remit of this report.[3]

This report aims to address the challenge of building confidence to ensure market breakthrough, institutional change and the building of the geothermal sector. We refer to this as building the institution or market scaffolding.[ii] In this report, we scope out the confidence-building actions that link sector potential with actual geothermal projects on the ground across NI. In doing so, we provide insight into existing geothermal market-based activities and flagship project experiences in NI. The report has three main sections:

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

Finally, the report concludes and outlines a set of recommendations for consideration by the NI Department for the Economy (DfE). This is an independent report produced by academics from Queen's University Belfast for the NI Department for the Economy (DfE).

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

[2] https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

[3] http://nora.nerc.ac.uk/id/eprint/531393/33/GSNI-%20NI%20Geothermal%20Energy%20Summary%20for%20GAC%202021_report.pdf

## 1.1 Geoscientific foundations and the N.I. Diamond

The geothermal sector is underpinned by geoscience research and related applied technologies.[4] [5] Much research work has been, and continues to be done, on developing and testing the potential geothermal resources in Northern Ireland (NI).[6]

The Geological Survey of Northern Ireland (GSNI) has been at the forefront of establishing a geoscientific evidence base. GSNI convenes a monthly meeting of the NI Geothermal Advisory Committee (GAC) and also reports annually on its activities in NI.[7] The GSNI office is situated within the NI Department for the Economy. The current and future role of GSNI is critical in building the geothermal sector in NI.

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.[8] 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. There is widespread referencing to geothermal activity made throughout this period in various NI energy reports, although most of that referencing has been tangential in nature.[9] There have been recorded questions on geothermal on the Assembly floor, for example by D. McKay MLA, among others, along with frequent direct enquires made on geothermal issues and activities to GSNI.[10]

Recently on the 15th of September 2021, a number of MPs expressed an interest in the UK's geothermal potential in a debate in the UK Parliament. The prospect of growing the geothermal sector had been raised during Prime Minister's Questions and subsequently, the MP for Crewe and Nantwich, Dr Kieran Mullan, met with the Prime Minister on this issue. A report has been commissioned to undertake a review into the UK's geothermal heat potential and Dr Mullan is expected to present the findings of his review in Spring 2022.[iii]

The Department for Business, Energy & Industrial Strategy (BEIS) has also convened a workshop in February 2022 to discuss the possibility of a UK Deep Geothermal Task Force with the potential to expand the remit, and membership, of an existing UK Mine Energy Task Force, co-ordinated by the North East Local Enterprise Partnership (LEP).[iv]

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

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[4] 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

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

[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] https://www2.bgs.ac.uk/gsni/GSNI_AR_2019-2020.pdf

[8] 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).

[9] 2009/2010 Assembly session: In a Committee for the Environment Inquiry into Climate Change (Vol. 2), there were two references to geothermal in this 688-page report. An exception of this is the recent NI 22-point Action Plan where geothermal activity is presented in the @Economy_NI 22-point Action Plan in 2022 for the Path to Net Zero.

[10] Verbal communication feedback from the Chair at the Geothermal Advisory Committee meeting on 1/4/2022

elsewhere.[11] Raine and Reay's (2021) GSNI report describes the geothermal energy sector in Northern Ireland as, *"either nascent (shallow GSHPs) or non-existent (deep)."*[12] That market descriptor remains accurate as of May 2022. 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. Our consultation shows that this fact is widely acknowledged by the geology community, with one of the global geothermal associations addressing the issue.

> **Boundary-spanning geo-communities:**
> "We have pivoted away from the internal perspective on geothermal and moved towards a more extraverted and market-facing perspective to engage the public more with our activities, just as solar and wind technologies have done. We are looking at it much more holistically… opening conversations with all of the communities."

*Dr Will Pettitt | Director| Geothermal Rising Trade Association, USA | 06/04/2022*

We believe that growing and transitioning the sector will require the geothermal shaper community to be more institutional boundary-spanning and advance conversations beyond the subsurface potential. 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.

The NI Executive's Green Growth strategy[13] 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.[14] 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.

To build and unlock the potential for the geothermal sector in Northern Ireland, the N.I. Diamond can bring together, open and create dialogues to;

- Unlock LZC, business and environmental efficiencies;
- Create a market-oriented and strategic approach to sector building;
- Absorb expert local knowledge, insight and passion from the emotional work of civic society including groups and communities (for instance, Friends of the Earth NI);
- Harness the research work and science capabilities of local education institutions such as GSNI, Geological Survey Ireland (GSI), Ulster University and Queen's University Belfast;
- Capture the interests and fulfil responsibilities of the NI Executive of energy in terms of security, environment, economic livelihoods and wellbeing.

[11] 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.

[12] Ibid.

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

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

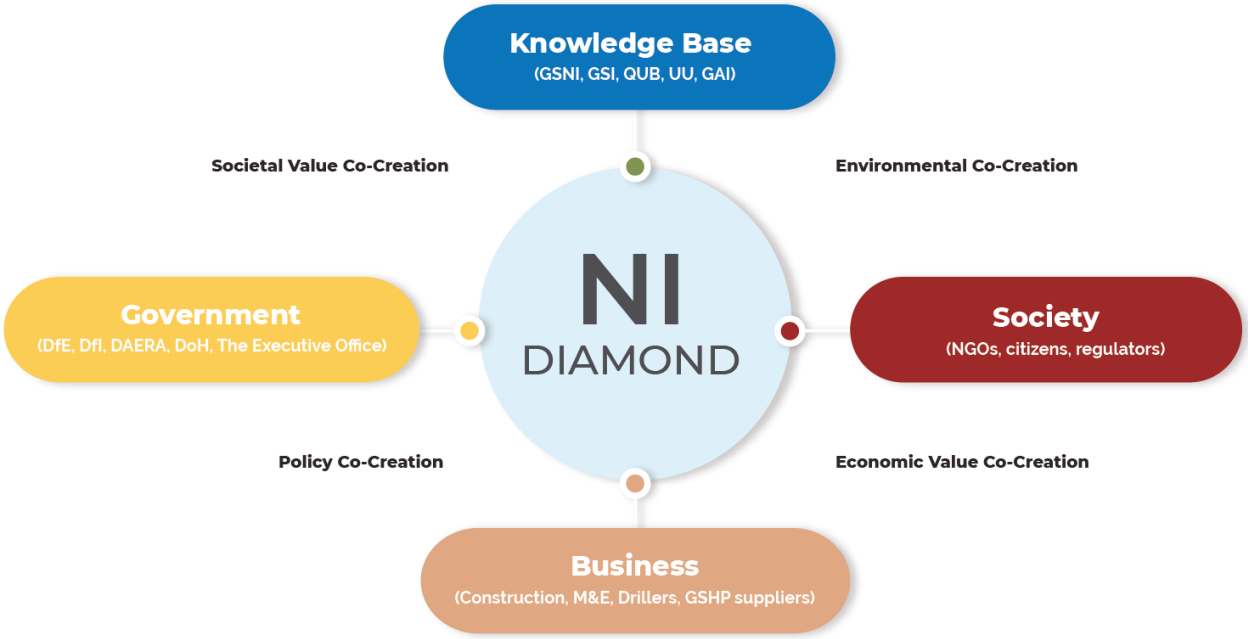


Figure 1.0: Geothermal and the NI Diamond

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

It is important that this engagement is viewed as an integral dialogue and part of building the geothermal sector and market-making; not a monologue or a one-off consultation, but as a series of community engagements and dialogues unfolding to build confidence and trust. In this respect, DfE is doing much in supporting events including the ongoing NI Geothermal webinar series and **#NIgeothermalweek**. These are positive examples of sector engagement. DfE, moreover, might consider proactively using such events to ascertain whether field actions are delivering against policy and to adapt policy where necessary and where appropriate.

We believe that meaningful engagement and consultation framed within this N.I. Diamond model approach will build the geothermal sector in NI and help create organising visions for the geothermal ecosystem. An important measurement outcome of that activity is the way that economic, societal, environmental and policy value is **co-created** at each side of the diamond. Within this, the articulation of organising visions will allow for a considered way forward that is consistent with behavioral attitude change science frameworks (See Appendix 2).[v]

We believe that the long-established geothermal schemes elsewhere in the UK, Europe and internationally further afield, effectively means that building the geothermal sector in NI is a market breakthrough phenomenon. Numerous flagship buildings are heated or cooled by geothermal technology including; the NATO headquarters in Belgium, the European Parliament in France and the Bundestag in Germany. Research by the British Geological Survey (BGS) provides a useful summary of the extent of deep geothermal activity in France, Germany, the Netherlands and Switzerland.[15] Market breakthroughs require insight into the different behavioural attitudes of communities towards the geothermal activities, as outlined in Box A below.

[15] Abesser, C, Busby, J P, Pharaoh, T C, Bloodworth, A J, Ward, R S. (2020). Unlocking the potential of geothermal energy in the UK .British Geological Survey, Open Report, OR/20/049. pp. 22.

**Box A: Types of Organizing Visions in Ecosystem Communities**

**Shaper community**

The shaper community represents technology adopters able to instigate sector change. The shaper community interprets and articulates the organizing vision for a technology and reinforces discourses on "what" the geothermal technology is, the strategies and capabilities of "how" to use it, and the "why" rationales associated with its use.

**Resistor community**

The resistor community perceives that the geothermal technology has weaknesses or disadvantages and these are used as rationale for non-adoption and are particularly skeptical about its benefit.

**Intermediary community**

An intermediary community represents the group where interactions with the geothermal technology occur because a governing institute articulates its use. Buildability mechanisms such as clear guidelines, governance, open communication and training are critical. Examples include the British Institute of Architects, Institute of Planners, the Royal Institute of Civil Engineering and Farmer's Union.

**Follower community**

An organizing vision has the power to create acceptance of the geothermal technology. The organizations that accept an organizing vision once it has become established within the industry represent a follower community. This follower group typically engenders cynicism towards geothermal technological change and, fostering a "why change" attitude.

**Ambivalent community**

This group is unsure of the benefits of participation but might be willing to use the geothermal technology. The ambivalent community has not formed either a positive or negative organizing vision for the technology.

Adapted from Standing, Standing, Love, Gengatharen (2017).[16]

## 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. Recent geopolitical events have resulted in energy volatility and price dynamics which raises questions on fossil fuel dependency, cost models and energy security. The UK Climate Change Commission report noted that, *"the cost-effective path to decarbonisation in NI requires action across **all sectors of the economy** and a joined-up approach."* [17] Extensive analyses on heat decarbonisation pathways by Imperial College London, concluded that, *"…there was **no single solution** and there would be multiple pathways to net zero targets"*[18] (emphasis on both quotations added by the authors). We believe that work strongly guides us towards a portfolio-driven approach in the energy market, as do other policy frameworks.

**Net zero targets**. The strategic importance of building a geothermal sector can be seen in terms of the scale of the deliverables to achieve net zero

[16] Standing, S., Standing, C., Love, P. E., & Gengatharen, D. (2017). The multiplicity of organizing visions. Industrial Marketing Management, 66, 196-204.

[17] Reducing-emissions-in-Northern-Ireland-CCC (2).pdf p.13

[18] https://www.birmingham.ac.uk/documents/college-eps/energy/publications/20200722-heat-policy-commission-final-report.pdf p.22.

targets. Several international and national geopolitical agreements have set the strategic framework for geothermal solutions. Chiefly, the Conference of the Parties (COP) has set out an agreed Climate Action Plan (CAP 21) for reaching net zero no later than 2050.[vi] Within this context, the UK has set a legally binding target of net zero emissions by 2050, with the Climate Change Committee advising that Northern Ireland's contribution is a 100 percent reduction in all greenhouse gas emissions.[vii] Northern Ireland has now also mandated its own Climate Act stating that *"all departments must ensure that the net Northern Ireland emissions account for the year 2050 is at least 100% lower than the baseline."* [19]

**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; building competitive markets; ensuring security of supply; enhancing sustainability; and developing energy infrastructure. 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. Respondents to the consultation supported the development of geothermal energy, and this was reflected in the December 2021 publication of DfE's The Path to Net Zero Energy, which referred to developing opportunities to take forward heat network trials and demonstrators using a range of energy sources including geothermal.

**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, as outlined in Table 1.1 below.

The Path to Net Zero Energy Action Plan provides a holistic view of geothermal provision. Interestingly, the interviewees with the trade associations highlight the importance of viewing geothermal activities holistically and viewing actions 15 and 16 from that holistic perspective.

**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."* A Heat and Buildings Strategy was presented to the UK Parliament by the Secretary of State for Business, Energy and Industrial Strategy (BEIS) by Command of Her Majesty in October 2021 and this reports that infrastructure, such as heat networks, can take time to develop and install. This report sets out the key technologies for decarbonising heating and states how geothermal can play an alternative role.[20]

**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. The societal and business impact of this instability is only emerging.[21]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."* [22] Previous geology research shows that one of UK's key onshore geothermal reservoirs, the

[19] Climate Change Act (Northern Ireland) 2022 (legislation.gov.uk)

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

[21] https://www.reuters.com/business/energy/cucumber-crisis-surging-energy-prices-leave-british-glasshouses-empty-2022-03-31/

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

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 3 SSG map for NI).[23] 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 4). [24] Building the geothermal sector from this Sherwood resource, we believe, can in part transition Northern Ireland towards more affordable, clean and secure energy.

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

Table 1.1: Replace fossil fuels with renewable energy

| Point | Action | Detail | Owner |
|---|---|---|---|
| **15** | Develop and commence delivery of low carbon heat demonstrator projects | Deliver up to £5million of support for the decarbonisation of heat in homes, communities, businesses and delivery of low carbon heat networks | DfE with Northern Ireland Housing Executive (NIHE) |
| **16** | Develop and commence delivery of a geothermal demonstrator project | Undertake feasibility studies to inform future decisions on suitable locations for accessing geothermal heat and to better understand the potential role that geothermal energy can play in Northern Ireland's energy mix. This will help catalyse growth in this sector. | DfE (with GSNI) |

Source: The Path to Net Zero Energy Action Plan 2022, emphasis added by authors[25]

[23] 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.

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

[25] https://www.economy-ni.gov.uk/energy-strategy-action-plan. P.7.

# 2.0 BUILDING GEOTHERMAL MARKET INSTITUTIONS IN NI

## 2.1 Exploration R&D activity

Building NI-wide geothermal resource requires within-sector and cross-sector collaboration and innovation. 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: from heat resource characterisation, site investigation, design of engineering infrastructure, construction and maintenance of facilities, integration between above surface and below surface systems, sensor technology for monitoring system performance and geosphere-engineering interactions and stronger compliance to data analytics and innovative sharing platforms. 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.*

All of this activity requires extensive and granular data, deep analysis and data sharing generated from Research and Development (R&D) activity and other forms of research activity. This is widely acknowledged by the Natural Environment Research Council (NERC)[26] and it is evident throughout our consultation. Establishing a programme of R&D activities is therefore a fundamental part for de-risking the geothermal sector in Northern Ireland. It is the basis of confidence building.

The UK Geoenergy Observatories (UKGEOS)[viii] project is one enabler for this R&D activity and that has been led by the Natural Environment Research Council (NERC) – UKRI. [27] [ix]The first UK observatory, the Geoenergy Observatory in Glasgow, is open for researchers and innovators to use. There was an official opening in December 2020 for the borehole infrastructure and research compounds, while the second phase of infrastructure construction is nearing completion in the next month or so. This part of the Observatory will enable the study of subsurface heat and groundwater flow processes typical of an abandoned mine water heat/storage scheme. [28]

> **Programme of investment:**
> "To build the sector, we need a funded programme of exploration led by a team of at least five people. Policy and regulatory teams will be needed in addition to this. Exploration and growth of the industry will generate large amounts of data and a team to process these data and make it available to support the sector, regulation and future policy is needed.."

*Dr Robert Raine| Geologist | GSNI | 29/3/2022*

The interviewees are clear about the baseline importance of working together on an exploration programme of R&D activity that generates data, and encourages open sharing and rigorous evaluation. Providing this R&D activity not only safeguards the environment but also

[26]http://nora.nerc.ac.uk/id/eprint/528673/1/OR20049.pdf

[27] NERC is the UK research council for investment in environmental science. Natural Environment Research Council. See https://www.ukri.org › councils › nerc

[28] Email correspondence with Dr Alison Monaghan| Geologist | Director UK Geoenergy Observatory, Glasgow| 11/4/22. Further information on this is available at https://www.ukgeos.ac.uk/facilities/glasgow

provides the gateway for the commercialisation of geothermal activities. The importance of exploration data predominates in capital investment appraisal and the financial means for building the sector.

> **Exploration data analysis:**
> "The investors are looking for this exploration data. If that data is not there, it might be a disincentive. Then when there are not enough geothermal projects, the data is not there. So it becomes a vicious cycle. No data brings no geothermal investment, which, in turn, equals, no geothermal projects, then no data and so on and so forth. So the geothermal laboratory bridges that cycle."

*Dr Alison Monaghan| Geologist | Director UK Geoenergy Observatory, Glasgow| 4/4/22*

> **Matching principle:**
> "There is a lesson in getting the right balance between the drilling costs and R&D investment. Factors like unexpected ground conditions might increase drilling time and drive up costs which means that R&D testing is cut short. Logging and understanding pressures, temperatures, the flow zones and rates, how the reservoir changes over time and connectivity between the wells are all equally important. Pressure on finance can result in having to reduce the time spent on testing which is not an ideal or strategic long-term approach to the R&D programme ..."

*Lucy Cotton| Geothermal Group Manager & Senior Geologist| GeoScience Limited United Downs and Eden| 4/4/2022*

Within this exploration programme of R&D activity, there could be policy supporting collaboration with the UK Geoenergy Observatories as well as other international centres including, but not limited to, the Net Zero Technology Centre in Scotland (previously Oil and Gas Technology Centre),[29] Norwegian Centre for Geothermal Energy Research (CGER), the University of Utah (Forge), University of Wisconsin-Madison (UW) and Lawrence Berkeley National Laboratory (LBNL) in the USA, and Sinopec Research Institute of Petroleum Engineering (SRIPE) in China. Geothermal research events could be hosted in NI at both universities. More generally, international intergovernmental organisations such as the International Renewable Energy Agency (IRENA) can also support and bring confidence to countries in their efforts to create sustainable energy futures.

The role of data, data sharing and establishing a commensurate programme of R&D activity with the borehole exploration, could be recognised and incorporated into policies, particularly credit for sharing and mitigating against negative early-stage competition effects. The building of the geothermal sector, we believe, requires collective action and 'zooming out' from individual orientated remits and narrow project terms of reference to find perspective for the benefit of building the whole sector. We believe that at the early stage of building the sector, a policy that fosters coopetition[30] is required.

We believe there could be two sides to this policy activity. First, building the R&D infrastructure and places where individuals can undertake this research activity. Second, a policy that shapes and nudges coopetition behaviours whereby emerging within-sector and cross-sector

[29] https://www.netzerotc.com/

[30] Pattinson, S. Nicholson, J. Lindgreen, A. (2018), Emergent coopetition from a sensemaking perspective: A multi-level analysis, Industrial Marketing Management, 68, pp. 25-35.

competitors are encouraged and incentivised to work together, promote sharing of project experiences and data and collaborate within consortia-type forms, bidding processes and procurement opportunities.[x]

This collaborative coopetition approach mitigates the deleterious competition effects within early-stage niche building within a sector. Coopetition geothermal activity is evident elsewhere in the UK.[31] Finding perspective can also be extended to the general renewables transition, as one interviewee noted.

> **Technology agnostic:**
> "Rather than operating in splendid isolation, getting everyone together to make a better song for renewables is required – CASE is agnostic about the renewable technology solutions but there must be active participation from all sectors of society in researching better outcomes."

*Martin Doherty| Centre Manager| Centre for Advanced Sustainable Energy (CASE) |31/3/2022*

Interviews with those project leaders have called for more data on specific maps of geothermal resources and support with the interpretation of feasibility geothermal studies and the decision-making processes. This raises another important policy consideration of how to incentivise coopetition practice and ensure the sharing data of R&D activity, but also inter-group sharing of experiences and outcomes of geothermal project activity. Developing expertise around the decision-making processes and how they can be facilitated will be critically important in building the geothermal sector in NI, particularly at the early stages of the niche development.

Government partners play an important role in ensuring that extensive and granular data, deep analysis and data sharing are undertaken. We find that DfE has published calls for research, development, demonstration, and deployment of geothermal technologies and solutions.[32]

## 2.2 Protective niche scaffolding

Research shows that consideration must be given to approaches that shield market and technology breakthroughs. 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, each of which is discussed in the second part of this report (See Sections 3.3, 3.4, 3.8 and 3.9). 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.

> **Early-stage sector development:**
> "Fair to say that the NI geothermal sector work is sporadic and bit of a patch quilt at this stage. I find that architects and M&C engineers do tick the LZC box as an option of BREEAM

[31] https://www.southwestgeothermalalliance.co.uk

[32] https://etendersni.gov.uk/epps/cft/prepareViewCfTWS.do?resourceId=4024243

> construction rules. I find many feasibility studies are carried out but clients don't stay the course and we can't get them over the line."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

Niches must be protected and given space[33] [34] from existing fossil intensive technologies, the LZC technologies, and financial and legislative regimes. Table 2.1 sets out stages of the niche trajectory of the geothermal niche development and how that normally evolves. At this stage in niche development, policy initiatives might include but are not limited to (i), levelling up the institutional conditions without technology bias (ii), strengthening the link between potentiality and actionality (iii), matching project development with resource capability, and (iv), building and maintaining temporary sector clusters in the niche stages.

> **Existing business approaches:**
> "The decision-making of the corporations is driven by first, spend/affordability; cashflows, Return on Investment, Net Present Value. Second, security and price volatility. Third, sustainability. The issue is that firms don't want the capital tied in and locked down but want "heat has a service" – like mobile phones, they don't want to buy the handsets, but would like the choice and service. So we need infrastructure providers. The role of the consumer can be to link in at the end. We keep on facing the problem rather than the geological solution."

*Dr Niall McCormack | Geologist| Managing Director of CausewayGT | 2/3/2022*

> **Non-monetary case appraisal:**
> "Having worked in business case analysis in my previous job, dealing with economists, the processes can be difficult in the absence of specific guidance. However, I believe that the tide is turning with business case guidance though. Non-monetary tests and weightings are part of Green Growth and there is the prospect that the formal appraisal process will be changing in order to have regard to non-monetary issues relating to climate action…"

*Kevin Hegarty | Director of Green Grow and Climate Action | DAERA| 6/4/2022*

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. Non-monetary criteria are used by developmental banks such as the World Bank, FMO (Dutch Government Development Bank)[35] both of which draw on social impact-based United National General Assembly's (UNGA) Sustainable Development Goals (SDGs).[xi]

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[33] Smith, A., Raven, R.P.J.M., (2012). What is protective space? Reconsidering niches in transitions to sustainability. Research Policy. 41, 1025-1036

[34] Kemp, R., Schot, J.W., Hoogma, R., (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. Technology Analysis & Strategic Management. 10, 175-195.

[35] https://www.fmo.nl/about-fmo

In this development phase, an emphasis might be placed on building pioneer projects with government working closely with the prospective investment partners – resource pooling in mutualised consortia – and GSNI. At the same time, there is a need for clear data generation through feasibility support measures, R&D testing activity, data sharing agreements, coupled with government infrastructure capital expenditure investments.[36] This data sharing would effectively ensure that the policy intervention supports technology workarounds, but also that it is market-focused and benefits the whole business sector and wider communities.[xii]

> **Building the niche out:**
> "We can get too involved in the big geothermal picture, the big visions, where it is going internationally. But I don't think we should lose sight of the 'baby small steps'. Get it done, get the geothermal projects up and running. Show the successes, then you have got 'flow'. Built it out from there. Look at Munich in Germany and in Kenya. That geothermal activity did not happen overnight."

*Dr Will Pettitt | Director Geothermal Rising Trade Association, USA | 06/04/2022*

Supportive policy interventions and infrastructure-building developments with the geothermal technology trajectory will provide businesses with consistent clear signals and therefore much-needed confidence in the sector. A niche strategy is not a 'get big fast' approach to the sector. Matching capacity and capability with market demand provides stable and consistent sector growth.

Nurturing activities can speed up the niche evolution of the geothermal sector. In this development phase, an emphasis can be placed more on policy to increase performance learning for all within the sector and collective institutional support. It is important that the geothermal sector draws on the knowledge of the existing institutional regimes.

The policy can then stretch and transition the geothermal sector further through the sector-coupling and hybridization of geothermal solutions in order to consolidate the geothermal niche in the maturity phase, before larger scaling up activities.

Intra-competition is not removed in shielding, nurturing or stretching niche building strategies but managed to animate the diversity of the market breakthrough ecology, technological trajectory and progress. Inter-competition is monitored and, where appropriate, moderated.

[36] Palmer, M., Toral, I., Truong, Y. & Lowe, F., (2022) Institutional pioneers and articulation work in digital platform infrastructure-building, Journal of Business Research. 142, 930-945.

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).[37]

> **Energy net zero solution mixes:**
> "What is the role of geothermal technology in delivering the net zero strategies and the 2050 targets? We can work backwards on what we have achieved so far to scale up wind and solar energy and understand how long has that taken to scale-up. There is not going to be one solution but many pathways, some mainstream and others niche. We know that heat is non-standardized, and drilling is non-standardized. So what are the 'must haves' in the mix of energy solutions for net zero. You can't scale everything, so you need to be pragmatic about the energy mix and build a combination. So in locating the borehole, can you bring geothermal heat into neighbouring buildings, what's the proximity, density and location of new developments with anchor 'on demand' heat customers to drive down the weighted average cost of capital?"

*Professor Michael Pollitt |University of Cambridge | 16/3/22*

> **Portfolio-driven approaches to energy transitions:**
> "There could be a better coordinated approach to the decarbonisation of heat in NI, an all government approach so to speak. Sometimes it feels as the loudest voice seems to get heard, the truth is decarbonisation will be a blend of various technologies combined with changes to existing societal behaviours. I think these are big and difficult challenges which will need multiple approaches. We need to stop dodging the tough decisions on energy and explore how we translate research into actions."

*Martin Doherty| Centre Manager| Centre for Advanced Sustainable Energy (CASE) |31/3/2022*

Table 2.2. outlines the dimensions of the niche strategy, policy considerations with illustrative insights from the interviewees from our consultation. The niche strategy and policy for geothermal can be viewed both in terms of upstream and downstream activities. Niche development policy might consider upstream prospecting and nudging market behavioural activity, seeking direction on the carbon in use of Invest NI's capital investment appraisals in the Letter of Expectations to the Strategic

[37] 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.

Investment Board from OFMDFM on heat decarbonisation and LZC technology neutrality within NI. The Strategic Investment Board (SIB) can also support the local councils in Northern Ireland and this requires attention.

Niche development policy might consider downstream prospecting and nudging market behavioural activity that could include;

- seeking an open letter direction from the UK Climate Change Committee (CCC) on setting detailed heat decarbonisation targets for Northern Ireland;
- the full implementation of The Energy Performance of Building Regulations (Northern Ireland) in relation to the adequacy of display of energy certificates for geothermal projects, consistent with **carbon in build** green procurement, **carbon in use** and **heat waste,** with the mandated seven-year energy performance review.

We believe that the mandated seven-year review within The Energy Performance of Building Regulations (Northern Ireland) is an opportune time to make this information digitally available to ensure that all businesses and institutions are supported in understanding NI heat decarbonisation policy and that adherence is monitored and followed up where appropriate.

Table 2.2: Niche development policy considerations

| Niche Policy | Nature of activity | Illustrative sector-building experience |
|---|---|---|
| **Decision-making measures** | Establish multiple R&D test project contexts and mutualised arrangements. For instance, business to business and business to encourage widespread acceptance. Ensure data variance from test piloting R&D projects to improve mainstream readiness and scalability. | **Mutualisation:** "A key lesson in the EU is that you need to mutualise the risk by having a pool of projects – that way there is no complete failure but only partial failure. You have coverage of risk. The lesson from Switzerland is that it must be higher than 80%. They attempted 60% and the Council Multiplicity there were not interested."<br><br>**Philippe Dumas\| Secretary General \| European Geothermal Energy Council (EGEC) \| 11/4/22** |
| **Vehicles** | Consideration of the institutional carries of the policy. For instance, City Deals, DfE, InvestNI, GSNI, Geothermal Association of Ireland (GAI), SIB, CASE. Temporary sector clusters such as, #NIGeothermalweek, or the European Geothermal Congress. | **Geothermal conferences:** "A congress like EGC2025 represents an important network and sector growth opportunity that will attract leaders in the geothermal sector to Ireland."<br><br>**Dr Riccardo Pasquali \| Geoservsolutions \| 1/04/2022**<br><br>**City Deals:** "City and Growth city deals are part of the driving force and vehicle for energy transformation. Co-operation and strategic alignment will speed technology adoption across NI, helping tackle issues of fuel poverty and rapid decarbonisation."<br><br>**Martin Doherty\| Centre Manager\| Centre for Advanced Sustainable Energy (CASE) \|31/3/2022** |
| **Staging/pacing** | Consideration of the sequencing across the niche development towards mainstream but matching capability. | **R&D activity:** "To build the sector, we need a funded programme of exploration led by a team of at least five people. Policy and regulatory teams will be needed in addition to this. Exploration and growth of the industry will generate large amounts of data and a team to process these data and make it available to support the sector, regulation and future policy is needed."<br><br>**Dr Robert Raine \| Geologist \| GSNI\| 29/3/2022** |
| **Differentiators** | Develop, clarify and deliver reciprocal geothermal value propositions. For instance, economic security, non-impact of weather, intergenerational, long-run sustainability, and benefits of Ground Source Heat Pumps.[37] | **Accessible language:** "It is difficult walking across the land and explaining this technology to farmers. I pointed to high temperature countries such as Iceland and how energy was in our own backyard. I also used the analogy of the fridge and how geothermal acted like a reverse fridge."<br><br>**Dr Riccardo Pasquali\| Geologist \| Geoservsolutions. 28/02/2022** |
| **Data collection and evaluation** | Consideration of the need for clear geothermal data sharing agreements, strong governance, and digital infrastructure. For instance, R&D test project monitoring and reservoir properties are delineated, but also that temporary sector clusters occur to share data amongst the market actors. Consideration of a central office/place/agency where all data is gathered, held and made available to all. | **Data sharing:** "There is a priority need for transparency in geothermal data – the idea of having mandated policy on open-source data with digital platforms to derisk projects and build general confidence in the sector."<br><br>**Dr Marit Brommer\| Executive Director\| International Geothermal Association\| 29/3/2022** |

## 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. This voice also includes government partners and the articulation of direction.

Narratives will depend on end-user choices, backgrounds, audiences and contextual conditions.[38] Research shows that the power of many voices is harnessed for shifting sector attitudes and is needed for sector building (See Appendix 5 for an illustration of this).

**Spanning communities.** Those narrative approaches must open up and span beyond the geothermal technical community and with broader market-spanning stakeholder and community engagement.[39] 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.[40] Identifying institutional vehicles that carry the dialogues is required.

Recent research suggests building on stakeholder analysis and exploring what communities understand as 'public value' and 'public good' for energy futures is important. These value mapping exercises can help understand public preferences and acceptance or disapproval of geothermal policy options. These can also reveal why preferences are formed.[41] [xiii]

**The NI Strategic Energy Frameworks (SEF)** set out four key energy goals, including, building competitive markets; ensuring the security of supply; enhancing sustainability; and developing our energy infrastructure, might assist with this multi-narrative process. Following on from this is the idea of having many narratives to legitimatise the technology acceptance within communities across NI.

**Local alignment.** One key geothermal narrative could be aligned with a community narrative to shape public attitudes towards geothermal energy projects and ensure that demonstration is 'anchored' in a local setting. For example, ensuring that the procurement of equipment, such as pipes, or drilling services, can be bought or supported locally in NI and also within mainland UK. In addition, articulating how the social aspects of local communities can benefit from geothermal projects.

**Land owner's engagement.** Meeting the full potential of geothermal heating networks and cooling schemes will mean finding ways of partnering with agricultural and industrial sector landowners. We believe that engaging with communities and cocreating dialogues for geothermal

[38] Ross, D.G. (2013) Common topics and commonplaces of environmental rhetoric, Written Communication, 30 (1): 91–131.

[39] 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

[40] Truong, Y. Simmons, G. Palmer, M. and Schneckenberg, D. (2014) An exploration of business model development in the commercialization of technology innovations, R&D Management.44(3), 306-321.

[41] Butler, C., Demski, C., Parkhill, K., Pidgeon, N., Spence, A., (2015), Public values for energy futures: framing, indeterminacy and policy making, Energy Policy. 87, 665–672.

activities will be vital for building confidence in the sector in Northern Ireland.

## 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. [42] [43] A fulsome outline of both systems has been recently published as a UK POST policy briefing in April 2022.[44]

**Shallow-deep/rural-urban/east-west.** We believe that there is an opportunity to build geothermal activity across Northern Ireland. Closed-loop geothermal shallow activity can be used as a confidence-building springboard for immediate priorities, while simultaneously deep well exploration could be built on a case-by-case basis. For deep geothermal projects, we believe pooling projects through mutualising partnerships effectively derisks the policy against any one-off failures. [xiv] We believe geothermal activities can provide an opportunity for a just energy transition and one which is both inclusive of rural-urban communities and also spans across east and west of the river Bann in Northern Ireland.

**Proof-of-concept options.** We believe that market selection works best when there is a range of 'proof-of-concept' options, variance and evaluation capacities, business sectors and community heat and cooling demands upon which to build the geothermal sector.[45] Consideration could be given to two or more showcase projects across a range of sectors and community initiatives which permit data to be elicited for geothermal R&D activity as well as other environmental, social and economic business modelling practices.

**A strategic niche management approach** to geothermal resources primarily relate to heating and cooling in Northern Ireland, rather than power generation opportunities. The consultation suggests that heating and cooling sector solutions should be prioritized at this stage. A critical prioritising issue is whether to induce market change with those operators that are likely to be most responsive to geothermal attention (i.e. the 'easy wins') or, more strategically, focus on the geothermal technology deployment selection possibilities that are likely to require more behavioural change to transition the market in a favourable strategic direction.[46]

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

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

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

[45] Battaglia, D. Paolucci , E. Ughetto, E. (2021) The role of Proof-of-Concept programs in facilitating the commercialization of research-based inventions, Research Policy, 50, 6. Early online.

[46] Flaig, A., Kindström, D. Ottosson, M. (2021) Market-shaping strategies: A conceptual framework for generating market outcomes. Industrial Marketing Management, 96, 254-266

Understanding the effort expended to accomplish behavioural change in mainstream business to consumer markets versus a pathway that relies less on consumer market behavioural change and relies more on industrial consumer change in a protected niche might be more pragmatic and offer more sector-building protection.[47] The case can be made for small field shallow geothermal activity but research also shows that market transitions upstream with industrial and commercial (business to business) partners enable and drive downstream activities (business to consumer), as exhibited in Box B. Building large-scale-up activity is not the immediate priority of niche-building efforts.[xv]

The geothermal opportunities in each sector can be strategically assessed by the level of challenge associated with their delivery. Those challenges could be more centred on the above surface issues of building sector awareness, shifting attitudes and enhancing capabilities to build end user confidence.[48] In considering the decarbonisation of heat in Northern Ireland, a useful assessment based on energy and carbon footprints is depicted in Figure 2.

**Box B: Target Markets**

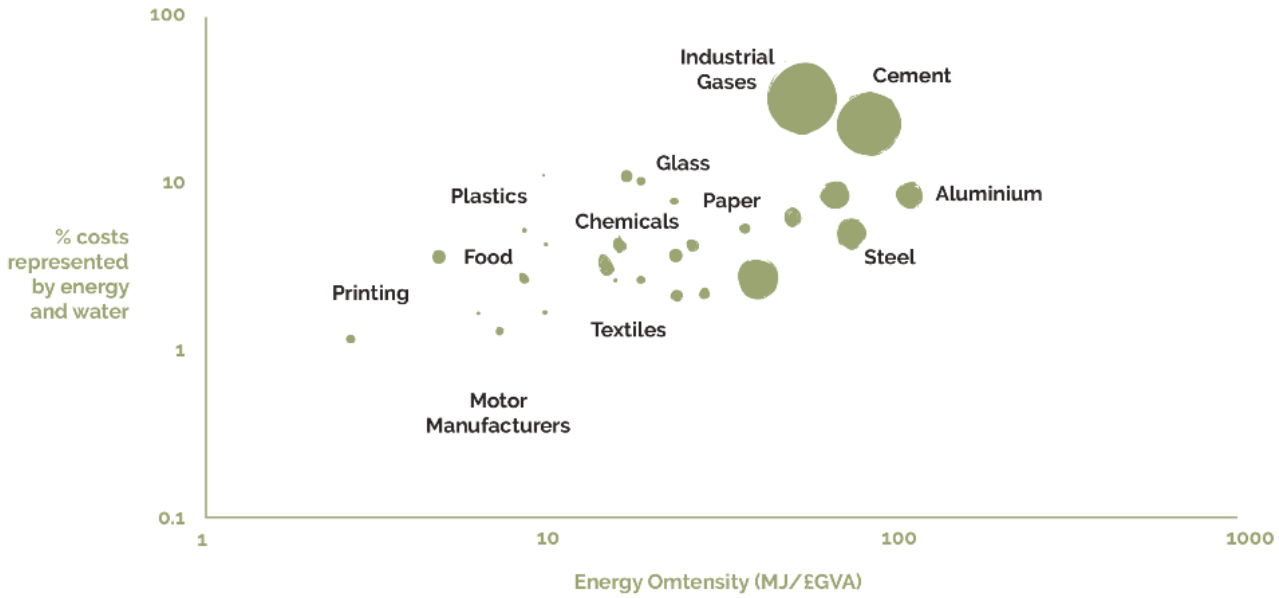
1. **Large industrial/commercial sites (B2B).** There are 17 sites in Northern Ireland involved in the European Emissions Trading Scheme which accounted for 22% of Northern Ireland's heat demand. Further exploration of those 17 sites in Northern Ireland and others with a Pareto analysis, could result in a significant reduction in heat decarbonisation gains. The seasonality of sector requirements lends itself to alternative ways that geothermal technology can be deployed.
2. **Individual consumers market based (B2C).** The previous renewable demonstrates throughout the UK demonstrate a market appetite for individual consumers and can be achieved in many other applications at a net additional cost. A market based may require the use of incentives and support mechanisms to increase the level of uptake. Further analysis is required on refining incentive options if this route is selected.
3. **Community-based regeneration schemes.** This report identifies that many urban city centre/high street regeneration areas that could be suitable for network heating and cooling geothermal schemes at a community level. Community based schemes in urban areas may require more geothermal data analysis and monitoring and therefore require some form of reform incentivisation. Further detailed analysis of the community options is required to examine the viability of this in more detail.

Source: Department for the Economy Report. p.6.

[47] White, K., Habib, R. and Hardisty, D., (2019) How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review and Guiding Framework. Journal of Marketing, 83(3), pp.22-49. (See also Appendix 2).

[48] Carnabuci, G. (2010) The ecology of technological progress: How symbiosis and competition affect the growth of technology domains, Social Forces 88 (5): 2163–2187.

Figure 2: Comparing energy intensities and percentage of energy and water costs for different industrial sectors in the United Kingdom.




Source: Griffin et al. (2016).[49]

The main cement production plants in Northern Ireland are Cookstown Cement Ltd (recently divested by Holcim) and Mannok (Aventas Group rebranded the Quinn Cement brand).[xvi] Evidence points towards the fit of geothermal with medium to low temperature range for manufacturing processes.[50] Recent research by colleagues at Queen's University Belfast shows that the food industry sits as a moderately energy intensive industry compared to others, and also an industry with moderately high energy costs.[51] Food and beverages are a significant manufacturing sector in Northern Ireland[52] [53]and are immediately relatable in the day to day lives of communities. The energy intensive aspects of the industry cut across food supply and agriculture. A strategic niche management approach to geothermal resource utilizations could group the sector as a series of 'Core', 'Further Ambition' and 'Speculative' options as exhibited in Box C and this segmentation can ensure that the level of effort is shared equally across the geothermal technology projects types.

[49] Griffin, P.W., Hammond, G.P., Norman, J.B. (2016) Industrial energy use and carbon emissions reduction: a UK perspective, Wiley Interdisciplinary Reviews: Energy and Environment, 5, 6, 1, pp. 684-714.

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

[51]Sovacool. B.K., Bazilian, M., Griffiths, S., Kim, J., Foley, A. Rooney, D. (2021) Decarbonizing the food and beverages industry: A critical and systematic review of developments, sociotechnical systems and policy options. Renewable and Sustainable Energy Reviews, Vol.143.

[52] https://www.daera-ni.gov.uk/news/report-northern-ireland-food-and-drinks-processing-sector

[53] https://nifda.co.uk/key-facts

**Box C: Grouping sector priority options**

**Core options** are those low-cost low-regret options that make sense under most strategies to meet the current 80% 2050 target. They also broadly reflect the Government's current level of ambition (but not necessarily policy commitment).

**Further Ambition** options are more challenging and on current estimates are generally more expensive than the Core options.

**Speculative options** currently have very low levels of technology readiness, very high costs, or significant barriers to public acceptability. It is very unlikely they would all become available.

Committee on Climate Change. Net Zero – Technical report Committee on Climate Change May 2019. London.P.12

Prioritizing should be aligned with UK blueprints from industry, schools and hospitals by the Business and Energy Secretary[54]. Multi-sector prioritization approaches, with illustrative sector examples, could include, but are not limited to;

- 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.[55]

- 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. [56]

**Agriculture and horticulture:** international cases showcase greenhouse environments, distilleries, fish farming and agriculture stock buildings.[57] 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

[54] https://www.gov.uk/government/news/major-blueprint-to-create-green-jobs-and-slash-emissions-from-industry-schools-and-hospitals

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

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

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

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.[58] 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%.[59] 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). Circular energy plans are called for in public Net Zero leadership practice.

**Retrofitting buildings**. Meeting the full potential of geothermal heating and cooling schemes will also mean finding ways of decarbonising existing buildings and retrofitting them. However, a recent report on retrofitting provides a stark conclusion: "No country has managed to make retrofit mainstream: it remains the preserve of enthusiastic practitioners, programme designers and customers. Retrofit is an immature market compared with the dominant sector of repair, maintenance and improvement (RMI)." Conservatism in the industry means that opportunities for retrofit are likely to be ignored in preference for the less risky, more familiar repair, maintenance and improvement (RMI) market.[60]

**Repurposing existing or disused mines and quarries.** Further research might be undertaken by the GSNI to assess the harvesting of geothermal resources at disused and/or active mines and quarries across Northern Ireland and the demand for heat and cooling provision in those locations.[xvii]

## 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.[xviii] 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 the latent buyer demands, interest and sector potentiality and doability.[61] 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.

There is the initial evidence of such geothermal sector clusters happening in Northern Ireland over the last year or so and promising plans are afoot on co-ordinating efforts to showcase the potential of the NI geothermal sector.

- A webinar series conducted through 2020/2021 had over 1000 active

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

[59] Ibid.

[60] Brocklehurst, F., Morgan, E. Greer, K. Wade, J. Killip, G. (2021) Domestic retrofit supply chain initiatives and business innovations: an international review. Buildings and Cities 2(1)(1):533–549.

[61] 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.

participants.[62] A further series of webinars are planned for 2022. These activities understand what the different communities and partners need and want to know, and how a meaningful response can be crafted to help support understanding and cocreated experiences.

- On 11 December 2020, the Geological Survey of Northern Ireland (GSNI) and the Centre for Sustainability, Equality and Climate Action (SECA) at Queen's University Belfast, jointly hosted a conference on the future of geothermal for Northern Ireland. This conference – called Building Back Better – A Future for Geothermal in Northern Ireland was held remotely due to the ongoing global pandemic. Over 300 delegates from across industry, academia, government, charities and investors engaging online participated in this event. Appendix 5 provides a summary overview of the participant profile.

- On foot, we observe that the NI Department for the Economy is proactively organising and leading a range of coordinating events and gatherings of experts, industry users, regulators, planners, academics and other stakeholder communities such as the **#NIgeothermalweek** in June 2022.

- We note that others are seeking to bring congresses such as the European Geothermal Congress (EGC2025) to build a network, sector growth opportunity, and attract leaders in the geothermal sector to Ireland.[63] There are opportunities to link with intergovernmental organisations that support countries in their transition to a sustainable energy future such as the International Renewable Energy Agency (IRENA). This can support international cooperation and can be a repository of policy documents, resources and financial knowledge on geoenergy. [64]

There is a higher level of coordinating efforts aimed at supporting and nurturing the geothermal sector with specific workshops[65], stakeholder clinics and virtual market place activity, for example, with councillors, Heads of Planning and Heads of Environment/Sustainability in local government, a Drillers' perspectives of how the capacity of the sector can be built, or with Planners', Regulators' or Financial Analysts' perspectives. This temporary cluster activity could link into future geoenergy road mapping activity as documented elsewhere in the World Bank's activities in building geothermal in international markets.[66]

> **Organising sector clusters:**
> "In Scotland, there is much enthusiasm and a heat network delivery plan. In practice there are things happening – for example feasibility studies. I attend

[62] See https://www.youtube.com/watch?v=VoxYhEaE8Vc&list=PLxpzCdkdwTWD3MyECoDIEwMe8ZVLkS_BV&index=28

[63] https://europeangeothermalcongress.eu

[64] https://www.irena.org/contact

[65] Palmer, M. Simmons, G. Robinson, P.R. and Fearne, A. (2015), Institutional maintenance work and power preservation in business exchanges: Insights into industrial supplier workshops, Industrial Marketing Management. 48. 214–225.

[66] Technology Roadmap: Geothermal heat and power. (2011) International energy agency. https://www.iea.org/reports/technology-roadmap-geothermal-heat-and-power

(2016) Chile - Technical Assistance for Sustainable Geothermal Development Project (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/171771481641733892/Chile-Technical-Assistance-for-Sustainable-Geothermal-Development-Project

> a Mine Water Task Force and last week BGS and Coal Authority held a Mine Water Energy Symposium for IEA geothermal. Regulators are asking questions on heat impacts, subsurface impacts and multiple pumping/recharge of water in geothermal operations."

*Dr Alison Monaghan| Geologist | Director UK Geoenergy Observatory, Glasgow| 4/4/22*

> **Market making:**
> "There is clear market failure in some areas that green growth and innovation must help address. We must therefore embrace market making and to do this we may need to take a first-mover risk. To help with this we must have a mandatory green growth test to help emerging technologies."

*Kevin Hegarty | Director of Green Grow and Climate Action | DAERA| 6/4/2022*

It is suggested that a range of a market-focused groups – Industry Associations, nongovernmental organizations (NGOs) - could be supported further with temporary sector clustering events in Northern Ireland. These exist in geothermal markets elsewhere in the UK and in the EU including the Netherlands and Ireland, institutions which can help support and build the interests of the geothermal sector in NI. Such institutions can act as advocates and ambassadors, address concerns from communities, and for illustration are exhibited in Box D. [67]

In addition, the NI Department for the Economy is actively researching the geothermal sector and building insights into the sector, including benchmark research on actions, policies and regulatory frameworks in other geologically comparable jurisdictions, including the Netherland as well as the UK, and Ireland that have been taken to facilitate the expansion of the geothermal energy sector.

Taken together, the assembly of organising activities should provide a clear signal to public authorities and private businesses, community leaders and investors alike – temporary clustering events are the precondition to marshal the sector development needs and is part of the first-mover advantage practice.

**Box D: Linking and building collective voices for the NI geothermal sector**

**Illustration I:** Platform Geothermie

Platform Geothermie is a Dutch non-profit organization (NGO) for the promotion of the socially responsible application of deep geothermal energy in the Netherlands. Dutch Association does this via knowledge transfer, communication and the organization of dialogue on geothermal energy using presentations, newsletters, publications, symposia and site visits.

https://www.geothermal-energy.org/about/our-members/affiliated-membership/dutch-geothermal-association/

**Illustration II:** The British Drilling Association (BDA)

The British Drilling Association is the trade association for those who drill holes in the ground, manufacture/supply drilling rigs and equipment, or supply services to the geotechnical and ground investigation industry.

https://www.britishdrillingassociation.co.uk/

[67] Other good examples include the Geothermal Association of Ireland (GAI) (see https://geothermalassociation.ie/ ) and the European Heat Pump Association (EHPA) (https://www.ehpa.org)

**Illustration III:** Ground Source Heat Pump Association (GSHPA)

The GSHPA represents the heat pump installation industry in the UK. It is the voice for the lowest running cost, lowest carbon, heating and cooling system for domestic and commercial buildings and heat sharing networks. The network coverage is presently limited in Northern Ireland. Memberships include Installers of ground source energy systems; Service, maintenance, diagnostics & repair of ground source energy systems installed by others; Consultants and advisers on ground source energy; Drilling and Piling Services to the ground source industry; Heat Pump suppliers; Suppliers to the ground source energy industry; Providers of Training services to the ground source industry.https://www.gshp.org.uk

## 2.6 Evaluation and stakeholder engagement

**Evaluation of targets and transitions**. Network goal-setting is evident in several policy energy and renewable heat documents. In 2010 the Department for the Economy (formerly known as DETI) concluded with two key recommendations:

(i) Develop a long-term strategy for renewable and low carbon heat based on achieving a 10% renewable heat share by 2020. Set up a cross departmental strategy group to do this.

(ii) Develop a Northern Ireland specific renewable heat incentive (RHI) scheme to aid in achieving the 10% target. [68]

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.

> **Prioritizing key performance metrics:** "As far as I can see, there is no baseline data- no setting, no measuring, no monitoring, therefore, no chance of getting it done. If there is a climate crisis, and the house is burning down, then this ought to be treated with urgency. We have seen how the government is able to react to the pandemic. Things happened quickly then. There is a sense that it is down the pecking order. Targets, don't forget are only staging posts."

*Stephen Agnew | Renewables NI | 15/3/2022*

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.[69] 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.[xix]

The research report found a divergence between expert and consumer perceptions, and limited joined-up

[68] https://www.economy-ni.gov.uk/sites/default/files/publications/deti/sef%202010.pdf

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

approaches to heat decarbonisation in Northern Ireland. This suggests that more workshop events, consideration and convergence of perspectives of the different communities are required. For geothermal, we believe that a more fulsome and dynamic stakeholder analysis and mapping are required and one that considers roles and indeed governance.

**Evaluation processes.** A strategic management approach for building the geothermal sector can support and enhance evaluation frameworks, where appropriate and where necessary. The overspending on a renewable energy scheme (Renewable Heat Incentive) has resulted in a 'shadow market spoiler effect' for the whole renewable sector and incentive scheme policy-making. Several reports draw attention to the cost of environmental governance failures and opportunities for reform[70] and we do not wish to repeat same here, nor do we pass over its significance in rebuilding confidence in renewable schemes and the difficulties involved in that.[xx] From the GAC feedback, we recognise and acknowledge the important progress made within the Assembly departments and NICS committees. These efforts help support sector building confidence but it is also important to acknowledge at this stage that this 'shadow' makes the role of policy work in building the geothermal sector in Northern Ireland more difficult.

In consulting widely, we found that there was a palpable awareness in the reactance to incentive schemes and a visible 'steering away' from the RHI scheme. This is not surprising and as a recent study by the UK Energy Research Centre attests:

> "Failure of the commercial RHI scheme and the knock-on effect of the closure of the domestic RHI scheme caused significant damage to the industry and to the reputation of low carbon heat technologies, leaving NI consumers without any explicit supporting mechanisms for low carbon heat supply." [71]

Institutions learn and adjust. To ensure that confidence in the geothermal sector is not harmed, the recommendations of NICS report into the RHI scheme should be fully implemented. We observe a science-led and informed approach from the NI Department for the Economy and with The Geological Survey of NI, and find evidence of preparatory review work undertaken of UK and international geothermal policy frameworks being assessed, benchmarked and created. In effect, diligent research approaches are working at the buildability of the geothermal sector in Northern Ireland. This research work builds sector confidence.

To further build confidence, we believe that objectives and strategies could be evaluated with "an eye not merely to the kind of low risk at issue but to the characteristics of different intervention tools; the cultures - attitudes, motivational postures and cognitive frameworks of regulatees; organizational settings including the regulators' resource positions, legal mandates and the systems of accountability and political sensitivities that (actually or potentially) impact on low-risk regulation; performance assessment; and finally and the need to establish systems that are marked by

[70] Brennan, C., Purdy, R. and Hjerp, P., (2017). Political, economic and environmental crisis in Northern Ireland: The true cost of environmental governance failures and opportunities for reform. Northern Ireland Legal Quarterly, p. 125

[71] https://ukerc.ac.uk/publications/barriers-and-opportunities-for-heat-decarbonisation-in-northern-ireland/

sensitivity to changes in risk characteristics."[72]

Further to this, The Strategic Environmental Assessment (SEA) is a well-established process for evaluating, at the earliest appropriate stage, the environmental consequences of implementing projects or initiatives. The SEA focuses on ensuring that the environmental consequences of plans and programmes are assessed both during their preparation and prior to adoption. We also believe that any geothermal scheme would benefit from 'a higher form of post build evaluation' for both understanding the user experiences and for safeguarding purposes. In the Netherlands, for instance, the Energie Beheer Nederland (EBN) is owned 100 percent by the Dutch government and contributes by bringing parties together and by contributing capital, infrastructure, knowledge and expertise in actual projects.[73] Importantly, it provides oversight, governance and evaluation of the geothermal sector.

Complementing the existing SEA technique and other financial auditing, a Design Science Research (DSR) procedure [74] could help with organising evaluation through a 6 -step process to ensure oversight, as outlined in Figure 3 (see overleaf).[xxi]

[72] Black, J.  Baldwin, R. (2012) When Risk-Based Regulation Aims Low: A Strategic Framework, Regulation & Governance, 6, 2, p. 131–148.

[73] https://www.ebn.nl/en/about-ebn/

[74] Peffers, K., Tuunanen, T., Rothenberger, M.A. and Chatterjee, S. (2007), A Design Science Research Methodology for Information Systems Research, Journal of Management Information Systems, 24(3), 45–77.

Figure 3: Geothermal build and evaluation journey process model


Source: Adapted from Peffers, Tuunanen, Rothenberger (2007)

**Evaluation tools to support and enable commercialisation.** The geothermal shaper community might wish to consider how to develop decision-support and enabling tools to empower partners and authorities to technically and financially optimize the commercialisation of the geothermal renewable technology. Project Managers in geothermal projects follow tried and tested evaluation practices, as exhibited in Box E.

**Box E: Geothermal exploration, extraction and continued management**[75]

**Evaluate** – survey and assess any geothermal resources and sites to ensure that they have suitable characteristics and geology.

**Monitor** – review and study the ground to ensure stability, performance, safety and sustainability.

**Remediate** – minimise any environmental effects and ensure responsible stewardship of the subsurface, especially in relation to conflicts of use.

**Predict** – model and estimate the likely impacts of resource extraction by understanding subsurface behaviour and any response to change.

Other renewable technologies have added evaluation tools to enhance sector wayfinding and readiness. For instance, the hydrogen-based GenComm project initially sought to demonstrate proof of concept (phase I) with the decision support tool (DST) and then later (phase II) with an enabling support tool (EST) in the sector to empower and ready industry, as illustrated in Table 2.3. Critically the project draws on a network of expertise across a range of European partners – it mutualises the transition with partners. Building a dynamic and collaborative decision support tool involving regional stakeholders is one aspect of a regional market transition strategy, engaging with communities to play an active role in energy transition.

There are useful geothermal risk tools available online that could be adopted and adapted to provide support for decision-making and wayfinding. [76]

[75] https://www.geolsoc.org.uk/~/media/shared/documents/policy/briefing%20notes/Geothermal%20Briefing%20Note%20Typeset%20FINAL%20Mar%202022%20(2).pdf?la=en

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

Table 2.3: GenComm's Decision Support Tools and Two-Phased Model

| Phase I: Decision Support Tool (DST) | Phase II: Enabling Support Tool (EST) |
|---|---|
| A demonstrator project sought to further accelerate the hydrogen technology deployment specifically by developing the Decision Support Tool (DST).<br><br>The GenComm project sought to demonstrate how hydrogen as an energy carrier could act as a buffer between energy demand and supply, while enabling flexibility between the potential energetic and non-energetic uses of renewable energy.<br><br>GenComm DST sought to demonstrate to stakeholder authorities and agencies how hydrogen could achieve its potential and overcome challenges, while maintaining the highest safety standards. | As an extension of GenComm DST, GenComm Phase II seeks to work with partners and authorities to technically and financially optimize the commercialisation of renewable hydrogen.<br><br>GenComm is developing an Enabling Support Tool (EST), a user-friendly online tool that can be used for proactive planning of green Hydrogen based public transport. The EST aims to inform, empower and enable policy makers, authorities and transport bodies to get the optimal solution for a given green H2 demand based on existing local structures. |

## 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.[77] [78]

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. 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 F: 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.
- **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

From a strategic international perspective, The World Bank also recognises and outlines the important role of governments in building the geothermal sector.

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

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

**Box G: Government support for the geothermal sector[79]**

■ **Ensuring that commercial development** is planned, coordinated, and focused on the best locations from a geothermal system perspective, taking into account the magnitude and quality of the resource (capacity factor and temporal profile), and proximity to demand centres.

■ **Obtaining good value for money** when carrying out competitive bidding through a better-informed regulator and off-taker, and by reducing the resource and regulatory risk for developers.

■ **Avoiding or minimizing adverse environmental and social impacts** by screening out sensitive locations, analyzing cumulative impacts, and facilitating transparent stakeholder engagement in the planning and investment process.

■ **Identifying alternative and potentially competing** uses of available natural resources and land to avoid conflicts and promote sustainable resource management.

■ **Supporting grid stability by providing the data** necessary to perform grid integration studies at the system level and grid interconnection studies for specific projects.

Elsewhere it is acknowledged that solutions to heat decarbonisation differ in different parts of the UK.[80] So does the geology. The NI government can therefore play an important organising role in building and supporting a market-focused framework for the geothermal sector.

Our initial showcase sector analyses highlight the widespread acceptance of international institutions embracing the role of government leading out and acting as market-maker; building, shaping, driving and evaluating geothermal technologies as part of market-focused sector building. At the same time, international institutions also embrace the role of government as a custodian in the preservation of the environment, sector, renewable goals and targets and geo-resources.

> **Government market-making:**
> "We have seen how the government is able to react to the pandemic. Things happened quickly then. Not to devalue research, technology pilots, or demonstrations, but if you have private investors or commercial organisations lined up, ready to commit, then government seem to get the potential and the action link. It derisks it. Governments struggle to be the catalyst but that is not to say they should not be making these markets. Government fall back into their more comfortable role of being the facilitator rather than leading, making."

*Stephen Agnew | Renewables NI | 15/3/2022*

Exploring the nature of that sector building and custodian intervention by the

[79] Adapted from World Bank Report. Knight,Oliver.Assessing and Mapping Renewable Energy Resources : Second Edition (English). Energy Sector Management Assistance Program (ESMAP) knowledge series,no. 025/16 Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/317661469501375609/Assessing-and-Mapping-Renewable-Energy-Resources-Second-Edition

[80] Committee on Climate Change. Net Zero – Technical report Committee on Climate Change May 2019. London.

government could include discussion with the geothermal shaper community on:

- **Clear signals about technology choices.** There is a need for clarity around technology trajectories and keeping a portfolio approach to technology choices open to reach Net Zero targets. At the same time, decisions can be made to end the installation of the most carbon-intensive heat options.

> **Signalling commitment:**
> "We need the UK government and the devolved administrations to signal long-term commitment for the sector. The geoenergy community hasn't seen that yet. We have seen how offshore wind has taken off when the government has stepped in with R&D funding and policy support…"

*Dr Corinna Abesser| Hydrogeologist| British Geological Survey| 4/4/2022*

- **Set and monitor targets.** We believe there is a clear need to set and promote clear targets on geothermal as well as on decarbonisation of heat in NI, with annual monitoring and with the support of the UK Climate Change Committee. The Department for the Economy might explore how to establish commitment from the UK Climate Change Committee on the decarbonisation of heat commitment for Northern Ireland in an open letter request;

- **Incentivize a range of communities, businesses and R&D projects.** The government plays an important role in incentivising actors with a range of LCZ technologies. Critical for confidence-building is clear and consistent signalling on subventions or financial support schemes which could be differentiated based on the type of;
  (i) Direct investment supports in form of Grants and Repayable Grants (loans);
  (ii) Damage mitigation supports in form of Insurance and Risk Mitigation Funds;
  (iii) Market stimulation supports in form of Feed in Tariffs and Subsidies.

Research suggests that the subvention and incentive instruments for funding vary across the development lifecycle of the geothermal sector. In an early niche stage, attracting private capital is commensurate with public support. For geothermal, there are various ways to structure a support system and funding instruments including;

(i) Insurance solutions
(ii) Grants
(iii) Contingency Grants
(iv) Guarantee for commercial loans
(v) Concessional Loans
(vi) Loans with redemption grants
(vii) Loans with indemnification clause.[81]

- To build confidence in the geothermal sector, we believe that mutualisation is required in accordance with other geoenergy sector building across the EU, particularly when considering the typically high up-front costs and risks of geothermal energy projects. Effectively, a geofund, perhaps as part of a larger Net Zero transition fund, for instance, a Green Growth Innovation Fund. This could be mutualised with funds allocated as part of the devolved programme for government, the devolved budgeting processes and also supplemented by direct HM UK Treasury Net Zero initiatives and with oversight from The Office for

[81] Kai Imolauer, M. U. (2015). Risk Mitigation Systems in Comparison. Melbourne, Australia: Proceedings World Geothermal Congress 2 cited in the work of https://www.egec.org.

Budget Responsibility.[82] Each of the NI Assembly departments, perhaps weighted based on energy consumption, along with each of the eleven councils would also contribute to this geofund, with a mutualised returns process.[83] As outlined in Figure 6 (See overleaf), the geofund would assist with building network collaboration, and incentivises technology deployment, businesses, councils, departments and communities with cohort partnerships in Net Zero market making and shaping. This mutual principle derisks against a complete market failure outcome, which can occur in a one-scheme, one-owner, one-project, one-end user, one-partner type scenario.[xxii]

- **Implement a UK-wide Geothermal Incentive Scheme (GIS).** A UK-wide Geothermal Incentive Scheme (GIS) has been called for and reported in research elsewhere [84] Consideration of how the UK geothermal incentive scheme (GIS) could be developed in conjunction with the characteristics of the geothermal technology deployment, but one which is aligned tightly with a UK-wide GIS. How those incentives could support the protective strategies of shielding, nurturing and stretching capacities within the sector will require more consideration. Provision for incentives could vary across the nature (shallow or deep) and also the sector evolution.[xxiii] In addition, we believe that ground source heat pump (GSHP) requires more market incentivisation, especially given the installed costs are in the order of £8,750 and £13,200 for an 8 kW ASHP and GSHP respectively. [85]

> **Geothermal incentive scheme:**
> "On the incentives, my experience is that there needs to be locks in place so that there is no 'secondary trading' or you end up with tropical fish farms and green houses springing up. Or the reselling of licences, with individuals speculating on land buying, which pushes the land prices up for other sectors. Nominal fees need to be collected to support the sector, training, apprentices etc."
>
> *Anonymous | International located interviewee| 3/3/2022*

- **Procure net zero funding and establish a geofund.** The UK government's 'Levelling up the UK white paper' [86] suggests that the "Green Industrial Revolution" will require significant investment in new infrastructure and production processes using new technologies. It suggests that investment could average £50 to £60bn of capital investment per year by the late 2020s and into the 2030s. The Department for the Economy might in consultation with the Department for Finance and with UK HM Treasury scope out capital energy infrastructure funding, for

[82] https://obr.uk/

[83] Cornwell Council contributed £1.4 million to The Eden project. See https://www.burges-salmon.com/news-and-insight/client-case-studies/eden-geothermal

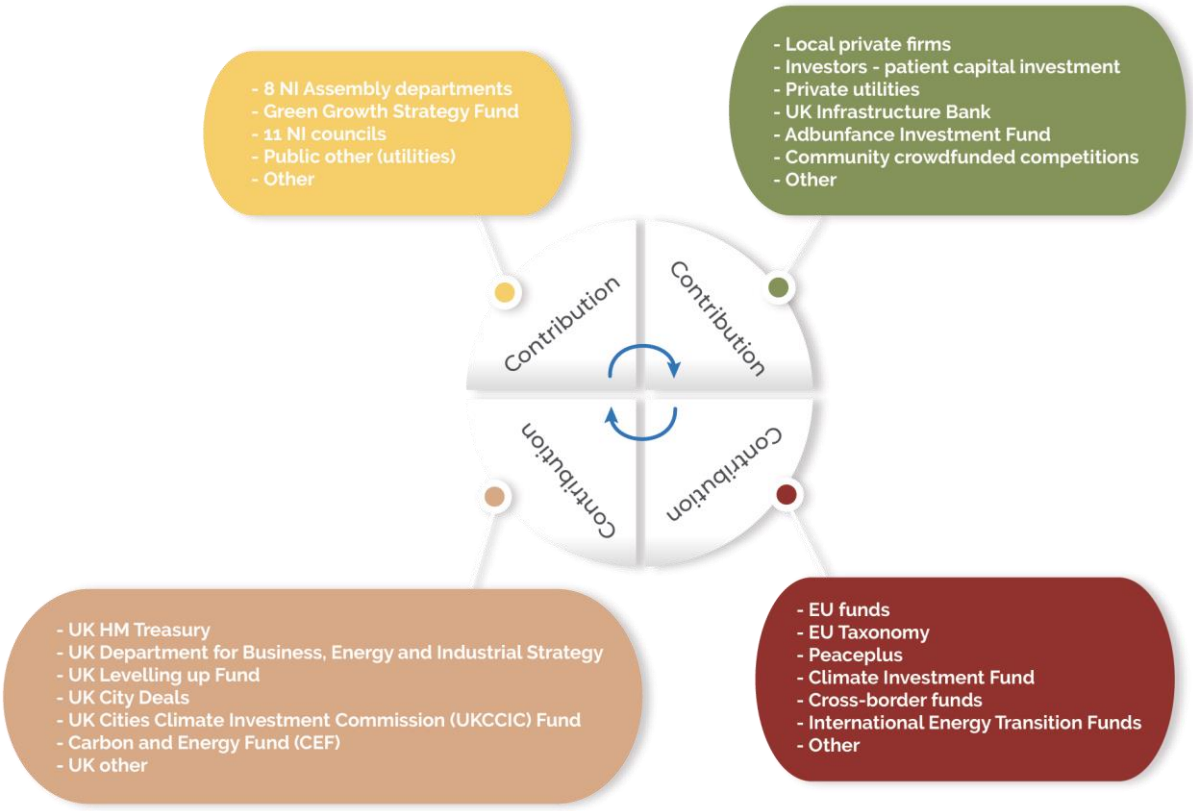
[84] https://www.r-e-a.net/wp-content/uploads/2021/05/Deep-Geothermal-Energy-Opportunities-for-the-UK.pdf

[85] https://researchbriefings.files.parliament.uk/documents/POST-PB-0046/POST-PB-0046.pdf p.41

[86] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1052708/Levelling_up_the_UK_white_paper.pdf

example with deep and heat networks. In the EU, the European Commission has proposed for consultation at the parliament level a major scheme to introduce an EU Green Bond Standard which builds on the recently established EU Taxonomy. As depicted in Figure 6 (see overleaf), there are a range of ways to build geofund contributions.

Figure 4: Geofund mutualisation example




Source: Developed by the authors

For example, the Climate Investment Fund and UK Infrastructure Bank can help provide confidence through default risk and other governance support with deep geothermal projects. From the perspective of investors, green bonds, and green finance represent long-term instruments that can redeploy capital towards building sectors such as the geothermal sector. Confidence building is also supported by funds such as UK Department for Business, Energy and Industrial's Industrial Energy Transformation Fund. [xxiv] When appropriate, a full review and consideration could add clarity for sector building.

- **Develop a geothermal energy roadmap** for the geothermal sector in Northern Ireland, which reflects, develops and outlines a vision for the sector. Activities and issues to be scoped out, considerations and questions debated and discussed, hurdles facing the sector and time schedules to work toward overcoming them are outlined (See Appendix 6);

- **Organise, map and coordinate activities**. When appropriate in the overall sector building process, consideration could be given to institutional governance and coordination activities, and integration of, various Departments, Centres, Offices and committees across government departments.

> **Building policy lintels:**
> "In Scotland, we have the Scottish Science Advisory Committee (SSAC) which asks the questions and sets the terms of reference for the Energy Subgroup Committee. That ESC brings the independent research to guide policy making decision-making. In this sector, there are lots of institutions all in pillars but in my opinion, too few lintels bridging and talking across the pillars. There are unintended consequences of this pillar building with one renewable technology in one place, say a wind farm, and what that does for another renewable technology deployment. For instance, what wind farms do to the subsurface in terms of data capture, measurement, monitoring, even insurance and indemnity issues and how geothermal be deployed alongside those. In Scotland, we have the Crown Estate (licencing wind farms) and Oil and Gas Authority and it is not always clear if they are aligned."
>
> *Professor John Underhill | University of Aberdeen. Member of Energy Subgroup Committee, Scotland | 11/3/2022*

- **Establish working groups and task mechanisms.** This might include, but is not limited to, the establishment of an Ad-Hoc Assembly Committee, and linking in with other cross cutting departmental committees such as the All-Party Group for Climate Action (APG). Clarity on the prescribed statutory role of the Geothermal Advisory Board, Geothermal Licensing Body, as well as what role the Office for Environmental Protection might play could be undertaken and how to bring about mutualisation governance, political oversight on the geofund and general heat decarbonisation goals and targets, as well as in relation to the governance of case-by-case large deep geothermal projects;

- **Create and support a just market-based framework approach** driven by consensus and consent through an open, balanced and inclusive environment, by experts from many disciplines who represent geologists, utilities, drilling, end-users, academe, governmental and regulatory bodies, and social, economic and environmental community stakeholders;

- **NI geoenergy infrastructure and review provision.** Consideration of the business model case development for the role of the government in building the geothermal infrastructure.

> **Infrastructure-building beyond the home:**
> "We would like to see the government invest in the ground loop infrastructure as gas and water have been previously. The key point here is street by street and town by town rather than individual houses.."

*Chris Davidson, Chairman and Technical Director, Genius Energy Lab. 14/3/22*

> **Carrying the infrastructure capital costs:**
> "How affordable is geothermal? Who is the geothermal solution affordable to? The end-user? Did end users carry the electricity power network infrastructure when those were being developed? Who has the ability to carry the geothermal capital costs? Look at what the government did in terms of building the electricity infrastructure. Nowadays, what is the strategic role of government in providing this geothermal infrastructure and setting up the heat networks and providing choice for end-users?"

*Dr Niall McCormack | Geologist| MD of CausewayGT | 2/3/2022*

- **Create the institutional conditions for technology selection.** To design protective strategies for strengthening technology selection and niche-building, with specific shielding, nurturing and stretching policy interventions that broadly showcase the potential and safety of geothermal technology deployments;

- **Ensure community engagement and conversations on pathways to net zero.** To institutionally and financially support community conversations with scientists, government and those leading out with LZC technologies to decarbonise sectors, which can address misleading national and local headline stories on Northern Ireland. [87] Elsewhere in the UK, an education package suitable for primary school age pupils has been created that is interactive and inclusive for all abilities. Two education animations; one for primary schools and the other suitable for secondary schools are available on our YouTube channel.[88] We also observe other initiatives and competitions on earth science and geothermal activities.

- **Consider geothermal insurance and indemnity.** Subsurface insurances are not universal in approach across countries. Iceland, for example, developed a public insurance scheme for geothermal risk —the National Energy Fund. This fund would reimburse up to 80 percent of the cost of approved drillings that were unsuccessful and also provide grant support for exploratory activities. Such geofunds play a key role in the early niche stage development when the sector market actors are less experienced and there is less R&D data activity on the geothermal resources. The interviewees suggest that both short-term and long-term resource risk is supported.[xxv] The first is the mutualization of risk and the process of dealing with the exposure to potential financial losses among several businesses, councils,

[87] https://www.theguardian.com/uk-news/2022/jan/18/northern-ireland-environment-plan-weak-flawed-dirty-corner-europe.

[88] See https://www.youtube.com/watch?v=0-R0oqaQZm0

government departments, insurance policyholders and investors. The setting of the threshold is a key determinant of uptake. The second is in the consideration of how insurance and indemnity provision for geothermal projects can be set up against risks if supply is disrupted from externalities, or where watercourse contamination occurs. Benefits and potential limitations could be explored through London insurance markets in which insurers can assess risks and offer policies for the particular risks, and where drilling and subsurface issues are covered by offer insurance products and underpinned by UK HM Treasury guarantee[89];

- **Create safeguarding custodian interventions.** The role of the government in building geothermal use in Northern Ireland and setting a strategic direction must also be balanced with its responsibility to safeguard the sector. We believe that consideration should be given by the Department for the Economy to its role as custodian of the subsurface resources. In particular, exploring the nature of that custodian intervention when conditions require the sanctioning of decontamination, decommission and site remediation work of a geothermal resource or resources;

- **Create data governance.** Consideration of the geothermal field data by the shaper community to ensure records and recording of geothermal borehole data is reported, updated and preserved. Having an accurate digital index in line with the industry drilling certification and compliance standards and the principle of the General Data Protection Regulation (GDPR) and the Data Protection Act 2018 requires discussion.[90] Presently there is a voluntary data index of geothermal borehole data in Northern Ireland.[91]The digital infrastructure appears to be in place and market-ready. We also note that from the initial showcase sector analyses, some specific borehole records are not always shown on the index of geothermal boreholes. Building and scaling up the geothermal sector will need data governance to be resourced to support accurate geothermal reporting, digital records and reporting. Borehole data governance, including water, also needs to be resourced to support accurate geothermal reporting, digital records and reporting. Presently, approximately forty deep water boreholes are monitored in Northern Ireland through the Land & Groundwater Team in the Regulation Unit, the Northern Ireland Environmental Agency (NIEA). It is advised that DAERA and Geological Survey of Northern Ireland consider how this can be jointly resourced and done.

> **Mandatory record-keeping:**
> "Consultants will ring around hoping the drilling contractors can remember what they did borehole wise. It is also the water logs too. There is no obligation – zero – for waterwell for contractors to keep records. There is frustration out there because it is unregulated."

*Niall Meehan| Meehan Drilling| 7/3/22*

[89] file:///C:/Users/Mark%20Palmer/Downloads/D-4.4-Study-on-risk-insurance-schemes-and-correctives-measures.pdf

[90] http://www.niassembly.gov.uk/about-the-assembly/assembly-commission/data-protection/

[91] https://mapapps2.bgs.ac.uk/GSNI_Geoindex/home.html).

> **Ensuring quality data generation:** "The obligation model and the willingness to collect and share the data varies throughout the UK. Just because you have a GS tool that does not mean that you get the quality data. How do you incentivise that?
>
> *Dr Corinna Abesser| Hydrogeologist and Groundwater Modeller | British Geological Survey| 4/4/2022*

- **Geothermal maps**. There is an important requirement to maintain and promote the publishing high quality resource maps and any underlying empirical data sets for understanding, and for that to be owned and managed. Understanding how this could be linked into the routine annual licence reporting such as those conducted in the ROI.[92]
- **Certification of drilling firms** and compliance with borehole recording would appear to be warranted, even mandatory, for growing the geothermal sector. Consideration is warranted in creating an office to implement data creation, application and storage and retrieval for geothermal developers in the geothermal application processes, where borehole data and maps can be used for initial site identification purposes, or to carry out prefeasibility. Box H provides an illustrative EU approach, while Figure 5 provides the overall roadmap cycle vision for this data creation, application, storage and retrieval system.

**Box H: 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

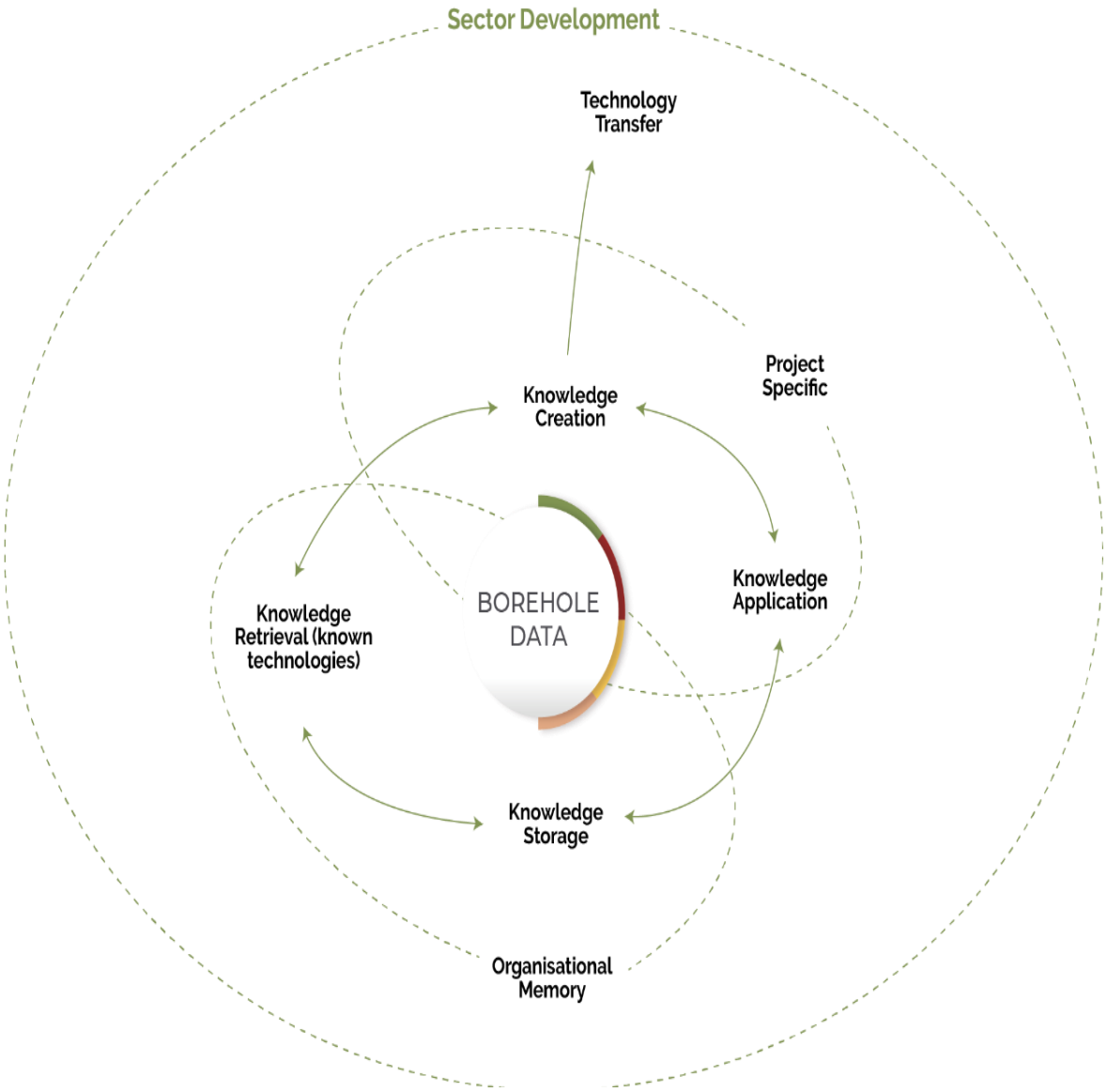
- **Build a viable and competitive tender bidding supply base.** Unlike Scotland and other markets where there is a tradition of gas and oil drilling, Northern Ireland does not have many of the elements for scaling up sector geothermal operations, particularly in deep rigs capacity. At least initially, there might be reliance on technologies and skills from mature

[92] https://www.epa.ie/publications/compliance--enforcement/licensees/performance/EPA-I&W-Enf-Report-2021.pdf

geothermal markets and oil and gas sectors. There is evidence of frequent tendering offers on sector websites.[93] Consideration of how the shaper community can build a viable and competitive tender bidding base through capacity building, professional certification and standard-setting is needed.

Figure 5: Building the knowledge links and creating data governance

Source: Adapted from Goulding et al. (2007)[94]




[93] For example, on https://www.newcivilengineer.com or https://thinkgeoenergy.com

[94] 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.

## 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.[95xxvi] 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. The sector standards can be supplemented by a range of government supported programmes, including but limited to:

- ***Industry Connections*** which explores emerging technologies to incubate new standards and solutions;
- **Conformity assessment and certification programmes** to speed up market adoption of standards, the technology use and build confidence in product functionality and safety, including training programmes for geothermal equipment installers;
- Incentivize with standards within a range of communities, businesses and technologists;
- **Training, skills and development programmes**, webinars, and other events to educate the market about key geothermal issues and sector coupling LZC technology and energy issues.
- Certification, quality assurance, professionalization.

**Voluntary and mandatory standards-setting:**

"We have established a drilling standard with the Microgeneration Certification Scheme Service (MCS) with the Ground Source Heat Pump Association (GSHPA) and is voluntary for the first 12 months but mandatory after that. Here, grants cannot be awarded unless there is an approved installer and registered. Issuing grants without this is just asking for trouble. Both boxes must be ticked now."

*Andrea Ellison| Director of the Ground Source Heat Pump Association| 14/3/2022*

**Consistency in policy:**

"We believe that above all a consistent policy creates installer confidence. It creates visibility for investment and has a blended and balanced mix of measures, funds, legal clarity, standards etc. We would also ask the government to do the full assessment. So, when calculating the provision of the ground source pumps versus air pumps, that models factor in the electricity requirement with on-peak/off-peak comparisons."

*Chris Davidson | Chairman and Technical Director| Genius Energy Lab| 14/3/2022*

Evidence suggests that standards and professionalism can build confidence for capital investment in equipment and grow sector capacity. In a geothermal sector, unregulated supply and drilling operations can jeopardize work practices, safety and the ability of those adhering to the standards being able to compete. Elsewhere in the UK, the MCS and the BDA have developed and published a Closed-Loop Drilling Specification standards in conjunction with the Ground

[95]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.

Source Heat Pump Association (GSHPA) in February 2022 and this should provide an opportunity for Northern Ireland to institutionally 'link in' with the standards elsewhere in the UK and to modify where necessary.[96] Other professional institutions can also support and assist with the qualifications and accreditation of relevant skill for subsurface aspects, including the Geological Society of London and International Association of Hydrogeologists.

## 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[97] [98] We believe this will require primary legislation and in accordance with UK Regulatory Policy Committee guidance.[99]

There are a range of measures that could be put in place under the legislation, regulatory framework and procedurality options. The options are:

Option 1: Do nothing, continue as is.

Option 2: Introduce primary legislation on geothermal activity and provide statutory provision for the roles of the Utility regulator and the Department for the Economy's Geothermal Advisory Committee in the application process and assessment and also in the sanctioning of noncompliance geothermal activity.

The geothermal sector is at an early niche stage and if the sector were to be boosted by government policy and resources, then it is prudent to have this legal clarity, not least because of the increased spatial proximity of neighbouring geothermal systems impacting upon each other and the legal implications thereof. There are also important environmental considerations on the solubility of the rock matrix as well as contaminants.

> **Finding regulatory responsibility for heat**
> "No one has the overall remit for regulation of geothermal in the UK. There is no bespoke regulator or anyone who coordinates the regulatory process. Heat is not legally defined as a resource – it therefore the resource itself is not licences or managed. This is not considered a priority at present by the environmental regulator or industry because of the low level of technology deployment. However, there is a lack of coordination in the way systems are regulated . Firstly, the environment agencies do not consider the impact on the heat resource but solely focus on

[96] https://www.gshp.org.uk/pdf/MCS_Specification_for_Ground_Source_Closed-loop_Drilling_1.0.pdf

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

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

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

> the impact of the operation on groundwater. Secondly, the health and safety regulation is essentially drawn down from the oil and gas regulations, which adds time and cost to the project. Finally, we have local planning with impact assessments. There is no one looking at the whole picture…I think we need the Department of Business, Investment and Industrial Strategy to assign a remit. In the Netherlands, they do assign responsibility through the Energie Beheer Nederland (EBN) …"

*Dr Corinna Abesser| Hydrogeologist and Groundwater Modeller| British Geological Survey| 4/4/2022*

After a period of consultation with industry, geological experts, local authorities, and other interested parties, a policy could put into place a licensing system and regulations for the exploitation of heat from shallow and deep geothermal sources for the direct use of that heat and cooling.

Interviewees believe that this clarification would create more stability and confidence and incentivize a range of communities and businesses by providing greater certainty for geothermal sector capital investments. The provision of legislation for geothermal development is regarded as an important dimension in providing end user/adopter confidence and thereby encouraging investment in building the geothermal sector in Northern Ireland.

**Legislation.** We find a range of legislation is presently being used in relation to shallow geothermal activity in Northern Ireland. Understanding how the legislation provision configuration applies in geothermal activity in Northern Ireland and how the legislative provision maps and fits together in that activity, might mean that it is timely to undertake a comparative research review of the legislation, particularly drawing on other UK regions and further afield. This is not within the remit of this report, or specifically this section. This report aims to address the challenge of building confidence in the geothermal sector.

Presently the sector is drawing down on a range of guidelines – a practice we term 'stitching and patching'. Without the legislative clarity, we find compensatory behaviours from those wayfinding on geothermal projects and, consequently, that is intensifying conservativism in the decision-making process of geothermal deployment within projects. Effectively, it is adding to decision-makers' caution and this undermines confidence.

In this section, we report the experiences of interviewees with respect to interacting with the legal aspects as these currently work in practice. The baseline finding is that we believe that it is necessary to try to make geothermal and subsurface legislation clear than it is at present. At present, interviewees are highlighting knowledge gaps in terms of definitions, legislation boundaries and legal protection. There is interest in regulatory provision in measuring the changes to groundwater temperature and how neighbouring geothermal systems can impact on each other. At the heart of this is making the subsurface property rights question clearer than it is at present. We believe that finding definition in depth between the shallow and deep is required as it is presently undefined in Northern Ireland legislation. We believe that these definitions could be further reviewed when drilling methods improve, when deeper depths may be more easily and cheaply accessed by technological advancements. A further consideration is the rise of groundwater temperatures occurring 'naturally' from the resulting temperatures from global warming. We believe that it is necessary to find definitions and also review those, as interviewees' experiences attest:

> **Finding a resource definition of heat:** "In Germany heat is defined as a resource. In the UK heat is not defined

> as a resource by law therefore you can't put a licence on it."

*Dr Corinna Abesser | Hydrogeologist and Groundwater Modeller| British Geological Survey| 4/4/2022*

> **Calls for policy direction:**
> "Firstly, the key point is increased knowledge and experience is necessary so a way to share the learning is needed. Secondly, we need support with the planning permission. We need a scope to explore – development rights for project exploration with renewable technologies. Planners simply don't know about these technologies and have no position in our aspirations. Thirdly, how do other geothermal projects nearby impact our project? We fear this and there is no legislation or even a paper on it. How does Victoria Quarter carpark development, or any adjacent development, affect our geothermal resource? Fourthly, we need geothermal guidelines – there are no parameters. We need a common set of facts – information sheets. It is a sellable prospect. We have lots of work to do and are not looking for more, or creating more work. We are on the fence. We need a base of research reports, more resources to resolve the issues."

*Clare McKeown| Sustainable Development Manager| Belfast City Council| 1/3/2022*

> **Subsurface ownership:**
> "…we have concerns about how to assess and identify patterns that emerge at and between boreholes. Where do we stand on resource erosion?

*Wendy Langham | Project Manager | Destination Hub | Belfast City Council, 01/3/22*

We find that the Mineral Development Act (Northern Ireland) 1969 legislation could provide a useful starting point as a statutory framework for the NI geothermal sector.[100] The exact nature of the property rights in natural resources located deep underground is also unclear and the lack of clarity regarding the definition of subsurface property rights. The experience of the United Downs flagship geothermal project provides insight into the unexpected discoveries of lithium in the subsurface. The question of who owns any minerals could be more salient for deep geothermal activity. This might mean that it is time to review the Mineral Development Act (Northern Ireland) 1969 legislation.

The Northern Ireland Law Commission's Report on Land Law Reform, following the Consultation Paper on Land Law, published on 1st June 2009 and the Supplementary Consultation Paper on Land Law published on 1st February 2010 does not specifically deal with the subsurface provision in Northern Ireland. [101] Further consultation is suggested with The Civil Law Reform Division (CLRD) of the Departmental Solicitors Office. [102]

Most interviewees highlighted the question of ownership and therefore being brought before the civil courts. We find some preliminary insights into the subsurface property rights question; some are quite assumptive and there is taken-for-granted and automatic entitlement (i.e. the *ad coelum* doctrine).[xxvii] Others

[100] https://www.legislation.gov.uk/apni/1969/35/contents

[101] http://www.nilawcommission.gov.uk/land_law_report_nilc_8__2010_.pdf

[102] https://www.finance-ni.gov.uk/articles/law-reform-northern-ireland.

emphasise the 'vicinity control' question and the ability of one geothermal project activities could influence the conditions and interfere with their subsurface activities. The application of common law of property trespass is reported in the literature in relation to unauthorized subsurface encroachments, or the effects of activity on the neighbouring surface, but that academic literature is comparatively scant upon an initial Queen's University Library QCAT database search. Due to the limited amount of geothermal schemes in Northern Ireland, there have been no known issues with interference between adjacent geothermal schemes, but any uptake in sector building would increase the probability of this occurring and requires the rights of third-party landowners to be considered beyond land ownership boundaries.

The Planning Act (Northern Ireland) 2011[103] remains largely silent on subsurface minerals, although Schedule 6(d) provides some provision in respect of the mineral site and extraction restrictions.[104] At this stage, we believe that it is necessary to try to make practice guidelines clearer than they are at present.[xxviii] While existing legislation in common law and planning exists at the local council, preparing for geothermal policy involves a much greater range of mutualised governance arrangements, and interviewees are acknowledging that these laws are not particularised for geothermal activity.[xxix] There is an appreciation that decision-making is bound up by third-party institutional processes.

An interviewee raised the question of the definition of shallow and deep geothermal activity and how that is precisely measured across the international sector and technologies are advancing. We believe that this distinction is precisely defined. We also refer to Section 2.2 where new technologies within niches must be protected from legal regimes and research provides useful guidance on the role of planners in making markets.[105]

> **Balancing technical and commercial safeguarding:**
> "It comes back to the fact that the sector is still in infancy. That means there is extra caution and supervision to understand the risk. A water well in GB is not applying that level of conservation in decision-making – I think they have a better appreciation of risk there. When you add in all of these technical layers of risk assessment, it gets to the point where it doesn't look good commercially."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

> **Customer regulation: "**
> "When you speak with industry, the attention given to the issue of decarbonising of heat changes when the industrial customers start asking for carbon-free products. So there is a careful balance to be struck between the mandated route and the customer focus approach."

*Martin Doherty| Centre Manager| Centre for Advanced Sustainable Energy (CASE) |31/3/2022*

[103] https://www.legislation.gov.uk/nia/2011/25/contents

[104] The BGS provide a useful summary on mineral ownership . See https://www2.bgs.ac.uk/mineralsuk/planning/legislation/mineralOwnership.html

[105] https://www.rtpi.org.uk/media/1412/planningmarketmaker2015.pdf

An initial scoping activity also indicates that supplementary statutory frameworks include The Water and Sewerage Services (Northern Ireland) Order 2006 [106] under Chapter III in the contamination of water, along with the notification of the British Geological Survey of borehole locations and activities as well as the Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency. Presently no resource permitting or licensing system exists in Northern Ireland. Of the small number of existing schemes in Northern Ireland, all are ground source heat pump (GSHP) schemes and installed to shallow depths.[xxx]

Exploratory interviews with one council suggest that it might be prudent for statutory consideration and clarification on the role of the Geothermal Survey of Northern Ireland as a consultee in geothermal planning applications. This question may become more salient as the sector develops.[xxxi]

> **Statutory clarification:**
> "What is the role of GSNI in the planning process? What is the role in applications and their direct involvement in that process?"

*Barry Diamond | Head of Planning | Antrim and Newtownabbey Borough Council | 12/4/2022*

Geothermal flagship project leaders reveal a shared view that more data should be made available in a central place and subject to the very careful consideration of the context and process of their actions. Interestingly, elsewhere in the UK statutory provision has been made for Heat Networks and this can bring more confidence in potential heat network investments from industry (see the Heat Networks (Scotland) Act 2021).

**Building a regulatory framework.**
Building the geothermal sector in Northern Ireland necessities the building of a specific strategic regulatory framework for regulators to employ when choosing intervention strategies for dealing with risks in the geothermal sector in Northern Ireland. The UK government's 'Levelling up the UK' White paper recently outlines principles for a successful policy regime and these are seen to be interlinked and reinforcing (See Box I). The principles are based on improving information, reshaping incentives and strengthening the regulatory institutions necessary for transitioning markets.

[106]https://www.niwater.com/sitefiles/resources/htmlfiles/information_management/water_and_sewerage_services_northern_ireland_order_2006.pdf

**Box I: Principles for a successful Policy Regime**

The UK government's Levelling up the UK white paper suggests principles for a successful policy regime which geothermal policy can respond to long-term and support:[107]:

**Longevity and sufficiency.** Well defined medium-term objectives provide clarity about the policy objective and anchor the policy change necessary to meet this objective. Targets like Net Zero for greenhouse gas emissions, used by the CCC, anchor decision-making to the long-term in a clear and consistent fashion. This suggests a levelling up of geothermal policy anchored in a clear set of medium-term targets or "missions".

**Coordination.** Institutions and frameworks that coordinate policy design and delivery are critical to system-wide success. The NIC's charter enables it to play this role, coordinating across multiple strategic areas of policy.

This is also true for the 25-year Environment Plan, which brings together stakeholders from the agriculture and energy sectors. This suggests a policy regime for levelling up geothermal in NI should embed spatial considerations, and coordinate policy actions, across central government.

**Local empowerment.** The principle of subsidiarity says that decision-making should take place at the most delegated or localised level at which it can be most effectively performed, provided it has effective leadership and adequate resources.

This suggests a levelling up geothermal regime needs to empower local leaders, subject to appropriate accountability to make decisions.

**Data, monitoring and evaluation.** The success and credibility of the Bank of England, CCC, NIC, NICE and OBR are all based on extensive and granular data and deep analysis. They are also based on a quantitative evaluation of the policy actions necessary to meet medium-term targets. This suggests a levelling up policy on geothermal R&D facility, resourced and grounded in granular data, sound monitoring and rigorous evaluation.

**Transparency and accountability.** The OBR, Bank of England, NIC, NICE and CCC have a public duty to publish their assessments of performance to inform policy decisions and debate. There are also clear, transparent and rigorous accountability mechanisms for decision-makers when acting in an independent capacity. This suggests a levelling up policy regime needs to be transparent, expert and accountable.

Source: Levelling Up the UK (2022), p.116-117.

We believe these principles could be used in relation to extending and building the specific regulatory interventions in the geothermal field. There are existing guidelines within the regulations in

107 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1052708/Levelling_up_the_UK_white_paper.pdf p.116-117.

relation to aspects of geothermal activity, including;

- **Ground Source Heat Pumps**, there is existing regulatory guidance on this topic outlined on NetRegs web page.[108]
- **Groundwater**, the Northern Ireland Environment Agency (NIEA) has detailed guidance for the monitoring, protection, regulation and sustainable management of groundwater.[109]
- **Hydropower schemes,** the Northern Ireland Environment Agency (NIEA) issues an abstraction or impoundment licence if the scheme uses more than 20 cubic meters of water per day.

Our research also highlights areas that might merit further consideration where existing regulations are drawn down to 'stitch and patch across' the institutional regulatory void and also expert knowledge gaps that exist on geothermal activity. Presently there is no one digital repository for this information for the geothermal sector.

> **Existing legislative approaches:**
> "Regulators are not sure about geothermal and in that uncertainty, they draw down on what they already know, the existing legislation on water efficiency and water extraction. Do we need one or two licences? A discharge licence and/or heat dispersion licence? What is the meaning of non-consumptive? A decision is reached that is not about environmental safeguarding but about knowledge gaps – they are still learning. However, building the sector will need a framework. We need to be documenting the project experiences and learning lessons…"

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

> **Neighbouring geothermal systems:**"
> :"…the changes to groundwater temperature and how neighbouring geothermal systems can impact … on solubility of the rock matrix as well as contaminants. In today's world we assess groundwater abstractions on whether they can impact on other receptors (including other abstractions) due to changes in groundwater levels. In tomorrow's world: Do we need to assess geothermal systems on whether they can impact other receptors (including other geothermal systems) due to changes in groundwater temperature? It would be good to have a baseline on potential thermal impacts to go towards informing any future policy requirements… There is also the aspect of climate change and global warming. If groundwater temperatures rise 'naturally' due to global warming, geothermal systems used for cooling are less efficient. If groundwater temperature is increased further due to neighbouring geothermal cooling system, it might be even less efficient."

*Dr Silke Hartmann | Integrated Catchment Planning Team Leader | NIEA*

How might a regulatory framework work in practice? A simple policy intervention approach would be to select one policy and apply this to all lower risk geothermal sites or activities. An alternative option would be to focus on the nature of the risk alone and to select intervention strategies with reference to the amount of regulatory

[108] http://www.netregs.org.uk/environmental-topics/carbon-reduction-and-efficiency/generate-renewable-energy/geothermal-energy-and-ground-source-heat-pumps/

[109] https://www.daera-ni.gov.uk/articles/groundwater

resources that each geothermal site demands (See Appendix 7 for an illustrative regulatory framework).[xxxii]

There is no exploratory and operational geothermal licensing process provided in Northern Ireland policy. There is no mandatory national or local reporting on geothermal projects beyond requirements under existing environmental and planning guidelines. The consideration of a broad market-focused regulatory framework might address the economic, social, and environmental values of geothermal development in a circular economy.

> **Geothermal licencing and permits:**
> "…the policy on this is not just about usage. We have proposed a scale approach and different approaches to licencing. We think it is about the characteristics of the site, maturity, and target capacity. Licence a resource (the water extraction and energy harvesting) and permit an activity set. The key metric to be recorded and, we believe, mandated, is the net energy usage per square metre and that would prevent risk in the subsurface. And automatic permitting for exploratory shallow drilling work. We think that the net energy usage per unit area will mean that they are not taking too much out and not putting too much in"

*Dr Niall McCormack | Geologist | Managing Director of CausewayGT | 2/3/2022*

A market-focused regulatory framework might include social learning capacity building activities such as (i) support guidance with decision-making, (ii) consultation capacity building; and (iii) awareness building activities including exchanges with other geothermal development countries such as Sweden, the Netherlands and the incorporation of feedback for sharing within the geothermal sector. A regulatory stakeholder engagement strategy, informed by a social assessment, could be considered on how to improve engagement with local communities and increase knowledge and awareness of scientific, social and environmental aspects of geothermal activity. If this approach is taken, and we suggest it is, then consultation with broader decision-making approaches will be required.

> **Utility Regulator short-term decision-making logics:**
> "The Utility Regulator is a blocker to long-run thinking on renewable technology deployment. It is mandated in a particular direction and we need primary legislation to change this mandate. There needs to be a better balance between costs, decarbonisation and customer savings in the long-run – carbons in use**.** The existing mandated model logic is that projects need to prove themselves with absolute certainty, on a project by project basis, upfront, and not on an anticipatory basis because the Utility Regulator mandate models say so. So their existing mandate looks at the costs/investments from the short-term – £3 million is better than £4 million logic – but does not look at the longer-term and long-run savings for customers which can significantly exceed that differential, not to mention the net zero targets. So one side of the balance sheet logic. This characterisation may seem unfair but it is how it feels when you endure it. Now compare that with the ROI model, then you observe a different logic, with more upfront investments for the long-term and then clawing it back long term."

*Stephen Agnew | Renewables NI | 15/3/2022*

**Building procedurality.** An initial assessment and mapping of geothermal potential does not require extensive or costly work but having simple and clear steps with procedures to follow will help to minimize the adopter and/or end-user

confusion. Those leading out on geothermal reports report that there is a lack of institutional procedurality and also how to interpret the geothermal feasibility results and this has made it difficult for confidently making decisions.

> **Decision-making procedurality:**
> "For geothermal applications, I go back to what are the processes (the whens, the hows, the how longs), the issues (including the risks, impacts, costs, noises, complaints) and the outcomes (including the benefits, derived benefits, costs of running, social,economic and environmental savings. These need to be outlined…"

*Barry Diamond | Head of Planning | Antrim and Newtownabbey Borough Council | 12/4/2022.*

Procedures that create a customer journey and funnel from an initial situation with possible options shifting towards a converged decision which leaves one option. An illustrative example of that is outlined in Figure 6 (see overleaf).

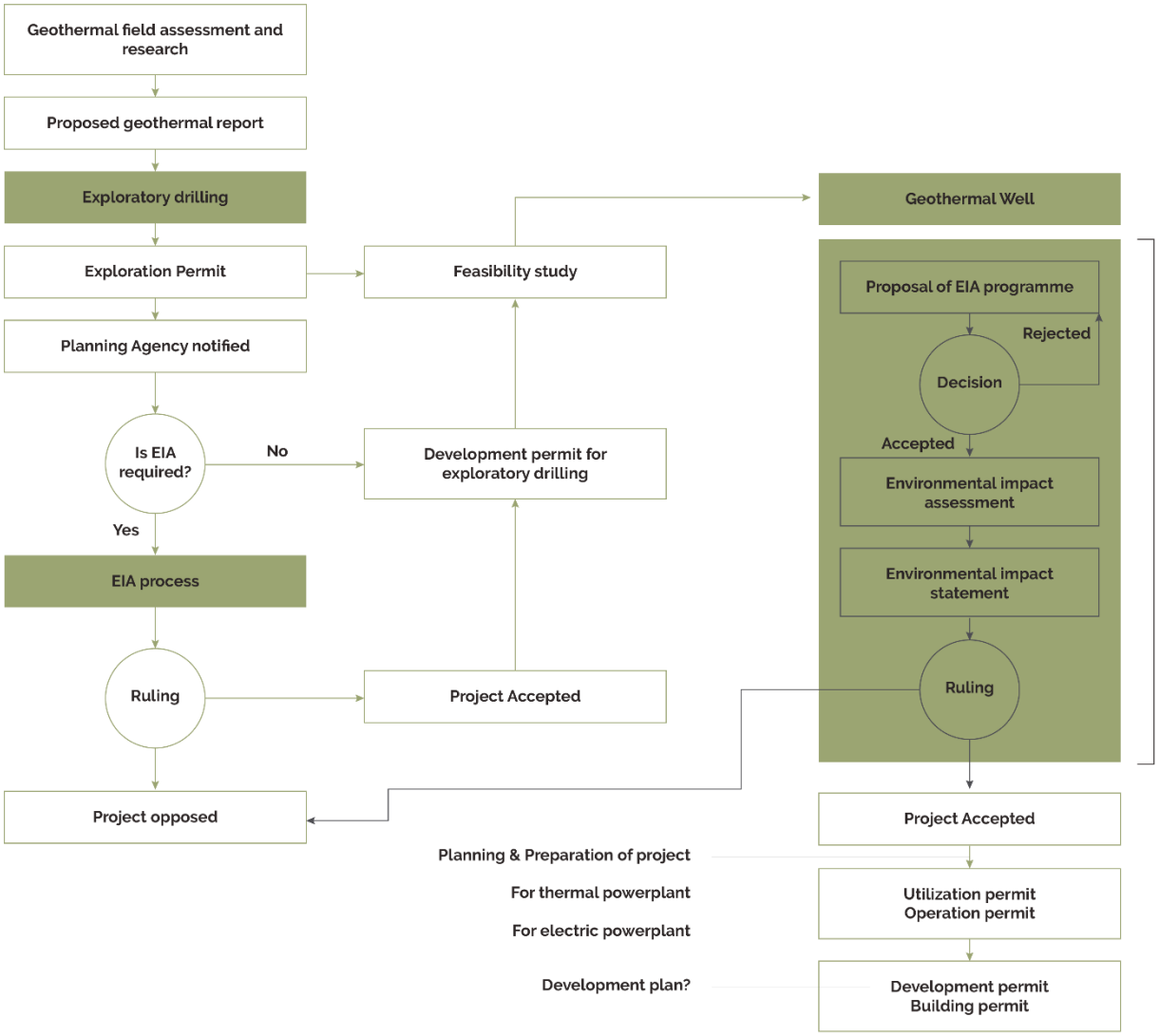



Figure 6: Illustrative procedural flow diagram for geothermal application

Adapted from Andrésdóttir et al., (2003). P.35.[110]

In this illustrative case, consideration of whether geothermal projects should require an Environmental Impact Assessment (EIA) are based on the following criteria: geographical location, geology and landscape, whether the area is exploited, relation to protected areas, recreational attraction and existing development plan. In some instances, substituted industries such as oil and gas drilling can assist with the procedural elements of the geothermal sector, but that should be adapted, where appropriate, to the specific characteristics of the geothermal sector and to the institutional conditions of Northern Ireland.

The identification of steps to strengthen the monitoring of awarded geothermal schemes could be undertaken to ensure compliance with investment, environment and related agreements as well as evaluation of bids, management of permit

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

and the licencing award process, and oversight requirements.[xxxiii] Geothermal procedural development might also 'link in' with and consider the following in-the-field project support for;

(i) feasibility survey, interpretation and skills training to boost existing capacity in the geothermal sector;
(ii) institute of coordination of work activities related to geothermal projects such as those of a Geothermal Technology Office (See Section 3.7 of this report);
(iii) capacity building needs in both geothermal installation and maintenance.
(iv) monitoring of the geothermal projects to ensure statutory compliance.

## 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.

Elsewhere, there are animated and fun ways of building understanding of the subsurface into the everyday home activities (for example, children's books, school local council visits, competitions), improving understanding between geothermal technology and what the environment perceives as important values.

> **Social licence:**
> "The social licence is hard to win but easy to lose. The nearest and dearest neighbours must be consulted on the issues, processes and outcomes. People don't like the drilling rig, but we find that they can handle this if they are, included, involved and consulted in dialogues. Geologists are the stewards of the earth and we must make the subsurface visible. "

*Dr Marit Brommer| Executive Director| International Geothermal Association| 29/3/2022*

> **Building technology acceptance:**
> "Let's go where we are wanted and warmly welcomed. Go to the communities that want us. Set up competitions for heat networks."

*Dr Niall McCormack | Geologist| Managing Director of CausewayGT | 2/3/2022*

> **Geothermal benefits:**
> "With geothermal, there are minimal visual impacts, no turbines on your favourite hill, no smell from the oil and gas when landed back onshore. If you look at the heat network in Southampton, it is the size of three car park spaces and a double story house. I'd point to Iceland in the 1940s which had daily yellow smog. Now it has the lowest carbon footprint of any country and that is largely down to geothermal."

*Professor Jon Gluyas |Executive Director | Durham Energy Institute| Durham University| 4/4/2022*

In speaking at the launch of the 22-point Action Plan for the Path to Net Zero Energy Path, the Economy Minster recognised the need for the plan to be endorsed by many organisations working in the energy sector, but also endorsed by

communities by working with the (elected) representatives of those communities.[111]

Ensuring inclusive practice and processes from the community voices will be important for building confidence in the geothermal sector. Some preliminary field feedback finds positive responses to geothermal activity in community consultation.

> **Social value spillovers for communities:**
> :"…there is social value in developing the estate with a geothermal installation which goes beyond the our regulatory obligations. The location and setting of Riddel Hall offered a perfect opportunity to incorporate a geothermal solution for the new building."

*Damien Toner | Director of Estates | Building Surveyor | Queen's University Belfast | 10/3/2022*

> **Community consultation:**
> "Queen's like to be good neighbours and let everyone know what is going on. We extended our pre-application consultation/open day on the Riddel Hall build with the local community. There were no issues with the geothermal side of things, only positive comments and the community were impressed. Any build concerns were not related to the geothermal but mostly about the lawn and carpark spaces."

*Jacqueline Kearns | Estates Manager | Quantity Surveyor| Queen's University Belfast | 4/3/2022*

The Environmental Assessment (EA) is a well-established process for evaluating, at the earliest appropriate stage, the environmental consequences of implementing projects or initiatives on the existing local communities and for safeguarding the social licence.[xxxiv] Local communities across the world are increasingly engaged in contesting new developments and mobilizing social movements[112] with social media targeted at firms or institutional project pioneers.[113]

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.[114]

A lesson drawn from the Iceland case is the importance of having a clear zonal resolution geothermal map of 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. Councils could then initially assess geothermal applications against the classified zones, whereby applications conforming to pre-agreed classifications would gain initial approval for exploration activity. This

[111] https://www.economy-ni.gov.uk/news/path-net-zero-energy-creating-jobs-and-more-affordable-energy

[112] Palmer, M. Simmons, G. and Mason, K. (2014), Web-based social movements contesting marketing strategy: The mobilization of multiple actors and rhetorical strategies, Journal of Marketing Management. Vol. 30, Nos. 3–4, 383–408.

[113] Temper, L., del Bene, D., Martinez-Alier, J. (2015), Mapping the Frontiers and Front Lines of Global Environmental Justice: The EJAtlas, Journal of Political Ecology 22(1): 255–278.

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

planning zoning could be linked with heat network zones, as outlined in statutory provision elsewhere in the UK (see the Heat Networks (Scotland) Act 2021).

With such a zonal resolution policy in place, this would protect and balance the interests of all communities across Northern Ireland. It can also safeguard against one-sided protests than can spoil the whole sector and which, ultimately, would curtail Northern Ireland's transition toward net zero greenhouse gas emissions.

We find from this initial research that the subsurface is viewed as an 'alien concept' and removed the idea of energy. This view is also reported from the development of the Glasgow Geoenergy Observatory. To succeed, a net zero transition must be accessible, fair, and without adverse effects on peoples' 'sense of place', their jobs and quality of life.

Just energy transitions highlight the importance of toponymy, meanings and a 'sense of place', family heritage on lands, within the context of Northern Ireland's mostly rurally dispersed population. We believe that a work package designed for building community engagement and awareness, in conjunction with council activities, and building the interactions between stakeholders on the subsurface is needed.[115]

There is an understanding that people need information, community forums, stakeholder interactions, advice, financial support and consultation opportunities. Recent levelling up research shows that the revenge of the places that are seen to "don't matter" produces a reaction in the form of politics rather than economics.[116] Policy solutions on geothermal deployment, therefore, need to be place-sensitive, that respond to the structural opportunities, potential, and constraints of each place.

[115] Le Feuvre, M. Medway, D., Warnaby, G., Ward, K. Goatman, A. (2016), Understanding stakeholder interactions in urban partnerships, Cities. 52, pp.55-65.

[116] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1052708/Levelling_up_the_UK_white_paper.pdf

## 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. At the same time, we find that opportunities for R&D data collection have been missed on early-stage geothermal projects in Northern Ireland that could have helped showcase the technology deployment and the resources more generally. This brings attention to the importance of showcasing geothermal activities to build confidence and grow the sector.

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. As previously noted in Section 1.1. of this report, 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.

> **Technology promotion and UK capacity:**
> "It is a standard technology that should be automatically on the list. In my view, it is to do with promotion. To build awareness we need more test examples of it working in Northern Ireland, with schemes in England, Scotland and elsewhere."

*Peter McConvey Hydrogeologist|Tetratech| Lyric Theatre geothermal cooling project| 30/3/202*

> **Technology trajectory assessment: "**
> "This is a mature technology – tried and tested elsewhere in the UK and the EU. Even Her Majesty The Queen has a geothermal system installed at Buckingham Palace. We are set a geological problem, but the answer is not a geological one. Geologists talk to one another, but we need to transcend those conversations to practical market conversations – to move from the exploratory phase to the market phase. We need more market traction."

*Dr Niall McCormack | Geologist| Managing Director CausewayGT | 2/3/2022*

There are strong interviewee opinions on the trajectory of showcasing activities and what geothermal offers in addition to the other renewable technologies. Key scoping and development of that activity will be important. These include amongst other issues, stability and predictability of supply, the geothermal resource across Northern Ireland, detrending seasonality, long-run productivity, cooling as well heating supply and storage capacities.

### 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.

The implications of this finding should not be seen as insignificant for building the geothermal sector, however. Interviewees suggest that this is arising for different reasons; partly because of the way behaviours are situated upstream in the adoption cycle, partly because the subsurface is beyond immediate visibility and reach and therefore taken for granted, but also because there are relatively few visible demonstrations flagship cases in Northern Ireland which public trust and confidence can be built through day-to-day interactions, with cumulative experiences of the geothermal heating in community facilities, recreation buildings and workplaces.

We believe that strategic geothermal technology showcasing could be undertaken in a holistic way that includes demonstrating with;

(i) Build assessment and reporting
(ii) Governments as demonstrators
(iii) Strategic market framework
(iv) Drilling operations capability
(v) Mobile Geothermal Observatory
(vi) LZC Technology Centre
(vii) Cooling projects
(viii) Community heat networks
(ix) Hybridization-sector coupling
(x) Narrowing and closing the gaps

A number of additional demonstration activities might include, but are not limited to;

**Showcasing business stories from multi-sector experiences**. The reporting of geothermal technology deployment in a narrow technical sense does not provide adequate insight into the scope of the technology applications and where the technology has worked well across business contexts. We believe that adopter/end user experiences need to be showcased across multiple sectoral contexts (e.g. leisure/tourism, pharmaceutical, horticultural, healthcare) and to evaluate and compare different approaches and allow for confidence-building at the early niche stage of the sector.

**Press Releases of new capital developments visibility**. In addition to the showcase build opportunities, we find little evidence in the recent Press Release announcements on capital works for Northern Ireland's major school building work programmes, transport hub, residential home/hotel and spa developments (e.g. Rostrevor), or retail horticulture (e.g. Dobbies in Antrim) and how such projects showcase renewables and geothermal resources across Northern Ireland.[xxxv]

**Event day visibility.** Research shows that high performing business models frequently outperform higher technical capabilities. Spanning the technical conversations is, therefore, an important challenge and opportunity for the geothermal shaper community. International event days are important to mark and pivot from such activities. Geothermal Day and Earth Day can provide an international setting against which local activities are promoted and conversations are opened and openly discussed each year.[117]

**Post-installation visibility.** One of the merits of geothermal technology is that once installed it is fairly invisible above the ground. Observations from the flagship geothermal flagships on the ground reveal little, if any, visible promotion of the geothermal technology. With demonstrations, thousands of end users walk in and around the geothermal heated or cooled buildings without any awareness of the geothermal technology. The Energy Performance of Building Regulations (Northern Ireland) mandates Display Energy Certificates (DECs) to help consumers make an informed choice by providing information regarding the specific heating/cooling and related

[117] https://worldgeothermalenergyday.org/home

environmental standards. We believe that this is a showcasing opportunity for the geothermal sector to build confidence in the technology.[xxxvi]

> **Post-delivery scheme:**
> " I find at the exploration stage there are many experts with everyone promoting optimisation – all with different views on how to do this, even when they don't know, they do it to save face. The consultants have the next project on the horizon, and we go off on our merry way. The client is left, maybe even with poor advice. I think there is merit in a post-delivery scheme – support for maintenance agreements and to retain the firm."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

**Visible geothermal and subsurface stories.** There is little evidence of any persuasive storytelling to showcase the geothermal activities – in effect, to emotionally engage, to bring in history of geothermal heating or cooling, mythology-making and the extent to which the Northern Irish communities can be transported into the geothermal narratives. Showcasing stories and mythology are evident throughout the Northern Ireland landscape and most noticeably at the geology of the Giant's Causeway.[118] [119] [120] We believe that further consideration of how to showcase geothermal as part of everyday life community experiences is required. [xxxvii]

**Visible stakeholder engagement.** A communication stakeholder engagement strategy could be developed to improve engagement with affected communities and to increase knowledge and awareness of scientific; social and environmental aspects of geothermal development. Activities could include, among others, developing communication materials and guidance notes, facilitating knowledge exchange, and strengthening consultation processes by facilitating stakeholders' access to independent expertise.

## 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.[121] 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.

> **RIBI stage 3 process:**
> "From our side, there is long-term stability. That is, our heat costs on that part of the estate remain constant and won't change for the next 100 years.

[118] https://www.thegiantscausewaytour.com/the-giants-causeway-story

[119] Green, M. C., Brock, T. C., Kaufman, G. F. (2004). Understanding media enjoyment: The role of transportation into narrative worlds. Communication Theory, 14(4), 311–327.

[120] Jones, M. D., & Song, G. (2014). Making sense of climate change: How story frames shape cognition. Political Psychology, 35(4), 447–476.

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

> That is visibility in costs. The building consultant was creating the right mood music through the RIBI stages, test pile results were as expected and positive. Of course, there were glitches but those got ironed out. The Low Carbon Report as part of the RIBI stage 3 process was critical for momentum. Renewable energy systems were presented there as part of the building project norm as a range of LZC technologies."

*Jacqueline Kearns | Estates Manager | Quantity Surveyor, Queen's University Belfast 4/3/2022*

> **Holistic views for end users:**
> "If you are sitting at the end user table: on the one hand, in shallow geothermal solutions, the off-the-shelf boxes/equipment is market-ready but it is missing the strategic design-led approach to energy solutions. On the other hand, in deep geothermal, there is a classical usage issue - the off-the-shelf boxes/equipment and skillsets are limited and there is a puzzle for the end-user to work out, but the design-led approach is there."

*Dr Riccardo Pasquali| Geologist | Geoservsolutions. 28/02/2022*

Additional assessment tools are used including, but not limited to, Low Carbon Energy Assessor (LCEA) with CIBSE Chartered Institution of Building Services Engineers (CIBSE).[122] 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. BREEAM 2018 New Construction Manual[123] includes a section which makes provision for showcasing technology innovation: **"To support innovation within the construction industry through the recognition of sustainability-related benefits which are not rewarded by standard BREEAM issues."**

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.[xxxviii]

The shaper community interviewees spoke of the "fine margins" from a short-term cost-benefit assessment, short-term business cases and return on investments perspective and called for a shift in the emphasis to support over the whole lifecycle of the building asset. The financial metrics may offer standardised ways of constructing certainty for what might be perceived as uncertain long-term financial models of geothermal technology. However, the interviewees from our research indicate that this is dwarfing productivity-driven LZC technology deployment opportunities. Moreover, there is some evidence that the regulatory bodies are mandated on short-term assessments of LZC technologies through existing legislation. A recent study also points to this issue and how long-run productivity LZC technology opportunities

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

[123]https://www.breeam.com/NC2018/content/resources/output/10_pdf/a4_pdf/print/nc_uk_a4_print_mono/nc_uk_a4_print_mono.pdf. P.357.

can be protected from financial regimes.[124] We find that showcasing geothermal assessment is required beyond the standard financial metrics and with non-monetary criteria. These non-monetary assessments might include public values criteria, such as decarbonisation, civil leadership, health, wealth creation, or distribution of power. In this respect, the UN Sustainable Development Goals could be helpful, along with provisions within the Climate Act (NI).

> **Levelling up financial logics:**
> "If we were going to build a 6500sq foot building, then we needed to balance that out in terms of that environmental footprint. We found that the business case had to work harder. But the School is growing significantly, there are growing fee-paying courses, but there are non-monetary reasons, too. There is a social and leadership value in doing this type of project, but how do you quantify that? It is leading in a self-determining way for social value. We were guided by the values of decarbonising our large estate; Queen's has a duty to lead civic society. There is a bit of the Northern Irish thing where we get a bit annoyed with others coming over here and telling us what to do. We have leadership and talent here and it needs to shine. The Swedish have been doing geothermal heating projects for years."

*Jacqueline Kearns | Estates Manager | Quantity Surveyor, Queen's University Belfast 4/3/2022*

> **Unknown subsurface and emotions:**
> "We find that businesses undertake the non-emotive analysis, the feasibilities, but then the decision-makers are overcome by the emotion of fear – of doing something in the unknown. The stickiness of today and difficulty of the change journey - the desire to remain where we are, with what we know."

*Dr Niall McCormack | Geologist| Managing Director, CausewayGT | 2/3/2022*

> **Financial case-making:**
> "The prevailing public logic is to do with financial husbandry – the taxpayers' money and is it in the public interest argument. The control or use of resources with business case analysis and measures close out the other value dimensions of the issue. But there are other trade-offs where other social and identity values can be found to weigh heavier, but do not fit into the financial assessment models. Arguments that have to do with energy futures, climate, children and future generations, and civil society leadership, occur in several forms and are perhaps of equal or a higher value. These need to be brought into consideration. But we have a complex project to deliver and energy is only part of that project management."

*Wendy Langham | Project Manager | Destination Hub | Belfast City Council| 1/3/22*

[124] Moll, J. (2017). The CFOs Guide to Technology Roadmapping. Association of Chartered Certified Accountants. Pp.1-25.

## 3.3 Governments as demonstrators

Geothermal use has been successfully demonstrated by governments throughout the UK and European Union.[125] [126] [xxxix] 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.** Elsewhere in this report, we have shown that geothermal has been discussed in the NI Assembly for over twenty years and has been referenced in key energy strategy documents (See Section 1.1.). We believe that following on from the dialogue work context, there is now an urgency to visibly showcase geothermal on the ground in Northern Ireland.

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. The decarbonisation of heat is not confined to the energy-specific sector investment portfolio but right across all capital investments. In 2010 the Department for the Economy (formerly known as DETI) outlined the role of Invest NI in sustainable energy technologies and this comprised mostly of promotion and awareness, along with supporting the growth mandate.[127] [xl]

We find some evidence of InvestNI promoting circular economy events[128] but not necessarily leading out on decarbonisation of heat in new capital build investments. For instance, in Scotland, we find evidence of heat decarbonisation imperatives with the merits of geothermal technology deployment and versatility in high control temperature environments, such as in distilleries and science laboratories. Northern Ireland has a great heritage in distilleries, and we believe there is an opportunity to showcase Northern Ireland in export markets around the world through net zero geothermal initiatives.

> **InvestNI greenbook appraisal:**
> "If you look at InvestNI's greenbook appraisal, there is no carbon chapter or set of metrics on Co2 measures in that. It only assesses job creation, skills, export sales and there's nothing on circular economy thinking – not only the efficiency in the economic but the efficiency in the social and the efficiency in the environmental. That is why carbon capture in capital investments on builds is being overlooked, what is being lost, dispatched or curtailed. For InvestNI, energy should not a separate division but is being treated as one and, as it were, the right-hand does not know what the left hand is doing…"

*Paul McCormack | GenComm Innovation Manager | Belfast Metropolitan College | 22/3/22*

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

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

[127] https://www.economy-ni.gov.uk/sites/default/files/publications/deti/sef%202010.pdf p.18.

[128] https://www.eventbrite.co.uk/e/zoom-resource-matching-workshop-with-invest-northern-ireland

**Feasibility cost shielding:**
"I believe that the costs associated with the feasibility could be looked at. InvestNI could support this feasibility activity – it is an extension of what they already do. InvestNI has boots on the ground when looking at investments and, I believe, could support this upfront geothermal exploration activity at this stage."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

**Decarbonising sectors:**
"In Scotland, there is an interesting project on decarbonising the distillery sector with geothermal – I am not sure if you are looking at the distillery sector in Northern Ireland?"

*Professor John Underhill | University of Aberdeen |11/3/2022*

**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. To build confidence in the geothermal deployment opportunities, our research finds that the local councils are seeking support with the following issues:

- Top-down policy direction and guidance from the Department for the Economy and Department of Infrastructure;
- Support with public communication materials to build awareness and understanding of what geothermal technology is and what geothermal technology is not;
- Temporary cluster events to share and discuss LZC carbon technology adoption and other net zero transition initiatives and projects;
- Case study sharing of best geothermal practice and roadmap support;
- Empowerment with strategic project opportunities and responsibility to lead out and deliver project initiatives in collaborative and innovative ways with public-private and public-public partnership activities;
- Resources and support by the Strategic Investment Board, the Department for the Economy and other departments where appropriate, to strategically engage with LZC technologies to deliver net zero outcomes.

To date, there is some evidence available on local councils in Northern Ireland seeking to showcase the role of geothermal technology, particularly with ground source heat pumps. On balance, there is strong evidence from the interviews that there is positive interest, curiosity and motivation, as indicated by the questions and the comments during the interviews.

The issue, therefore, is not one of a lack of willingness, or omission, but a need for more direction-setting, information, understanding and knowledge transfer in relation to geothermal activity. Moreover, councils are seeking reassurance, policy commitment and communications on how geothermal activity fits within the overall strategic priority of the NI energy strategy. Our research sample suggests that councils do perceive geothermal as an opportunity for the boroughs with the appropriate strategic and financial support. This is evident in the comment below.

**The direction of travel:**
"We would like more direction from DfE on their approach to geothermal as part of the sustainable energy plans going forward.. We have been historically

mindful to look towards geothermal within our council area as an opportunity. We look towards the energy strategy for NI to provide a framework for this work going forward. We would be keen to participate in a community competition or similar arrangement for geothermal projects in the future."

*Majella McAlister| Director of Economic Development and Planning | Antrim and Newtownabbey Borough Council | 12/4/2022.*

To build confidence, the council interviewees are calling for strategic opportunities to work in public-private arrangements to lead out on geothermal projects. In order to mutualise the risk and accrue social benefits for communities, it might be helpful to bring all of the councils together and to ascertain how this could be enabled and accomplished. We believe that recent research across the UK and the EU that sees planning professionals in local councils acting as important 'market makers' is instructive in the overall work needed for transitioning towards net zero goals in Northern Ireland.[129]

Further important insight into the institutional council environment relates to the out workings of the restructuring change across councils in Northern Ireland. There is some evidence of innovative network collaboration for the benefit of all of the councils across Northern Ireland, particularly leading out on net zero transitional projects, notably with OZEV and the ORC scheme, to maximise the savings and costs and also the social benefit for communities. Such network collaboration is important given the nature of solving the 'collective action problem' of net zero transition. This will be dependent upon the belief that each of the eleven councils have more to gain as part of the innovative council network arrangements than by acting alone – a notion known as 'super additivity'.[130]

We believe there is merit in incentivising council 'super additivity' specifically for the purposes of building the geothermal sector and creating mutualised geoenergy funding arrangements. There is therefore a need for a further policy on innovative collaboration networks at the council level and incentivisation by the Department for the Economy and other departments on net zero market transitions, both east and west of the river Bann.

**Council and public awareness:**
"There has been general talk about geothermal energy, but few councils have taken it any further, it's not a tried and tested technology in Northern Ireland. I feel there needs to be a council and public awareness and education programme to highlight the technology and how it can contribute to the decarbonisation of heat and lower energy bills, The public are not technically minded; they don't want to know about the technical issues, the majority of them look to have a warm cup of tea in a warm room. Most people don't understand geothermal or see it as a renewable source. It is something that happens in another country because they have warm ground there, we (the public) have a cold ground mind set."

*Leo Strawbridge| Energy Manager | Derry City & Strabane District Council | Chairman Northern Ireland Local Government Energy Managers Forum|12/4/2022*

**Council super additivity**
"I have worked with the 9 out of 11 Councils in Northern Ireland on an

[129] https://www.rtpi.org.uk/media/1412/planningmarketmaker2015.pdf

[130] Ibid.

funding application to OZEV ( Office for Zero Emission Vehicles) to install EV Charge points in NI through the on street residential charge point scheme (ORCS). There are clear benefits of making that funding application together by maximising the funding and providing value for the consumer. I have also led a consortium of 10 councils to procure electricity and gas for the council estate. Whilst councils are willing to work together, it is sometimes difficult to start the process, like in the case of the ORCS funding, someone had to stand up and take ownership to drive the consortium forward. Councils on the whole are risk-averse and sometimes this can be a barrier to effective partnership working."

*Leo Strawbridge| Energy Manager | Derry City & Strabane District Council | Chairman Northern Ireland Local Government Energy Managers Forum|12/4/2022*

Another interviewee was quite critical of the council energy plans in relation to bringing forward circular energy ideas. On balance, there is some evidence of three councils across Northern Ireland notably Belfast City Council, Antrim and Newtownabbey, and Mid and East Antrim Borough Council, having conversations and scoping, or engaging in technical feasibility studies. We believe that geothermal can cocreate social value within communities and deliver public value of local boroughs.

**Council energy plans:**
"What part do councils play in Co2 reduction in NI? Waste is an energy opportunity, and the technology has caught up, but waste is currently narrowly defined by the councils in Northern Ireland. There is an education transition needed at the council level. Yes, my bins are being collected, but is that energy being optimised? Could that energy be captured? They should be leading the way in building energy secure communities. We are asking for a review of all the NI councils' energy activities…"

*Paul McCormack | GenComm Innovation Manager | Belfast Metropolitan College | 22/3/22*

**Displaying geothermal instalment:**
"I believe that all public buildings should be mandated to consider geothermal energy. We need to make geothermal more recognisable and every day – show and lead out on the signs, measuring success and even symbols. So when I bring the kids to the swimming pool, they understand where the pool heating is coming from. There is a disconnect now and we need to reconnect with the earth and the energy it can provide."

*Dr Niall McCormack | Geologist| Managing Director CausewayGT | 2/3/2022*

Most councils in Northern Ireland have declared a climate emergency and established climate change working groups or task committees. Validating the geothermal technology in those working groups and task committees can help situate geothermal within the net zero pathways. In addition, collective institutional arrangements, such as the Northern Ireland Local Government Energy Managers Group, Sustainability Northern Ireland or others, can be equally be important institutional carriers for dialogues in building the geothermal sector in Northern Ireland.

This dialogue is particularly acute given that council interviewees raise the association of geothermal technology deployment with the technique of fracturing (commonly known as fracking). The interviewees request that there is a clear narrative and communications plan that sets out how geothermal activity differs from fracking. In this regard, a

range of fact sheets have been prepared by the European Geothermal Energy Council (EGEC, 2013) and that might be a useful resource. We believe that the articulation of this distinction in the regulatory framework is of utmost importance.

We believe there is an opportunity for all levels of government 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) levels. Circular energy plans are called for and where existing council plans are institutionally constrained in public leadership for circular energy approaches, then it is suggested that a review is undertaken of such NI council constraints.

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. The project manager reflects on her experiences below and also in Section 3.11:

Project management remits

"I feel like I'm being asked to measure geothermal outputs which is distracting when you are trying to deliver a complex project on time and against key construction performance targets."

Wendy Langham | Project Manager | Destination Hub | Belfast City Council| 1/3/2022

## 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.

There is a palpable interest in how the government can build confidence in the geothermal sector by mitigating the risks of geothermal projects and frontier business models. While the severity of the risk and recommended mechanism to mitigate these risks will vary by geothermal project, an observation from other countries is that mitigation measures of the sector risks are strategically targeted in policy, as outlined in Table 3.0.

Table 3.0: Building geothermal sector confidence from risk mitigation measures[131]

| Risks | Issue-driven questions | Mitigation measures with illustrative experiences |
|---|---|---|
| **Market demand risk** | Do you invest in one pilot project with one heat demand, or do you create multiple pilot projects with a variety of buildings and demands?<br>How do you design geothermal projects to maximise the heating or cooling demand of multiple stakeholders? | **Multi-stakeholder needs**: "The shallow wells serve individuals' energy heating and cooling solutions. The deep wells serve multi-stakeholder needs." **Dr Marit Brommer\| Executive Director\| International Geothermal Association\| 29/3/2022** |
| **Investor risk** | How do you support long-run investment that matches geothermal lifecycles? | **Promote and target patient investment returns:** "The Climate Change Commission has run various scenarios – 'balanced, tailwinds' etc. We know from their advice the costs of Net Zero for NI will cost at least £1.2b annually from 2030 split between the public and private sectors. Work by the UK Government OBR is suggesting a 25% public:75% private split. How do we incentivise the private sector for the net zero challenge? We in government have a role to play in regulation, incentivisation as well as legislation. We need to start with targeting and promoting the vanilla investments that are long-term and not venture capital type returns."<br>Kevin Hegarty \| Director of Green Grow and Climate Action \| DAERA\| 6/4/2022 |
| **Resource risk** | Do you opt for a multi-lateral or a unilateral approach in project selection? | **Adopt mutualising principle**: "The mutualise principle works to collectively reduce risk. Everything should work toward reducing the risk and making the risk bearable by mitigating it. When the risk is too high for one stakeholder, then you are not mutualising enough."<br>Philippe Dumas\| Secretary General \| European Geothermal Energy Council (EGEC) 11/4/22 |

[131] https://publications.iadb.org/publications/english/document/Unlocking-Geothermal-Power-How-the-Eastern-Caribbean-Could-Become-a-Geothermal-Powerhouse.pdf

| | | |
|---|---|---|
| **Exploration risk** | How do you get boots on the ground to do exploration feasibility survey activity? | **Support consultancy costs:** "The consultancy costs around the exploration stage can be high. I think there is an opportunity for InvestNI to do something to support this activity – their boots are on the ground anyway with new capital builds. It would be an easy 'bolt on' to get more geothermal projects across the line. I think that could drive the market more." **Conor Lydon\| Hydrogeologist \| Tetra Tech\| 05/4/2022** |
| **Construction risk** | Do you select a one-house solution approach or multiple operators in the construction?<br><br>Do you select oil and gas operators and/or build existing in-market capacity? | **Leverage North Sea Oil and Gas Capability**: "We have not only the task of decarbonising the oil and gas production in the UK (between 2-5% Co2 omissions), but we have a 'long tail' of disused oil and gas bore wells. We have the geological expertise and knowledge with the off-shore personnel, that data points and a supply chain that can turn and transition towards the geothermal resource."<br><br>Innes Auchterlonie\| Founder of Director\| Asset Integrity and Asset Management, Engineering and Consultancy Services\| Scotland\| 30/3/2022<br><br>**Clear fields but capacity building gaps:** "In Northern Ireland, I see that there are little, if any, oil or gas wells. That is an advantage in one way. If you bring in the oil and gas operators from overseas, the project costs will go up for experienced 'in field' drillers. Most operate open tenders from thinkgeoenergy.com."<br><br>Anonymous \| International Observer\| 3/3/2022 |
| **Technical risk** | How do projects overcome the non-standardised ground operations and technical conservatism? | **Balancing technical and commercial safeguarding:** " It comes back to the fact that the sector is still in infancy. That means there is extra caution and supervision to understand the risk. A water well in GB is not applying that level of conservation in decision-making – I think they have a better appreciation of risk there. When you add in all of these technical layers of risk assessment, it gets to the point where it doesn't look good commercially."<br><br>Conor Lydon\| Hydrogeologist \| Tetra Tech\| 05/4/2022 |

| | | |
|---|---|---|
| **Operating Risk** | How do geothermal projects create performance-based results for post installation operations? | **Post scheme instalment optimisation:** "I think the installations need optimisation – the installation of pumps, any niggling concerns after the keys are handed over. There needs to be a handover period."<br><br>Conor Lydon\| Hydrogeologist \| Tetra Tech\| 05/4/2022 |
| **Political and social risk** | How do you build social acceptance in communities? | **Managing community perceptions:** "Sharing information about geothermal technology and its application will be essential to the community. We will need to explain key aspects such as the carbon benefits, efficiencies, security of supply, transferability and community benefits? As a public authority, we are mindful of the public value for the borough."<br><br>Majella McAlister\| Director of Economic Development and Planning \| Antrim and Newtownabbey Borough Council \| 12/4/2022. |
| **Environmental risk** | How geothermal projects adapt to the environmental ground conditions and community concerns? | **Adaptation to ground conditions:** "Designs are designs. We need to change them, but the original designers can stick to the original plans and stick to their guns. We need to adapt to what we have found in the ground."<br><br>Conor Lydon\| Hydrogeologist \| Tetra Tech\| 05/4/2022 |
| **Regulatory risk** | How do regulators deal with individual arbitrage and unintended regulatory effects at an early niche development stage? | **Existing legislative approaches:** "Regulators are not sure about geothermal and in that uncertainty, they draw down on what they already know, the existing legislation on water efficiency and water extraction. Do we need one or two licences? A discharge licence and/or heat dispersion licence? What is the meaning of non-consumptive? A decision is reached that is not about environmental safeguarding but about knowledge gaps – they are still learning. However, building the sector will need a framework. We need to be documenting the project experiences and learning lessons…"<br><br>Conor Lydon\| Hydrogeologist \| Tetra Tech\| 05/4/2022 |

Source: Adapted from Gischler et al., (2017)

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.

This mutualised principle creates opportunity for the NI government to work together with local councils as well as individual private firms. We find that derisking from the private firm's perspective might be different to that of a sector-building derisking perspective, however. 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:

> **Procurement of specialist services:** "In developing the geothermal project and siting the location of the bore well we were told that based on procurement rules, no public authority could procure heat from private lands. We are looking to build the infrastructure and then operate and maintain the energy on the basis of a 25 year agreement. For the Health Trust, the rules were unclear – how do we bid for such as specialist service."

*James Crawford| MJM Renewables |QUB| Arup| GEL consortium 7/03/2022*

> **De-risking from the private perspective:** "When we spoke with the political parties and local councils, the automatic reaction is that they don't have a project to 'pin on it.' We had to bring in consultants to convince the council it was safe. We sought to derisk the project – one customer, one single site, one council, one stable revenue stream for 25 years."

*James Crawford| MJM Renewables |QUB| Arup| GEL consortium 7/03/2022*

## 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. The UK mainland has existing oil and gas drilling skill sets and those working there could be targeted through supported schemes, and other training and apprentice schemes. Interviewees highlight that there is promising expansion capacity of the ground source heat pumps in mainland UK with firms, such as Kensa Heat Pumps, enabling UK PLC and the front end of the operations to be realised.

What appears to be more problematic is the drilling capacity. The interviewees indicate that drilling costs are approximately 40 percent higher on both sides of the border than in mainland UK and EU. The transporting of the drilling rig in and out bears significant costs as well. We identify that there are some local firms that work in all aspects of modern geotechnics and foundation engineering but do not specialise in geothermal activity. These firms could be incentivised to extend the scope of their operations and supported, where appropriate, with international training schemes.

A short sector audit of drilling rig capacity, skills and related technologies could be undertaken. Comparatively few firms specialise in the drilling setting conductor casings for wells. Site construction, soil stripping, benching and tubular construction to installation of running roads, traffic management and reinstatement back. One interviewee is calling for the certification with heat pump installers and drillers – a geothermal association standards institute. Specifically, an education programme building on international standards and a series of workshops for building awareness, along with machinery. This interviewee is also calling for the temporary convening and organising to map out and build consensus amongst the drillers, while also capturing the local knowledge and learning of the experienced generation of drillers see table 3.1 below.

Table 3.1: Construction operations experiences in geothermal

> **Intermittent work-limiting capital investment:** "I've been in the thick of it here…[Ireland]… but you can count on your hands, the geothermal projects across Northern Ireland. There is no continuity and consistency in the work – which detracts the industry from investing in drilling rig technology. The drilling rigs are expensive. I do not see anyone spending on upgrading the rigs and so we end up with a low base of older equipment. There are rigs that remove the steel but all of that steel is being left in the ground because of the equipment not being upgraded."

*Niall Meehan| Meehan Drilling| 7/3/22*

> **UK heat pumps capacity**: I have been involved at the feasibility stage with a large manufacturing plant with cooling requirements in Belfast. However, it never went ahead despite favourable conditions. Building this sector is very achievable. The mainland UK has some really interesting and innovative Ground Source Heat Pump firms such as Kensa Heat Pumps. The UK PLC capacity is there at the front end… "

*Peter McConvey |Hydrogeologist|Tetratech| Lyric Theatre geothermal cooling project| 30/3/2022*

> **Drilling Association and organising interests:** "The British Drilling Association has no idea what is going on here with the 26 drilling contractors and we are not meeting up and organising ourselves. If you look at Denmark or Germany, they know every hole and records are up to date. We need a big conversation about how to deliver this to make it sustainable."

*Niall Meehan| Meehan Drilling 7/3/22*

> **Standards and certification**: "The geothermal sector needs more design….One, on the backfills, the protective material. Two, on groundwater responsibility, for example, septic tanks and that sort of contamination. Being aware of and mindful of the distances. The USA have an apprentice scheme which requires the drillers to work 3000 hours to own a rig. Mainland UK has an NVQ system. There has been some organising effort from SEAI …[Sustainable Energy Agency Ireland]… and move towards courses in Carlow. But if the scale is added, who is going to manage this and ensure standards & environmental regulations are adhered to?"

*Niall Meehan| Meehan Drilling| 7/3/22*

> **NI based drilling plant and equipment:** "Geothermal is less proven in terms of uptake in Northern Ireland. Even when the exploration analysis is neck and neck with the other solutions, clients are leaning toward the proven. Drillers are part of
>
> the jig-saw. We don't have the plant and equipment in NI and then there is the cost of moving that into place."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

> **Quality assurance:** "There is no regulation of the drilling rigs. Most of the rigs are bought for water well drilling and bought from the US, Germany, Italy and Korea. Nobody will go out on a limb with the capital expenditure. For instance, nobody

here is set up to take the steel tubular out of the ground, yet that drilling kit exists elsewhere."

*Niall Meehan| Meehan Drilling| 7/3/22*

## 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. As previously noted in Section 2.1 in this report, 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.

To build and unlock the potential for the geothermal sector in Northern Ireland, a **Mobile *Geothermal Observatory*** can bring together the geothermal community to;

- Advance geoscience and its technical and industrial applications;
- Unlock efficiencies for private sector firms in geothermal activities;
- Create a data pool for experiments and testing;
- Harness science expertise and capabilities;
- Develop the critical IPR needed to succeed;
- Mobilise projects and add exploration capacity.

Interviewees are mindful of the capacity building for developing the geothermal sector in Northern Ireland. Given the support required, the level of expertise and where expertise is located, there is a need for a network of geoscience-led in the local universities in both Ulster University and Queen's University Belfast. In addition, we believe there is also a need for supporting East-West and North-South institutional geothermal arrangements. Moreover, there is a need to harness expertise on and across the islands to ensure the critical IPR needed to succeed.

**Resource capacity:**
"We currently have one minerals geologist to advise 11 council planning departments. Minerals planning and safeguarding is complex and not fully understood. Councils do not have natural resource scientists and this (geothermal) requires, I believe, a central comprehensive and supportive resource."

*Dr Marie Cowan, Geologist| Director of GSNI | 25/3/2022*

***Mobile Geoenergy Observatory***.
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.

Underground field laboratories are visible in leading geothermal building markets. Unlike the other UK nations where geothermal laboratories exist, Northern Ireland does not have a dedicated Geoenergy Observatory to institutionally support fieldwork and contribute significant scientific data.

The United States of America have a significant underground field laboratory at Forge as part of the University of Utah, and is sponsored by the Department of Energy (DOE) for developing, testing, and

accelerating breakthroughs in enhanced geothermal systems technologies to advance the uptake of geothermal resources.[132] The R&D resources are mostly fixed and tied to one specific location. 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 centre 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. In comparative terms, The Rijswijk Centre for Sustainable Geo-energy (RCSG) in the Netherlands supports geothermal activity and provides firms with the opportunity to de-risk their new well technology (drilling) tools and materials for geo-energy applications by testing them in a controlled laboratory environment. The RCSG offers companies access to modern and unique facilities that are otherwise difficult to access and costly to build for testing.[133]

The capacity and skills base from the UK North Sea oil and gas platforms is an invaluable resource, with many transferable skills from the offshore drilling community. Consideration might be given to how an East-West geothermal corridor might be established and maintained to support building the geothermal sector in Northern Ireland. 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).[134] 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.

> **Levelling up the renewable technology mix:**
> The elephant in the room is that renewables are all vying, with separate vested interests, and the existing ones can close out the others or the new ones. That is the narrative in the background. How different is the technology – and why? The lines are all blurring in energy and so there is going to be a mix of solutions. Strategic investments are balanced across the board given the scale of the targets. NI is small, so we should be able to be flexible and move more quickly at the reorganising for this Net Zero challenge."

*Stephen Agnew | Renewables NI | 15/3/2022*

> **Mobility schemes:**
> "…visiting schemes can help with capacity building, training for permitting. We found that those with an oil and gas background don't always know the geothermal area."

*Philippe Dumas| Secretary General | European Geothermal Energy Council (EGEC) 11/4/22*

[132] https://utahforge.com

[133] https://www.rcsg.nl

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

**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. According to the iCRAG website, it drives research in areas that are critical to society and the economy, including:

- Sustainable discovery of energy resources and raw materials required for decarbonisation.
- Securing and protecting groundwater and marine resources.
- Protecting society from Earth's hazards such as flooding and landslides.[135]

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.

A Mobile Geoenergy Observatory could build and collaborate with a range of research affiliations, partnerships, centres, institutes and offices located in close proximity to help deliver on the deployment and maintenance of geothermal activity.

**Mobile Geoenergy Observatory location.** Our research finds that QUB has currently three test boreholes drilled for research purposes. The wells are located on the QUB campus in Belfast city. Specifically, the boreholes are located in a staff carpark between the David Keir and Ashby buildings of the School of the Natural and Built Environment and this represents an opportunity for securely 'housing' the Mobile Geoenergy Observatory when it is not in communities and this case could be evaluated further with an organising task force. This research consulted with the geoenergy observatory in the UK and insights from this consultation is outlined in Table 3.2 (see overleaf).

Table 3.2: A view from the UK Geoenergy Observatory, Glasgow

| |
|---|
| **Geoenergy Observatory data sharing:** "As per NERC data policy, users with data from the observatory have two years so they can publish the findings in a journal. Then they need to deposit the data in a NERC repository. But it can be difficult to get follow through and generally we need to follow up." |
| **Geoenergy Observatory's flexible role**: "We have an observatory that can be flexible - we don't have a heat user, though there is geothermal infrastructure for subsurface |

[135] https://www.icrag-centre.org

perturbations that mimics a user heat load/heat storage. The observatory is a NERC facility for the whole science community – has a pay as you use model."

**Measuring Geoenergy Observatory impact:** "We are monitored in terms of the benefits realised. What impact are we having? Obviously, it is very early days for us but you are looking at things like #use of data, # number of talks, #number of enquiries and users. The observatory will play a key role in ensuring a research base to understand the subsurface-surface environment and ensuring that it is planned out."

## 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 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.

**LZC Technology Centre:**
"A support platform hub for R&D research activity can act as the vehicle to collect and stream data, group boreholes, assess, identify patterns that emerge at and between boreholes."

*Dr Riccardo Pasquali | Geoservsolutions. 28/02/2022*

**Scottish Netzero Technology Centre:**
"A centre that identifies and looks for the innovation to be deployed on transitioning the energy market and which works with SMEs and the supply chain. Setting the challenges with scientists for what technologies need to be doing. Industry needs support and to be led too. A centre with the convening power that can cascade authority. The reach out ability with all and making it inclusive."

*Professor John Underhill | University of Aberdeen| 11/3/2022*

**LZC Technology communities:**
"The idea of centres or hubs are interesting but the word 'centre' …maybe you should think about how to reach out and into the communities – how to democratise renewables, including the west of the Bann."

*Stephen Agnew | Renewables NI | 15/3/2022*

> **LZC Technology participation:**
> "Having a centre that is solution-led – I could work within that. Hydrogen has so many pathways within the circular economy with the other technologies and we need a place to do this for Northern Ireland PLC."

*Paul McCormack | GenComm Innovation Manager | Belfast Metropolitan College | 22/3/22*

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[136] A LZC Technology Centre could provide an industry-led and policy-led hub to bring all of the various energy centres together. The centre would focus on delivering the application of technology on the ground. It could also support the distribution of subventions for Net Zero transitions projects – similar to the provision made in the Environment Act (1990). [137]

Consideration could be given to how a centre could respond to information data requests from end users, assist with policy alignment and compliance measures, help integrate decision-making within and across projects, quality assurance initiatives and maintenance, ensure the licencing of resources, publish permits for activity (exploration and production), help co-ordinate planning and control authorization, along with policy consultation and initiatives with InvestNI. Moreover, consideration might be given to InvestNI energy being located, in part, within this centre. This centre could also lead out on solutions, for instance, on the decarbonisation of heat and work with the built environment representatives. An LZC Technology Centre, we believe, could increase communication, collaboration, sector coupling and technology hybrid work applications.

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[138] and rebrand this centre as the LZC Technology Centre of Northern Ireland and to boost this centre.

> **Reorganising governance possibilities:**
> "We think we presently add value to the economy and advance sustainable energy in Northern Ireland. I think there might be a sound rationale for CASE to evolve into not only an industry-led zero carbon research centre but integrating evidence based policy outcomes as these two can't exist in a vacuum. Maybe the next Energy Strategy action plan could consider how a trusted independent low/zero carbon centre could pull those two actions together, accelerating and achieving effective action that on the ground? "

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

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

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

*Martin Doherty| Centre Manager| Centre for Advanced Sustainable Energy (CASE) |31/3/2022*

In the case of geothermal projects, the geothermal shaper community might consider whether there is a need for a Geothermal Technologies Office (GTO) and whether an LZC Technology Centre is the appropriate location. This GTO might have core activities including but not limited to 1), Use of proceeds (UoP), 2), Process for geothermal project evaluation and selection, 3), Management of proceeds, 4), reporting. 5), A grievance redress service. We find that presently there is no one single location for managing this activity, but this is understandable given the nascent stage of the sector. There is also the question of how government departments, local councils, public utilities, InvestNI, companies and multinationals can work together on market-focused strategic R&D projects and in collaboration with research institutions and institutes such as GSNI. Working on the ground with projects also raises questions on the statutory role of GSNI.

Consideration of the Centre's activities could include but are not limited to;

- Renewable technology project management support (for instance, data reporting, data support and analysis, case building support);
- Establishing market-focused collaborations for sector opportunities, benchmarking and inter-project comparison;
- Cross-technology office collaboration, brokering and hybridisation of renewable technology applications and project management integration;
- Acceleration hub programmes for renewable energy projects and programmes;
- Showcasing events for a range of communities and reciprocal community engagement;
- Administrative function for professional certification;
- Policy-led change recommendations.

This institution would provide a clear statement of intent by the Department for the Economy and help support policies in practice, delivering Northern Ireland's net zero targets and the decarbonisation of heat. There are net zero/ energy transition centres elsewhere in the UK, including at Aberdeen University but are established as mainly interdisciplinary research centres (e.g. Centre for Energy Transition [139] and the Shift Geothermal Centre [140] ).

**Heat Authority.** Based on this research, another consideration is the establishment of a Heat Authority which places the emphasis on the solution. There is no specific authority, or department taking responsibility for the decarbonisation of heat. In NI, responsibility for the promotion of energy efficiency in the public sector is the statutory responsibility of DoF. This is described in legislation as "DoF may take such action as it thinks appropriate for the purpose of promoting the efficient use of energy by public bodies."[141] To illustrate, DoF has responsibility for public bodies; DfC responsibility for the domestic sector; DfE by the voluntary and community sector; InvestNI industrial businesses. [xli]

[139] https://www.abdn.ac.uk/news/15601

[140] http://www.shiftgeothermal.com/about-1

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

## 3.8 Geothermal heating flagship project demonstrations

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 life-cycle of the building, as the Estates Manager and the University Director of Operations experiences below highlight. Some initial experiences are reported below:

> **Geothermal as a heat source:** "Once we understood geothermal as a heat source at the backend and that the front-end that our maintenance crew had, more or less, the existing skill-sets to do that, then we were less nervous. The take-off is important but so too is the soft landing. The maintenance of our estate is the soft landing."

*Jacqueline Kearns | Estates Manager | Quantity Surveyor, Queen's University Belfast 4/3/2022*

> **A psyche of ambition:** ""There was a collective ambition for the best possible outcome for all with Riddel Hall. We normally work to pre-set BREEAM standards however, with Riddel we were looking beyond that, this was our psyche with the Riddel Hall project. Incorporating the geothermal solution into the building at an early stage was key'."

*Damien Toner | Director of Estates | Building Surveyor | Queen's University Belfast, 10/3/2022*

> **Long-run growth trajectories:** "Riddel Hall was a brownfield site used as a former running track and carparks. There was a real opportunity to maximise this new building opportunity from many perspectives – ecological, scale, quality and innovation. The Management School is one of the most successful schools in the university and the Riddel Hall site is strategically important. All of these factors were critical in building the business case for investment at Riddel Hall."

*Damien Toner | Director of Estates | Building Surveyor | Queen's University Belfast, 10/3/2022*

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.

> "Techno-economics development: Having reviewed the academic evidence of deep geothermal systems, we are confident that CausewayGT as an NI/ROI start-up are a world-leading pioneer on deep geothermal activity with heat exchangers and this project can enable expertise working together to enable the techno-economics for energy systems, thermal dynamics and heat pumps systems."

*Dr. Simon Todd| CausewayGT 23/06/2022*

> "Decarbonisation of heat solution: Our project is seeking to decarbonise the data centres but also we have broadened that out to other sectors including agriculture and healthcare cases. We have worked on state-of-the-art energy use and how an energy efficient approved geothermal solution set can feed into and deliver that."

*Dr. Simon Todd 23/06/2022*

> "Expanding sector applications: As the first geothermal CASE project, it contains a range of work packages from the basic energy efficiency appraisals, subsurface resource mapping, techno-economics and sensitivity analysis, and helping develop the policy and regulatory framework. Key to the technology progression is reducing drilling cost of closed-loop borehole heat exchanger while maximizing the Coeffcient of Performance of the heat pump system. We believe that being able to economically deliver steam from a geothermal heat pump plumbed in to NI geothermal heat opens a whole tranche of new industry and commercial use potential."

*Dr. Simon Todd 23/06/2022*

## 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.

> **Post connection, environmental performance:** "I have worked here for 10 years. I was not aware of that technology in use here. There are no visible plaques in the building about this, nothing and, as far as I am aware, nobody promotes the environmental good from this technology operating in this building."

*Anonymous | Receptionist | Lyric Theatre Belfast | visited 4/3/2022*

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. As previously noted in Section 2.4 of this report, 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. Some initial experiences are reported below:

> **Low noise solution:** " In my experience, there was a willingness by the client to drive this. It was an ad hoc necessity. At the planning stage, the project ran into issues around noise disturbance of the air conditioning units due to its urban location – so geothermal was a low noise solution."

*Conor Lydon| Hydrogeologist | Tetra Tech| 05/4/2022*

> **End-user experience:** "The proof of the pudding is in the end-user experience of the heat and cooling. What is the level of complaints and our ability to turn it up and down."

*Jacqueline Kearns | Estates Manager | Quantity Surveyor, Queen's University Belfast 4/3/2022*

## 3.10 Demonstrating heat networks

There are presently no 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. A heating network can serve only a limited number of homes (eg.15-50), or they may serve a combination of housing, community use buildings and commercial development facilities such as a crèche, pharmacy, gym, restaurants and shops. 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 communities and building development.

Academic evidence suggests that contests effectively solicit innovation. It is proposed that the contest mechanism offers a unique approach to geothermal heat network deployment. The Department for the Economy might consider an open call for three or four energy networks for a private building firm, a community, a housing project, involving a fun competition geothermal and a public celebration of the winners. 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.[142] Northern Ireland has a limited number of mines but there are disused quarries and the repurposing of old disused quarries matched to heat demands might be explored further. 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 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.

**BOX J: Heat network in Spain**

In Spain, the state mining company Hunosa is responsible for pumping water out of disused mines and keeping it at safe levels to avoid damage to buildings and other infrastructure. Using the geothermal energy in the mine water is seen as a potential way to make money from it, as opposed to viewing it as a waste product. In 2020, a district heating scheme began supplying the residential buildings, a secondary school and the main university building. A similar project, under construction in nearby Langreo, will supply homes, a sports centre and a public health centre. Hunosa guarantees its prices at lower costs than traditional fossil fuel sources, explains the firm's head of innovation, Noel Canto.

Source: https://geographical.co.uk/nature/energy/item/4045-heat-from-beneath-the-huge-potential-to-keep-warm-with-old-coal-mines

## 3.11 Geothermal technology hybridization and sector coupling

This section briefly highlights a further opportunity for sector development. As outlined in Section 2.2, building the protective niche scaffolding for the sector, the baseline finding is that the geothermal

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

sector is at an early stage in niche development as of April 2022.

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. The Parliamentary Office of Science and Technology POST reports on the potential for Underground Thermal Energy Storage UTES potential.[143]

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.[144] In effect, projects do not detract from the initial geothermal sector building and risk creating reputational liability. At this stage, a scoping review could be undertaken in relation to wastewater recovery, extreme weather events planning and drainage solutions. We believe that NI Water is a critical stakeholder in the development of the geothermal sector in Northern Ireland.

We believe that geothermal policy and resource allocation could follow the normal temporary cycling between both technology exploration and exploitation. In these circumstances, we view that niche 'stretching' activity is not an immediate policy priority for the geothermal sector building in Northern Ireland, but this could be reviewed in three years. As the share of wind and solar in the energy solution mix rises, where energy storage can support the stability and flexibility of heat, we believe that this might be reconsidered and reviewed at a later stage by the Department for the Economy in conjunction with The Geological Survey for Northern Ireland.

> **Hybrid energy solutions:**
> "There is a specification-led approach to the projects. There is an opportunity for a more integrated approach to energy. Wastewater, drainage solutions, stormwater. Or there is a maximisation of the technology, e.g. heat pump, view of things."

*Dr Riccardo Pasquali | Geoservsolutions| 28/02/2022*

> **Waste water recovery:**
> "Firms are not sharing the level and extent of their wastewater and data on what temperature that is at. This circular thinking can make new industries. There are new technologies lining up to exploit this in Scotland."

*Innes Auchterlonie| Founder of Director| Asset Integrity and Asset Management, Engineering and Consultancy Services| Scotland| 30/3/2022*

> **Continuum of opportunities:**
> "What has it ..[geothermal technology]... got to offer? Heating, cooling and storage? Individuals point to the 'extreme cases' but in reality, there is a

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

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

> sliding scale or a continuum of harvesting opportunities."

*Dr Riccardo Pasquali| Geologist | Geoservsolutions. 28/02/2022*

In the meanwhile, further R&D research activity could be supported and undertaken. There are interesting cases of geothermal stretching and transitioning in markets further afield that could be shared more widely at temporary sector events to build awareness and confidence.

As noted previously in Section 3.3., given that feedback from council interviewees raise the association of geothermal technology deployment with the technique of fracturing (commonly known as fracking), we do not think that enhanced techniques need to be expanded any more than it is at present. We suggest that consideration of **a hiatus is placed on all future new 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. We believe that the geothermal sector working in conjunction with the Department for the Economy and with Ministerial approval takes the policy lead on this hiatus.

We believe that confidence-building with monodexterity in the early stage of the sector is more important than demonstrating technical stretching capacity and ambidexterity. Effectively growing the sector with proven technical capacity with the development of geothermal activities and building out the sector. We locate the justification for such a hiatus to sever the unfounded links between the technique of fracturing with geothermal activity.

## 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. One insightful respondent discussed that much of building project management takes place beyond the energy considerations and outside the sphere of expert energy consultants. That creates an isolated experience, without support, and this results in the project team questioning why they should 'go out on limb' for the geothermal technology. This experience illustrates the reliance on evidence-based geothermal protocols and decision-making tools in decision-making. The expectation to search for and distil the data themselves, or hire consultants with the expertise, provoked frustration. Several of the flagship project leaders held the view of having one central place with offices to address issues within the geothermal sector.

There was also a palpable awareness of the timeframe of geothermal projects from the inception, drill, build and connection. Interviewees suggest that measures should be put in place to limit the resource and other strains on existing institutions and prevent undue delays in the planning cycle on geothermal applications. Pioneering operators were

asking for more visibility, evaluation frameworks and governance processes based on the nature of the heat usage, subsurface risk profile and particularised project characteristics. For details see Table 3.3 below.

Table 3.3: Geothermal execution gap experiences

> **Engineering consulting competency**: "I'd suggest it's one of two things that made it go. Fixation on initial cost with no reason or incentive to consider lifecycle. Poor knowledge of the consulting engineer involved when appraising GHSP. We are doing multiple feasibilities for these with GSHP coming out top almost all the time.
>
> We find that there is an experience gap – of course, the consultants will not admit that they don't have the experience or know-how of ground source – there was a study in the US that found that 80% of viable projects were dismissed due to poor advice from engineers."

*Chris Davidson, Chairman and Technical Director, Genius Energy Lab. 14/4/2022*

> **Insurance of geothermal subsurface activities:** "We went to our insurance company and asked about insurance. They said, oh right. We don't do that. You need to see London about that. We wouldn't know where to start to assess risks in the subsurface. How do be price risks in the subsurface?"

*James Crawford| MJM Renewables |QUB| Arup| GEL consortium| 7/03/2022*

> **One end-user sector point of entry:** "I'm a pragmatist and I understand that you might need to visit 6 houses to get a project over the line, whether that is licensing, permits, building control, planning, data follow-up. But to attract end users, or investors, you need the confidence of, and ease of access to, one house – I can go to one office, point A. At the present time, that does not exist…"

*Dr Riccardo Pasquali | Geoservsolutions | 28/02/2022*

> **Drilling rig technology upgrading:** "The drilling rigs are expensive and nobody is spending on upgrading the rig and so we end up with a low base of older equipment. There are rigs that remove the steel but all of that steel is being left in the ground because of the equipment not being upgraded. If you take Riddel Hall, 40 boreholes 42 metres each, that is 1680 metres of steel casing in the ground with the growing price of steel. That is unnecessary when using more modern equipment and that is permitted."

*Niall Meehan| Meehan Drilling| 7/3/22*

> **Planning delays:** "We allowed 4 years for our solar farm. With geothermal, I don't know. The pre-application and then the full application. Our planners' statements

> are outdated for advanced technology and the decarbonisation targets. I'd like to see a structure similar to what they have in the Republic of Ireland with an Appeals Board system or an independent standalone office to deal with geothermal at the Department of Infrastructure or on its own. That is why things are getting done in
>
> the Republic. It is months not years there. That is the model that needs to be used here. Without precedence, they are lost. How do we achieve our renewables targets in that?"

*James Crawford| MJM Renewables| QUB | Arup| GEL consortium 7/03/2022*

> **Team work on site:** "With Eden Geothermal, there were multiple contractors on site but at United Downs there was one main contractor supplying many of the drilling services. Interestingly, having multiple contractors on site forced the whole team to communicate better and build good relationships between the different service companies and the operator and service companies. This added more to the team… "

*Lucy Cotton| Geothermal Group Manager & Senior Geologist| GeoScience Limited United Downs and Eden| 4/4/2022*

> **Driller profile and succession planning:** "There is an ageing generation of drillers, probably three or four in NI and numbers are dwindling. Most drilling operators are father and son family concerns. We find that southern contractors move up north for the work up there. In my hay day, I had twelve rigs – those numbers are unheard of now. There is a limited pool. Some had three or four drilling rigs but have scaled that back to one. Drillers fall victim to carrying the extra burden of costs – there is no support or protection there, just a standard civil engineering contract. I am not sure if that is appropriate for the subsurface. There is no voice on this "

*Niall Meehan| Meehan Drilling| 7/3/22*

**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 work 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. Flagship leaders perceive institutional technology voids; they identify that they are having to build the scaffolds to support their efforts, but often feel that they carry the brunt of the learning burden. See Table 3.4 below for details.

Table 3.4: Geothermal evaluation gap experiences

> **Preparatory work: "**"The daily cost on site was about £50,000 including the rig, personnel and ancillary equipment and now diesel prices are higher with the new diesel fuel regulations."

*Lucy Cotton| Geothermal Group Manager & Senior Geologist| GeoScience Limited United Downs and Eden| 4/4/2022*

> **Available and accessible information:** "I'm an architect by training but this was a different scale in terms of articulation – I could not ask about the finer details to understand the outputs so we could be in a better position to proceed as an option, with for example the operational expenditure, the capital expenditure and the carbon reduction measures on geothermal and to bring the project on to the next stage. A layperson crib sheet would have been helpful."

*Lindsay Totten | Project Manager | Belfast City Destination Hub*

> **Predictability of geothermal outcomes:** "Buyers of geothermal technology want to invest to save and not to explain an energy experiment without the necessary information knowledge to understand the key deliverables."

*Wendy Langham | Project Manager | Destination Hub | Belfast City Council, 01/3/22*

> **Drilling sector attractiveness:** "I can trundle away on my own behind the ditch close to my home. There is an easier way – I scaled back my rigs. Why should I chase after larger work with large competitive tender bids – it is not worth my while. It is a small base or work and most of us talk – we are struggling to fulfil the existing workloads and how do you attract young lads that there is a career in this for them?"

*Niall Meehan| Meehan Drilling| 7/3/22*

> **Terms of reference support:** "What are the terms of reference for a geothermal feasibility project. We don't know. We are not experts on this and so considering geothermal as an aspiration for our heating brings new challenges. We need predictability that we were investing to save and not to spend. The evidence is inconclusive and then we have to look to justify the investment with unknow returns. It is not possible to give this the attention required whilst managing the competing priorities on a complex project…We needed more reasons to invest and we were not provided with the right tools to build the case…"

*Wendy Langham | Project Manager | Destination Hub | Belfast City Council| 1/3/2022*

Interviewees from the Belfast City Council faced unfamiliar forms of technical geothermal detail which created uncertainty and this meant that the project became an aspiration for them. The informants strongly express the view that project managers must "translate" technical expertise residing in geothermal advice provided to them into a broader project. The project managers currently perceive the geothermal process as more effortful and also experience lower satisfaction with both geothermal processes and outcomes. We believe that measures should be put in place to limit the resource and other strains on existing institutions and prevent undue delays in the planning cycle on geothermal applications. Interviews with flagship project leaders reveal a shared view that more data should be made available in a central place and subject to the very careful consideration of the context and process of their actions.

# 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 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.

We have considered a range of ways to unlock Northern Ireland's geothermal resources. We have noted, in particular, market-focused scaffolding and the status of flagship project experiences to date. The Geological Survey of Northern Ireland (GSNI) is an integral institution in building the geothermal sector in Northern Ireland and its statutory role will evolve as the sector develops.

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. There is therefore an opportunity for a series of timely, incremental aggregation of market scaffold-building actions. Most significantly, investment in the geoscientific evidence-base and R&D activity is a requisite for unlocking Northern Ireland's geothermal resources.

Important as well is the demonstration of buildability through flagship geothermal projects. The geothermal sector is presently in an early development niche phase in Northern Ireland. Some geothermal projects are at the design stage, some are only just up and running, and the few that have become established have little, if any, visibility in terms of trade or public awareness, even from the individuals working within the buildings where geothermal technology has been successfully running. In those buildings, geothermal is a lonely secret, with little, or any, public and end-user awareness outside technical geoscientists and geo-consulting specialists. There is an exciting opportunity to unlock Northern Ireland's geothermal resource with protective strategies for the different types of geothermal technologies. An opportunity to demonstrate geothermal in use and as part and parcel of people's daily lives.

Unlocking Northern Ireland's geothermal resource requires institutional and mutualised financial capacity support. The R&D activity and operations capability can be bridged with East-West and North-South institutional support arrangements. A research-led dual-purpose Mobile Geoenergy Observatory, combined with an industry-led and policy-led LCZ Technology Centre within Northern Ireland working for all of the renewable technologies could deliver and build a carbon free Northern Ireland. An LCZ Technology Centre could allow private companies and public institutions to work together on market focused solutions, and enable hybrid and sector-coupling solutions and strategic renewable energy projects in collaboration with research institutions. For capacity building, 'linking-in' institutionally with East-West (Net Zero Technology Centre in Aberdeen, Scotland) and North-South (iCRAG Centre in Dublin, ROI) can provide an ecosystem for collaboration in areas identified by GSNI and industry, as being strategically important.

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.

While other markets might be ahead of Northern Ireland in building their geothermal sector, with the right scaffold support and confidence building through demonstrating buildability flagship projects, Northern Ireland can successfully build the sector and help the transition towards Net Zero targets. The challenge now for the geothermal community is to get to grips with the market scaffold issues, ready and secure capital investment commitment, to build consensus on what the geothermal energy sector might look like and how to accomplish that task.

## 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 and sub-actions for consideration to build sector confidence |
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| **UK and NI government commitment and direction statements** | (1) Ministerial/Departmental engagement to elicit UK government strategic direction on the geothermal sector, to provide a clear statement of commitment and policy steer to the devolved administration to lead out on geoenergy.<br><br>(a) NI to 'link in' and take up the issues arising from the Prime Minister's commissioned review of the UK geothermal sector.<br>(b) NI to elicit UK government leadership on geoenergy funding with guidance on how to procure, organise and govern geofunds for Net Zero transitions.<br>(c) Find NI representation within the UK Geothermal Task Force.<br><br>(2) Ministerial/Departmental action to elicit NI government leadership on the geothermal sector building, with a clear statement of commitment and policy steer to each of the Executive departments and the 11 Local Councils' Energy Plans across NI on Net Zero transitions and geothermal activity in particular. |
| **Policy alignment – building pillars and aligning lintels** | (3) DfE to align the growth and management of geothermal activity with the net zero pathways, NI Green Growth Strategy plans, NI energy policy, the DfE Energy Strategy and the accompanying 22-point energy action plan.<br><br>(a) Create an NI geothermal policy lead at DfE and develop this policy capacity commensurate with the growth of the sector.<br>(b) Find representation on each of the key policy transition Net Zero pathways, ensuring voice for geothermal heating and cooling solutions.<br>(c) Find coordination mechanisms across each of the Executive departments and the respective estates for the development of geothermal activity.<br>(d) DfE to promote alignment of the local Council Energy Plans with NI energy policy, the DfE Energy Strategy and the accompanying 22-point action plan (specifically with points 15 and 16). |

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| | (e) Accord an invitation to all NI Council CEOs to raise awareness and elicit an nominated representative per each council for communications.<br>(f) DfE and DfI to engage with the 11 councils to discuss their energy plans, low zero carbon technology adoption and raise awareness of geothermal activity and alignment.<br>(g) Establish and align geothermal policy within a strategic balanced energy portfolio analysis.<br>(h) DfE to design policy initiatives that support and incentivise 'super additivity' across the NI councils for the energy transition and geothermal activity. |
| **Goals with key performance indicators** | (4) DfE to lead Geothermal Advisory Committee to establish geothermal activity goals in Northern Ireland aligned with Sectoral Plans, with key performance indicators on an interim basis until 2030 and then incrementally to 2050 with annual reviews by the GAC.<br><br>(a) DfE to lead and convene a representative Geothermal Advisory Committee to establish heat decarbonisation goals in Northern Ireland, with key performance indicators.<br>(b) Align the heat decarbonisation goals against the scenario analysis of the UK Climate Change Commission, green growth goals at the NICS Board and NI Executive.<br>(c) Establish an annual digital reporting mechanism for reporting of goals.<br>(d) Annually convene a progression meeting on geothermal goals and supporting key performance indicators relative to sector capacity.<br>(e) Accord an invitation to the Office for Environmental Protection to bring scrutiny and monitor geothermal targets and heat decarbonation targets digitally. |
| **Exploration R&D activity** | (5) DfE to bring forward a business case for developing a programme of investment in R&D geoenergy infrastructure in Northern Ireland.<br><br>(6) DfE to resource and institutionally support geothermal R&D activity in places where individuals can undertake this research activity.<br><br>(7) 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.<br><br>(a) Design and resource R&D policy that enables pro-social and coopetition behaviours that promotes the sharing of geothermal project experiences and borehole data.<br>(b) Design and resource R&D policy that promotes collaboration within consortia-type forms, joint bid processes and procurement opportunities in the geothermal sector.<br>(c) Resource and link the R&D programme to a mutualised geo-fund and that which is commensurate with the geothermal sector activity in the field. |

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| | (d) Resource a R&D exploration team of at least five personnel, including geologists, but could also include additional individuals with environmental, social and business economic case experience.<br>(e) Establish an annual report digital reporting mechanism to produce evidence of the risks, benefits, costs and opportunities of geothermal harvesting systems and quantify the potential, energy security, economic and environmental impacts on the geothermal sector in Northern Ireland.<br>(f) Form a central accessible repository for data on geothermal resource itself and monitoring data – i.e. data from exploration, installation and operation of geothermal systems;<br>(g) Data reporting requirements of operators to be linked to planning, licensing/permitting, training/skill development and research. |
| **Protective niche strategy** | (8) DfE to build and resource a protective niche strategy for strengthening the geothermal sector, with specific shielding and nurturing policy.<br><br>(a) Build a geothermal strategy across arenas and vehicles, developing staging/pacing and differentiators.<br>(b) Create upstream and downstream prospecting and nudging activity, ensuring that geothermal projects are shielded from regimes.<br>(c) Establish non-monetary criteria on niche development stage projects which are used by developmental banks such as the World Bank, FMO (Dutch Government Development Bank) and which draw on social impact-based United National General Assembly's (UNGA) Sustainable Development Goals (SDGs).<br>(d) Strengthen the link between potentiality and actionality.<br>(e) Engage with agencies that monitor and manage the other subsurface resources (e.g. water, onshore oil & gas, minerals) to learn from the expertise of existing regimes.<br>(f) Incentivize a range of communities, businesses and technologists to get down on the cost curve and up on the performance curve.<br>(g) Bring forward and table a range of prospecting opportunities, tailoring efforts to the specific location, geology, industry, context, and use, while also looking to increase standard template efficiencies wherever possible. |
| **Sector priorities** | (9) Geothermal heating and cooling activities to be prioritised in building out the geothermal sector in Northern Ireland.<br><br>(a) Establish a continuum of promising sector deployment opportunities between small field shallow operations and larger deep field projects.<br>(b) Focus on the Sherwood Sandstone Group predominantly in the hosting of open loop, deep geothermal projects in the short term and this can be reviewed after seven years.<br>(c) Focus of geothermal activity in the hosting of closed loop, shallow geothermal throughout Northern Ireland, with support of the GSHPA.<br>(d) Where the geological and institutional conditions exist to host geothermal projects, each of the eleven councils could have one deep geothermal site operational in their council borough area in the medium term.<br>(e) Tourism demonstration projects could be used to help aid geothermal familiarity in the everyday, make the geothermal technology readily accessible, but also showcase Northern Ireland's transition towards net zero. |

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| | (f) Where deep geothermal projects are selected, these should be multi-stakeholder and mutualised within and across sectors.<br>(g) Departments of Health, Infrastructure, Education, Justice and respective Asset Management Plans and capital expenditure projects should be prioritized in the short term.<br>(h) Northern Ireland's eleven councils and respective Asset Management Plans and capital expenditure projects should be prioritized in the short term.<br>(i) Strategically locate and select areas where geothermal projects can generate high potential as an energy and economic multiplier, with climate impact metrics, but also one where there are social benefits for a just energy transition (e.g. health and fuel poverty). |
| **Multiple narratives** | (10) 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.<br><br>(a) Improve understandings attached to the attitudes and feelings towards social acceptance of geothermal technology deployments.<br>(b) Establish a communications and engagement plan with supporting information, visits, clinics and virtual marketplace activity.<br>(c) Create multiple narratives as a 'benefit to the local', rural/urban, east/west of the river Bann.<br>(d) Cocreate narratives of how environmental justice issues can be addressed to mitigate against any potential exclusion from communities.<br>(e) Build a network and transition pathways for geothermal shaper community to permit boundary-spanning and broader debates.<br>(f) Work with councils to support communications and engagement within the Climate Action Task Committees.<br>(g) The findings of this report and future key reports to be presented at the All Party Group for Climate Action to support understanding of geothermal energy technology. |
| **Evaluation and stakeholder engagement** | (11) DfE as custodian of the subsurface resources to create a safeguarding strategic-level oversight evaluation process with governance.<br><br>(a) DfE might consider using temporary sector cluster events as well as the primary legislation consultation to develop a coherent Monitoring and Evaluation framework.<br>(b) Capture and evaluate ongoing adopter/user and stakeholder experiences and adjust accordingly.<br>(c) Create the links for geothermal knowledge creation; knowledge application; and knowledge storage and retrieval.<br>(d) Unite communities with supporting, visits, clinics and virtual marketplace dialogues.<br>(e) Ensure an ongoing monitoring and the issue-attention cycle and risk analysis.<br>(f) Create a rapid response team committee to advise on public and community engagement issues. |

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| **Maintaining temporary sector clusters** | (12) Steer and unite sector visions and growth by creating and maintaining temporary sector clusters.<br><br>(a) Unite key institutional geothermal and energy actors around the Net Zero transition and the geothermal sector-building.<br>(b) Cocreate engagement and dialogue with each of the targeted communities within Northern Ireland and further afield.<br>(c) Cocreate engagement with the geology community with planning, financial, building and architect professions.<br>(d) As part of this temporary sector cluster events, DfE to invite respondents to provide details of any issues that currently need monitored.<br>(e) Support the organising and building of Industry Associations to ensure the sector has a platform and voice across Northern Ireland at the early niche stage.<br>(f) Host national and international events on geoenergy and related industries in Northern Ireland to support network sector-supporting activities.<br>(g) Create opportunities to link in with intergovernmental organisations such as the International Renewable Energy Agency (IRENA) to transition NI to a sustainable energy future.<br>(h) Capture knowledge embedded in the experiences of the geothermal projects through workshops and publish report on this activity at the early stage of sector development.<br>(i) Ensure NI representation from NI on UK Deep Geothermal Task Force and other relevant Task Forces and ensure that is reflected in the DfE's Geothermal Advisory Committee.<br>(j) The International Geothermal Association is seeking Geothermal Ambassadors to represent their countries and we believe that NI or UK representation as a geothermal ambassador to the IGA. |
| **Sector building with government partners** | (13) Set the strategic direction with market-making activities while also balancing its responsibly to safeguard the sector and the subsurface resources.<br>(14) 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.<br>(15) Develop a geothermal energy roadmap for the geothermal sector in Northern Ireland, which reflects, develops and outlines a vision for the sector.<br>(16) Design an interim set of actions that ensure the geothermal niche commercial development is strategic, portfolio-driven within the energy mix.<br><br>(a) Visibly and consistently, signal to the whole economy through DfE communications and through the NI energy strategy and related action plan documents, a LZC technology portfolio-driven energy approach for reaching Net Zero targets.<br>(b) Harness the N.I. Diamond framework to bring together, open and create dialogues to create and support a just market-based framework approach driven by consensus and consent through an open, balanced and inclusive environment.<br>(c) DfE might explore how to establish commitment from the UK Climate Change Committee commitment on the setting heat decarbonisation targets for Northern Ireland in an open letter request. |

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| | (d) Ensure a planned, coordinated, and focused geothermal niche-building strategy in the best locations from a geothermal system and community perspective.<br>(e) Incentivize a range of communities, businesses and R&D projects to build out the early stage niche geothermal sector.<br>(f) DfE to collaborate across Executive departments including the Department for Finance, DAERA (leading on Green Growth Strategy) and also UK HM Treasury and others such as the UK Climate Investment Fund to procure and build a long-term capitalised mutual geofund.<br>(g) Identify, explore and secure a range of geofund sources and review how these can be mutualised to build confidence in the sector.<br>(h) Establish an incentive scheme for the installation of 8 kW Air Source Heat Pump (ASHP) and a Ground Source Heat Pump (GSHP) for geothermal activity.<br>(i) Link in with cross cutting departmental committees such as the All-Party Group for Climate Action (APG) to bring about mutualisation governance, political oversight on the geofund and general heat decarbonisation goals and targets.<br>(j) In the event of a UK-wide Geothermal Incentive Scheme (GIS), consideration of how the UK geothermal incentive scheme (GIS) could be developed in conjunction with the characteristics of the geothermal technology deployment, but one which is aligned tightly with a UK-wide GIS.<br>(k) Create data governance from geothermal field to ensure records, maps and recording of geothermal borehole data is reported, updated, preserved, owned and managed.<br>(l) When appropriate, resource and appoint one staff member to undertake digital data governance within GSNI on borehole recording and reporting and review after two years.<br>(m) Establish a policy and regulatory team commensurate with the sector growth.<br>(n) Design and build-in custodian intervention policy when conditions require the sanctioning of decontamination, decommissioning and site remediation work of a geothermal resource(s).<br>(o) Consider how to build a viable and competitive tender bidding supply base for building out the niche geothermal operations. |
| **Standards** | (17) Consider how the early stage niche development of the geothermal sector can follow national and international standards.<br>(18) Consider developing one website with universal resource links for the geothermal legislation, regulatory guidelines and procedurality.<br>(19) Consider how to link any geofund or start-up subvention awards with sector-promoting and-growing activities.<br><br>(a) Link geothermal subventions and/or incentives with data R&D sharing activity and governance from geothermal field, with outcomes published for the whole sector to help aid the early stage niche development.<br>(b) Link geothermal subvention and/or incentives with standards initiatives from geothermal activity within the field. |

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| | (c) Review and consider adopting the existing the UK Microgeneration Certification Scheme Service (MCS) with the Ground Source Heat Pump Association (GSHPA).<br>(d) Create a geothermal standards working task group to discuss sector-wide standards, skills and development through training programmes and equipment procurement and/or upgrading.<br>(e) DAERA and DfE to consider additional staffing requirements for Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency and commensurate with geothermal sector growth.<br>(f) DfE to organise compliance training workshops on geothermal borehole data recording and digital submissions.<br>(g) DfE to organise workshop for drilling firms, GSHP installers and for developing quality assurance scheme for such activities.<br>(h) Link in with the Department for Infrastructure's existing Housing Scheme for the skills and training programme for plumbers for the installation of Ground Source Heat Pumps.<br>(i) Review and devise an action plan with the NI Colleges of Further Education and Universities for developing sector skills.<br>(j) Identify and 'link in' with professional institutions to lead on the qualifications and accreditation of relevant skill for subsurface aspects, including the Geological Society of London, International Association of Hydrogeologists and others.<br>(k) Convene a meeting to assess the existing drilling equipment located and based in Northern Ireland, audit and develop an action plan for capacity building for the equipment upgrading where appropriate.<br>(l) Review existing drillers based in Northern Ireland and implement a financial support for technology upgrading and skills building support.<br>(m) Consider policy financial initiatives for developing, upgrading or diversifying firms' existing drilling operations based in Northern Ireland.<br>(n) Consider policy initiatives for international training schemes and temporary secondments, placements, transfer for apprentices for installation and drilling operations to another active geothermal market such as Indonesia, Kenya, Turkey, USA, Sweden, the Netherlands. |
| **Legislation, regulatory framework and procedurality** | (20) It is necessary to make legislation, the regulatory framework and procedurality clearer than it is at present.<br>(21) Ascertain which statutory authority prescribes standards of performance in connection to geothermal activity.<br><br>Legislation:<br>(a) Review the subsurface property rights and heat as a resource questions and make clearer than it is at present.<br>(b) Find definitions that delineate between shallow and deep geothermal activity and clearly define for Northern Ireland geothermal activity.<br>(c) Find definitions that delineate between consumptive and non-consumptive in geothermal activity and clearly define.<br>(d) Consider undertaking a comparative, national and international, review of geothermal related legislation, along with some primary research, to obtain a better understanding of the legislation on the Northern Ireland subsurface. |

(e) Undertake a brief consultation with Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency, as well as the legal sector and insurance industries on the subsurface activity.
(f) Find definitions of heat usage and storage in geothermal activity and clearly define for Northern Ireland.
(g) Consider a mechanism to review the specification of shallow and deep geothermal in circumstances of 'definitional redundancy' driven by technological advancements and rising 'natural' groundwater temperatures within the context of global warming.
(h) Consider the role of primary legislation to require businesses to report borehole data if they do not agree to do it 'voluntarily'.
(i) Consider reviewing the role of the Utility Regulator in relation to its long-run assessment mandate and subsequently whether primary legislation is required to enable geothermal project activity.
(j) Consider undertaking a comparative review of the NI Planning capacity in relation to the geothermal applications.
(k) All geothermal primary legislation to adhere to Regulatory Policy Committee guidance, on primary assessment and scoring of primary legislation measures.
(l) Consider providing statutory provision for any Geothermal Licensing Body, and ascertaining the role the Office for Environmental Protection and other agencies might play in KTP oversight.
(m) Consider primary legislation for heat network zones using geothermal heat sources.
(n) Consider primary and secondary geothermal legislation provision within Northern Ireland Land Act 1925; Mineral Development Act (Northern Ireland) 1969, Criminal Justice and Public Order Act 1994 (Disruptive trespassers), The Water and Sewerage Services (Northern Ireland) Order 2006; Energy Act (Northern Ireland) 2011; The Planning Act (Northern Ireland) 2011.
(o) See below also legislative recommendation 14 (i),& (j).

Regulatory framework:

(22) 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.
(23) 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.

(a) Undertake consultation with Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency on their potential future role in geothermal sector activity.
(b) Consider creating a continuum approach to regulation: (i) create and streamline a simple regulatory approach with one policy and apply this to all lower risk shallow single geothermal sites or activities; (ii), create a second regulatory approach which focuses on the nature of the risk of the

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| | regulatee and risk type, and select intervention strategies with reference to the amount of regulatory resources that each geothermal site demands.<br>(c) Consider a scaled regulatory approach to the geological and spatial boundary conditions and characteristics of the site, maturity, and target capacity.<br>(d) Ascertain and outline the policy for types of permitting activities and licencing of resources in relation to shallow and deep geothermal activity.<br>(e) Consider under what conditions permitting is prescribed and proscribed.<br>(f) Consider the nature of the licencing of the resource including harvesting energy, water extraction, heat dispersion and geothermal storage.<br>(g) Create a set of key metrics to be recorded and mandated on energy usage per square metre.<br>(h) Identify and create a weighted regulatory continuum based on a risks scale and volume of licence activity.<br>(i) Ascertain the appropriate location of a Geothermal Technology Office (GTO) to undertake core geothermal activities as outlined in the main report.<br>(j) Establish a central digital provision with the regulatory guidance on geothermal activity including ground source heat pumps and specific guidelines for groundwater and hydropower schemes.<br><br>Procedurality:<br>(24) Enhance the clarity given on project steps, procedures and guidelines.<br><br>(a) Procedurally consider the organisation of how geothermal projects are to be managed from their inception and in ongoing data monitoring.<br>(b) Procedurally map out the touch points for the shallow and deep geothermal application from an end-user perspective.<br>(c) Procedurally map out the licencing process with a view of standardising the geothermal journey 'touch points' including post installation optimisation and maintenance.<br>(d) Geothermal procedural development might consider the nature in-the-field support including advisory, feasibility survey, coordination, installation, maintenance and compliance with standards.<br>(e) Engage with planners in relation to planning capacity on geothermal issues, processes and outcomes, both with the procedures of local councils' planning applications, and also alternative dispute procedures adjudication process may need to be considered. |
| **Social licence** | (25) Ensure that the geothermal transition is accessible, fair, and without adverse effects on peoples' 'sense of place', their jobs and quality of life.<br>(26) Link geothermal subventions and/or incentives with community social value in developing geothermal projects and beyond procurement social metrics.<br>(27) Link to primary legislation and the statutory authority that sets out consultation and standards performance of geothermal activity.<br>(28) Outline an integrated communication actions plan for community engagement and with social justice groups. |

(a) Identify vehicles for community engagement and consultative practice and processes to ensure voice within communities on geothermal activity.
(b) Link to primary legislation and the statutory authority that prescribes consultation and standards performance of geothermal activity.
(c) Undertake community competitions in animated and fun ways for building understanding of the subsurface into the everyday home activities (for example, miss molecule).
(d) Link geothermal performance standards to community redress.
(e) Where appropriate 'link in' with any Fuel Poverty Task Forces in NI and other energy social justice groups and institutions.
(f) Organise and financially support temporary workshops or sector events to consult with social justice energy institutions.
(g) Establish an Independent Inspection Panel in conjunction with the Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency in circumstances of non-compliance with policies and procedures.

## 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 and sub-actions for consideration |
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| **Flagship visibility** | (1) The geothermal shaper community to become more visible in their efforts in demonstrating the scope of geothermal technology applications.<br><br>(a) Showcase geothermal technologies in a holistic way from both above surface and below surface as well as upstream and downstream in the market.<br>(b) Ensure that adopter/end user experiences across multiple business sectoral contexts (e.g. leisure/tourism, pharmaceutical, horticultural, healthcare) are showcased.<br>(c) Consult with the PR agencies to ensure that Press Release announcements on capital works for Northern Ireland connect with geothermal net zero issues in reporting.<br>(d) Mark and pivot from international Geothermal Day, Earth Day and other Net Zero day activities to open up and bring into sharp focus conversations each year.<br>(e) Create opportunities for post-installation visibility.<br>(f) Create storytelling on the subsurface to engage communities with heritage geothermal narratives. |

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| | (g) Ensure the webinar series is supported and share the report findings with the geothermal world.<br>(h) Link in with the Ground Source Heat Pump Association's (GSHPA) education engagement programme, bringing more attention to geoscience and geoenergy into the NI school curriculum.<br>(2) A communication stakeholder engagement plan could be developed to improve engagement with affected communities and to increase knowledge and awareness of scientific; social and environmental aspects of geothermal development |
| **Build assessment and reporting** | (3) Develop activities that shed light on geothermal practice and solutions in the presentation of building assessment and reporting process.<br>(a) Engage with The Royal Institute of British Architects (RIBA), Chartered Institution of Building Services Engineers (CIBSE) and Building Research Establishment (BRE) on showcasing geothermal projects.<br>(b) Develop a series of data sheets for building awareness of geothermal solutions for distribution at the Royal Institute of British Architects (RIBA), Chartered Institution of Building Services Engineers (CIBSE) and Building Research Establishment (BRE).<br>(c) DfE to financially support temporary workshops or sector events to consult with civil engineers and invite the Institutes in 32(b) to lead out on training to cover the RIBA Stages, Low/Zero Carbon Energy Reporting, BREEAM 2018 New Construction Manual's provision for showcasing technology innovation.<br>(d) DfE to financially support temporary workshops or sector events to consult with The Institute of Management Accountants (IMA) and Association of Chartered Certified Accountants (ACCA) to discuss prescribed standards on budgetary requirements, financial models and metrics and to lead out on training to cover non-monetary decision-making criteria as outlined in the Sustainable Development Goals.<br>(e) Consider the promotion of geothermal plaques at the entrances of those places using geothermal technology and/or zero carbon clocks to showcase as part of the CSR corporate social responsibility and sustainability.<br>(f) Link to primary legislation and the statutory authority that prescribes consultation and standards performance of carbon in use and heat waste, with the mandated seven-year energy performance review. |
| **Government as demonstrators** | (4) Showcase geothermal buildability through visible flagship geothermal demonstrators within the NI Assembly and local council estates.<br>• Consult with the Energy Management Unit (EMU) and support their Energy Management strategy and action plan with geothermal projects proposals for department estates.<br>• DfE to financially support temporary workshops or sector events to consult with the local councils and support the inclusion of geothermal projects within their Energy Plans estates and strategic business development within their respective boroughs.<br>• Adopt a strategic portfolio-driven approach to the Northern Ireland Strategic Investment Board's decarbonisation of heat strategy.<br>• Link to primary legislation and the statutory authority that prescribes on the decarbonisation of heat standards performance for the Northern Ireland Strategic Investment Board. |

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| | • Link to primary legislation and the statutory authority that prescribes on the decarbonisation of heat standards performance for InvestNI.<br>• Link to primary legislation and the statutory authority for InvestNI to include a carbon in build and carbon in use assessment criteria for capital programme investment developments.<br>• Provide policy direction and guidance to the local councils;<br>• GSNI to support local councils with public communication materials to build awareness and understanding of the nature and scope of geothermal technology deployment.<br>• GSNI to provide case study sharing of best geothermal practice and roadmap support.<br>• DfE to consider council super additivity incentive schemes to promote innovative council network arrangements for geoenergy transitions.<br>• DfE to financially support elected representatives and local council scoping and knowledge visits to other geothermal projects throughout the UK and the EU. |
| **Strategic market-focused** | (5) Showcase geothermal buildability through a strategic market-focused approach that mitigates risks.<br>(6) 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.<br>(7) Ensure that deep geothermal projects are multi-stakeholder in nature and mutualised across a range of heating demands and contexts.<br>a. Target, promote and prospect long-run patient capital investment that matches geothermal long-run lifecycles.<br>b. Adopt a mutualising principle on geothermal subvention and incentive schemes.<br>c. Financially support in-the-field exploration costs with support with feasibility surveys and interpreting such surveys.<br>d. Devise policy approaches to build a residual geoenergy skill base within Northern Ireland from international expertise.<br>e. Convene with relevant stakeholders and statutory bodies to review the provision of procurement rules of specialist heat services from public authorities.<br>f. Convene with relevant stakeholders and statutory bodies to review the specific planning capacity in relation to geothermal and, where appropriate, introduce and strengthen, both within procedures of local councils' planning applications, but also alternative dispute procedures adjudication process.<br>g. Ensure support and guidelines for post scheme instalment optimisation in a specified and confirmed period of scheme handover.<br>h. Ensure a geothermal policy performance review at least once a year to capture unintended regulatory effects at an early niche development stage.<br>i. Consider innovative geothermal business models such as heat as a service. |
| **Operations capability and capacity** | (8) Organise and financially support a workshop to consult and elicit drilling operators' views and experiences.<br>(9) 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. |

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| | (a) Host an NI breakfast network event with the mainland UK Ground Source Heat Pump firms with an open call for NI distributor and resellers across Northern Ireland.<br>(b) Host an NI breakfast network event with an open call for Northern Ireland drilling and utility firms.<br>(c) If drilling operations are outsourced, consideration to be given for host market labour spillover skills development policy intervention.<br>(d) Ensure subvention support that Northern Ireland geothermal drilling operator activity is not disproportionally disadvantaged by costs that are estimated to be 40% higher than mainland UK and EU.<br>(e) Voucher support exploration feasibility surveys assessment.<br>(f) Ensure subvention support is linked to geothermal labour market skills development.<br>(g) Link in with the Ground Source Heat Pump Association's (GSHPA) development of Low Carbon Technician Apprenticeship & Training Programmes. |
| **Mobile geoenergy observatory and exploration capacity** | (10) Consider the business case for building a Mobile Geoenergy Observatory, scoping out a dual-purpose science-led facility and industry R&D exploration capacity.<br>(a) Establish a DfE, University and industry task committee to scope out the strategic and operational functional activities of the Mobile Geoenergy Observatory; detail the opportunities, understand where expertise needs to be developed; and understand the capacity opportunities.<br>(b) DfE to develop a business case in conjunction with the NI universities to deliver a Mobile Geoenergy Observatory to be located in Belfast to harmonise a range of activities.<br>(c) GSNI to develop clear data sharing agreements data governance, and digital infrastructure for reporting.<br>(d) DfE to link subvention geothermal project support with R&D data sharing at early stage niche to help grow the whole sector. |
| **LZC Technology Centre for Northern Ireland** | (11) 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.<br>(12) 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.<br>(13) 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.<br>(14) 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.

(a) DfE to establish a task force including the CASE Manager to scope out the possibility of boosting the strategic and operational activities of the LZC Technology Centre; detail the opportunities, understand where expertise needs to be developed, technology offices, and understand the capacity opportunities.
(b) Harmonise the industry and policy roles of the LZC Technology Centre, with the international standard environmental categories: climate change mitigation, climate change adaptation, natural resource conservation, biodiversity conservation, and pollution prevention and control.
(c) Align the LZC Technology Centre GTO with a digital repository for prospective adopters and end-users including information on geothermal policy, guidelines, procedures, along with data sheets and information, planning application support, the day-to-day permitting, licencing borehole logging and compliance reporting, along with post-installation geothermal information on maintenance.
(d) Cultivate and align the role of the LZC Technology Centre GTO with R&D geothermal data sharing and governance, with specific consideration of how the mobile geoenergy observatory's geoscience data can be shared with industry activity.
(e) Host and cultivate a series of workshops, training and education awareness within the LZC Technology Centre with industry leaders, policy-makers, local councils, public utilities, InvestNI, companies and multinationals to work together on LZC R&D projects and in collaboration with research institutions across Northern Ireland.
(f) Align the role of the LZC Technology Centre GTO with the Land and Groundwater Team within the Regulation Unit in Northern Ireland Environmental Agency environmental agency and all statutory bodies.
(g) DfE and GSNI to consider the role of the GTO within the LZC Technology Centre, including responding to information data requests from end users, assist with policy alignment and compliance measures, help integrate decision-making within and across projects, build skills initiatives, licencing of resources, permits for activity (exploration and production), planning and control authorization.
(h) Align the work of the LZC Technology Centre with the work of InvestNI and the Strategic Investment Board.
(i) Legislate provision on guidance for Departmental financial assistance for environmental Net Zero transitions project funds to the proposed LZC Technology Centre and other not for profit trusts as per the provisions made within the Environment Act (1990), Section 153, for any part of Northern Ireland.
(j) Legislate Department guidance for the programme known as the special grants programme outlined in the Environment Act (1990), Section 153, provision as it relates to the protection, improvement or better understanding of the subsurface environment of, or of any part of, geothermal activity in Northern Ireland.

(15) DfE to consider supporting an East-West and North-South capacity and capability institutional corridors.

| | |
|---|---|
| | a. DfE to consider supporting a East-West geothermal capacity and capability institutional corridor with the Net Zero Technology Centre in Aberdeen, Scotland (formerly the Oil and Gas Technology Centre (OGTC)) and other complementary geothermal associations such as the Ground Source Heat Pump Association (GSHPA).<br>b. DfE to consider supporting a North-South geothermal capacity and capability institutional corridor with the iCRAG centre, which is hosted by University College Dublin (UCD), and other complementary geothermal associations such as Geothermal Association of Ireland (GAI). |
| **Geothermal cooling demonstrator solutions** | (16) DfE to organise and financially support a sector workshop to promote cooling geothermal solutions for firms operating within high controlled and precision temperature environments.<br>a. Invite UK and International AgriTech artificial intelligence (AI) firms for sector coupling intelligent autonomous solution opportunities in high controlled horticultural environments.<br>b. Invite UK and International LabTech firms for sector coupling intelligent autonomous solution opportunities in high controlled pharmaceutical and laboratory environments.<br>c. Link in with Queen's University's Intelligent Autonomous Manufacturing Systems and Energy Power and Intelligent Control research clusters. |
| **Heat networks** | (17) 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.<br>(a) DfE in conjunction with GSNI to design and present an open bid invitation for proposals for heat network competitions within Northern Ireland.<br>(b) Heat network competition criteria to be reflective of all communities within Northern Ireland.<br>(c) Seek NI representation and support from the UK Cities Climate Investment Commission for developing geothermal heat network deployment. |
| **Technology stretching and sector coupling** | (18) Geothermal policy and resource allocation should follow the normal temporary cycling between both technology exploration and exploitation.<br>a. DfE to support R&D research into the range of hybridisation solution-led approaches between the geothermal thermal, water utility, where appropriate others, and ensure sector readiness.<br>b. DfE to support R&D research into the Underground Thermal Energy Storage and ensure sector readiness.<br>(19) 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** | (20) DfE and GSNI to work at initiatives for narrowing the evaluation gaps from the existing geothermal projects and specifically;<br><br>o Narrow the preparatory work gap.<br>o Narrow the information availability and accessibility gap<br>o Narrow the project terms of reference gap.<br>o Narrow the predictive outcomes gap. |

- Narrow the drilling sector attractiveness gap

(21) DfE and GSNI to work at narrowing the execution gaps from the existing flagship and specifically;

(a) Narrow the engineering consultancy competency gap.
(b) Narrow the insurance and indemnity gap.
(c) Narrow the drilling rig technology upgrading gap.
(d) Narrow the point of entry ease of access for the end-user.
(e) Narrow the in-the-field site teamwork gap.
(f) Narrow and close the geothermal planning system to be digitised, making geothermal project plans more accessible online.

(22) DFE and GSNI to set out a UK White paper on the feasibility, design and installation of Ground Source Heat Pumps.

## 6.0 Further research

The geothermal shaper community might wish to map out and prioritise a number of research activities for building the geothermal sector. These could include, but are not limited to:

- **Stakeholder map and governance – Geothermal Stakeholder Energy Map.** An immediate priority might be to provide a stakeholder analysis and mapping exercise of the development of the geothermal sector. This analysis could include the nature of the interaction amongst the stakeholders and how that relates to the overall geothermal governance within Northern Ireland.

- **Mutualisation and geo-risk.** In addition, a useful piece of research would be to show how mutualisation of geothermal governance might work in Northern Ireland. This could include governance in relation to the eight government departments, the eleven councils[xlii] and a geofund fund as part of a Green Growth Innovation Fund. A review of insurance and indemnity could be provided as part of this research.

- **Ownership and statutory framework.** It would seem prudent at this stage to undertake a scoping paper on the question of subsurface ownership across the UK and further afield, both for the regulator and legislative review, if necessary. This review could provide the basis for consultation and Ministerial review.

- **Technology roadmap – Geothermal Energy Map (GEMap).** We propose that more clarity is given through the articulation of a geothermal energy roadmap, evidenced through reporting from engagements events, dialogues and the co-creation of reciprocal value propositions within stakeholder communities.

- **Scientific data collection, reporting and organisation.** The geothermal shaper community might wish to consider the organisation of how geothermal projects, especially borehole data collection, reporting, sharing and organisation are to be managed from their inception and in ongoing data monitoring, with a view to establishing the scope, and level of detail and governance approach required. A key consideration is how to incentivise data sharing and ensure quality data returns.

- **Regulatory framework.** We propose a comparative review of the regulatory framework and propose the GRID framework for identifying potentially useful regulatory tools for the borehole network, permits and licencing, to obtain an understanding of the integration or how such institutions work together to manage the Northern Ireland subsurface resource.

- **Geoenergy financial incentive schemes.** Understanding the range of the existing national and regional financial support systems dealing with the geothermal resource and technical risks in Europe and worldwide would assist with synchronising schemes with the evolution of the sector.

- **Heat network competition schemes.** A research review of the role of innovation contests in relation to promoting the role of a heat network scheme might support policy-making in developing heat network schemes in Northern Ireland.

- **Project procedurality and standardizing**. We propose that more clarity is given on project steps, procedures and guidelines. It is recommended that consideration is given to the organisation of how geothermal projects are to be managed from their inception and in ongoing data monitoring. For instance, standardising drilling permitting and licensing process.

- **Existing wells, costs and modelling assessments.** We propose the analysis of two existing wells and the related operating costs of those local operations. More reporting of this analysis would build sector confidence.

- **International modelling assessments.** We believe that there is scope for additional benchmarking research on international schemes. For instance, The Agence de l'environnement et de la maîtrise de l'énergie (ADEME) in France has assessed and modelled heat networks. More reporting of this analysis would build sector confidence.

- **Maintaining temporary sector clusters**. We propose that all events are reflected upon by shaper community and evidenced through reporting with the communities.

- **GSNI statutory role and the Geothermal Advisory Committee (GAC).** It might be useful to produce a White paper in relation to the activities of the GAC and also its statutory role in the development of the geothermal sector in Northern Ireland.

- **Ongoing research into experiences of adopters, dis-adopters and communities**. Multiple groups and opinions will always exist, but a values system analysis is shown to be more important for understanding communities. The geothermal shaper community might wish to think about strategies for value system analysis and how that can assist geothermal technology acceptance. Research on comparable exploratory drilling projects and the differences in how long it takes developers to obtain the necessary permits.

## Appendix 1: Methodology

This report was commissioned by and compiled for the Northern Ireland Department for the Economy. The purpose of the Geothermal Advisory Committee (GAC) is to inform and advance the development of geothermal as a strategic low-carbon source of heating and cooling in Northern Ireland.

The authors consulted with those that have led out on geothermal projects in Northern Ireland and elsewhere in the UK and these provided valuable input throughout the development of this report. Thank you to the interviewees who provided valuable insight and feedback.

Thanks also to Dr Marie Cowan and Dr Robert Raine from The Geological Survey of Northern Ireland (GSNI), along with members of the Geothermal Advisory Committee for insightful feedback. Dr Nicola Barron for assisting with our work. Finally, the author is appreciative of Professors Michael Pollitt, University of Cambridge, and Jon Gluyas, Durham University for their sector insight.

The methodology followed the Department for Environment, Food and Rural Affairs (Defra)/Natural Environment Research Council (NERC) guide titled The production of quick scoping reviews and Rapid Evidence Assessments: A how-to guide.[145] The peer-reviewed literature was searched using the database platforms Web of Science and Scopus.

Key issues were then discussed with those who had experience in leading geothermal projects in a series of interviews. Those experts included geologists, architects, consultants, project leads, heads of associations, a drilling rig operator, academics and stakeholders from the geothermal sector within Northern Ireland and further afield. The initial plan had been to select four or five flagship cases to showcase the potential of the geothermal sector in Northern Ireland but the research adopted a more holistic approach to that showcasing as the data inductively emerged. We believe that our scoping piece of research does exactly what Bent Flyvbjerg suggests that our work should be, "an activity done in public for the public, sometimes to clarify, sometimes to intervene, sometimes to generate new perspectives, and always to serve as eyes and ears in our ongoing efforts at understanding the present and deliberating about the future." (Flyvbjerg, 2001, p.166).[146]

[145] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/560521/Production_of_quick_scoping_reviews_and_rapid_evidence_assessments.pdf

[146] Flyvbjerg, B. (2001). Making social science matter: Why social inquiry fails and how it can succeed again (Sampson, S. , Trans.). Cambridge University Press.

List of Abbreviations

ACCA – Association of Chartered Accountants

AMIC – Advanced Manufacturing Innovation Centre

APG – All Party Group

BCC – Belfast City Council

BDA – British Drilling Association

BEIS – Department for Business, Energy and Industrial Strategy

BGS – British Geological Survey

BRE – Building Research Establishment

BREEAM - Building Research Establishment's Environmental Assessment Method

CASE – Centre for Advanced Sustainable Energy

CCC – Climate Change Committee

CCNI - The Climate Coalition NI

CGER – Centre for Geothermal Energy Research

CIBSE – Chartered Institute of Building Services Engineers

CLRD – Civil Law Reform Division

COP – Conference of Parties

CSR – Corporate Social Responsibility

DAERA – Department of Agriculture, Environment and Rural Affairs

DEC – Display Energy Certificate

DEFRA – Department for Environment, Food and Rural Affairs

DER – Distributed Energy Resources

DETI – Department of Enterprise Trade and Investment

DfC - Department for Communities

DfE – Department for the Economy

DfI – Department for Infrastructure

DoE – Department of Education

DoE – Department of Energy

DoF – Department of Finance

DoH – Department of Health

DoJ – Department of Justice

DSR – Design Science Research

DST – Design Support Tool

EA – Environmental Assessment

EBN - Energie Beheer Nederland

EGC – European Geothermal Congress

EGEC – European Geothermal Energy Council

EMU – Energy Management Unit
EPBD – Energy Performance of Buildings Directive
ESC – Energy Subgroup Committee
EST – Enabling Support Tool
EU – European Union
FMO – Dutch Development Bank
GAC - Geothermal Advisory Committee
GAI – Geothermal Association of Ireland
GB – Great Britain
GDPR – General Data Protection Agency
GEL – Geothermal Energy Limited
GIS – Geothermal Incentive Scheme
GSHP – Ground Source Heat Pump
GSHPA – Ground Source Heat Pump Association
GSNI - The Geological Survey of Northern Ireland
GSI – Geological Survey Ireland
GTO – Geothermal Technology Centre
GW – Gigawatt
IEA -International Energy Agency
IGA – International Geothermal Association
IMA – Institute of Management Accountants
IRENA- International Renewable Energy Agency
KPI – Key Performance Indicator
LCEA – Low Carbon Energy Assessor
LEP – Local Enterprise Partnership
LNBL – Lawrence Berkeley National Laboratory
LZC Technologies – Low and Zero Carbon Technologies
MCS – Microgeneration Certification Scheme
NATO – North Atlantic Treaty Organisation
NEA -National Energy Action NI
NERC – Natural Environment Research Council
NGO – Non Government Organisation
NI – Northern Ireland
NICS – Northern Ireland Civil Service
NIEA – Northern Ireland Environment Agency
NIFHA-Northern Ireland Federation of Housing Associations
NREL -National Renewable Energy Laboratory

OFMDFM – Office of the First Minister and Deputy First Minister
OGTC – Oil and Gas Technology Centre
PLC – Public Limited Company
QUB – Queens University Belfast
RCSG - Rijswijk Centre for Sustainable Geo-energy
R&D – Research and Development
RHI – Renewable Heat Incentive
RIBA – Royal Institute of British Architects
ROI – Republic of Ireland
SDGs – Sustainable Development Goals
SEA/SESA -Strategic Environmental (and Social) Assessment
SEAI – Sustainable Energy Authority of Ireland
SECA – Centre for Sustainability, Equality and Climate Action
SEF – Strategic Energy Framework
SIB – Strategic Investment Board
SME – Small and Medium Sized Enterprises
SoBS – School of Biological Sciences
SRIPE – Sinopec Research Institute of Petroleum Engineering
SSAC – Scottish Science Advisory Committee
SSG – Sherwood Sandstone Group
UK – United Kingdom
UKGEOS – United Kingdom Geo Energy Observatories
UKRI – United Kingdom Research and Innovation
UNGA – United Nations General Assembly
UoP – Use of Proceeds
USA – United States of America
UU – University Ulster
UW – University of Wisconsin-Madison
VRE -Variable Renewable Energy
WB/WBG - World Bank/World Bank Group

## Appendix 2: Transitioning markets with a behavioural SHIFT framework

The SHIFT behavioural tool has been developed by Professor Katherine White at UBC Sauder School of Business, University of British Columbia, and her colleagues and this provides an accessible behavioural science framework that shows how end-users/buyers are more inclined to engage in behaviours when the message or context leverages the following psychological factors:

(i) **Social Influence**. Consumers are impacted by the presence, behaviours, and expectations of others. How can geothermal flagship projects help others understand better geothermal projects?

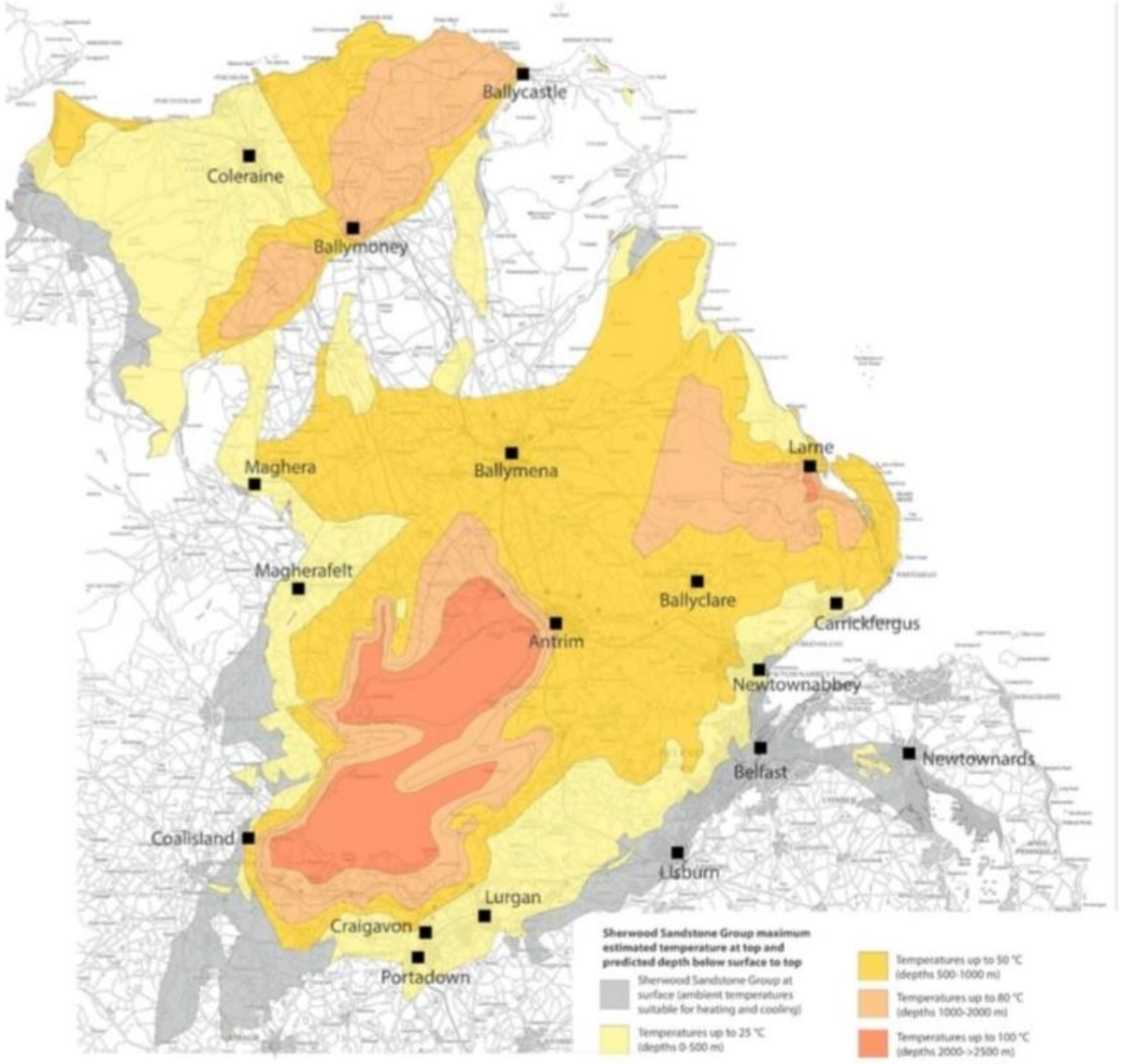
(ii) **Habit Formation.** Habits refer to behaviours that persist because they have become relatively automatic over time as a result of regularly encountered contextual cues. How can the geothermal projects be made simple, accessible and part of the everyday energy consumption habits?

(iii) **The Individual Self**. Factors linked to the individual can have a powerful influence on consumption behaviours. How can geothermal policy create personal advantages such as stability, environmental, and financial, to attract individuals to adopt geothermal heating and cooling solutions?

(iv) **Feelings and Cognition.** The concepts of feelings and cognition are together because, generally speaking, consumers take one of two different routes to action: one that is driven by effect or one that is more driven by cognition. How can all citizens be provided with clear, concise information when considering geothermal heating or cooling? How can geothermal projects provide positive emotions and feelings of satisfaction?

(v) **Tangibility.** One unique facet of sustainable consumption is that eco-friendly actions and outcomes can seem abstract, vague, and distant from the self. How can the geothermal shaper community make geothermal project encounters tangible?

## Appendix 3: Triassic Sherwood Sandstone Group (SSG) Map for NI



# Appendix 4: 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.

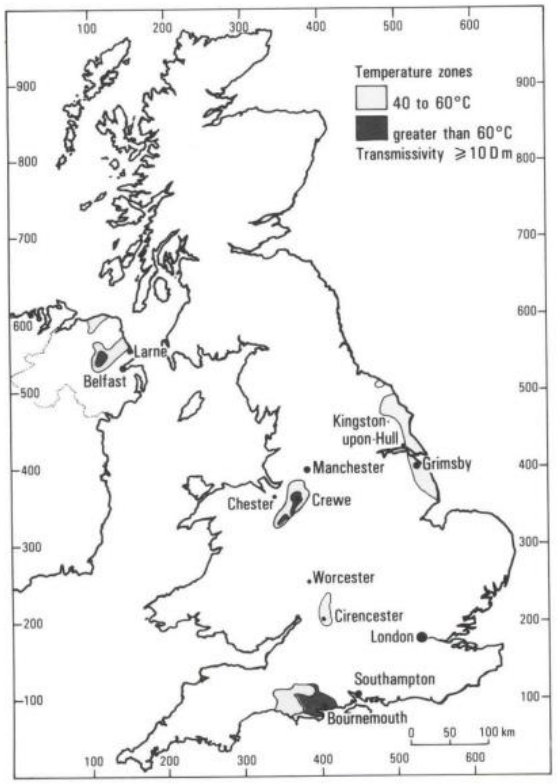
† Assumes heat pumps would not be used and hence rejection at 30°C.

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.**

## Appendix 5: Geothermal community narratives

| Illustrative examples of geothermal narratives | Illustrative market actor networks | Illustrative examples of associated market 'how' considerations |
|---|---|---|
| Geothermal as part of public authorities leadership response to decarbonisation #roadtozero and making the technology part and parcel of everyday life. | All key regional infrastructure in Northern Ireland. All local government departments, including Agriculture, Environment and Rural Affairs, Communities, Education, Health and Infrastructure.<br>All 11 councils in Northern Ireland.<br>Examples include, UK's Swimming Pool and Allied Trade Association. Northern Ireland Local Government Energy Managers Forum | How to generate public and departmental debates on energy in each department – a priority filter criterion might be a 24-hour energy requirement.<br>Horticulture (e.g. glasshouses), agriculture (e.g. fisheries), Healthcare (e.g. hospitals), transport (e.g. airports), tourism (e.g. hotel spa, hubs, observatory), education (e.g. college buildings), business (e.g. distilleries), and justice (e.g. prisons). |
| Geothermal small field **shallow** development for heating and cooling as local community leadership response to decarbonisation #roadtozeroNI. | All 11 councils in Northern Ireland.[147] Royal Institute of Civil Engineers. Institute of Planners. Institution of Mechanical Engineers (IMechE) Northern Ireland. Heat pump association.<br>Office for Environmental Protection. Geological Society of London and International Association of Hydrogeologists. | How to focus on small field sites to empower local communities.<br><br>Heat deployment<br><br>Decentralised solutions that enable people and communities to be active participants in the energy transition<br><br>Public and public-private led mutualised consortia. |

| | | |
|---|---|---|
| Geothermal as **deep** field development for heating and cooling for energy security for Northern Ireland. | All 11 councils in Northern Ireland. Royal Institute of Civil Engineers. Institute of Planners. Institution of Mechanical Engineers (IMechE) Northern Ireland.<br>Quarry MPA is the trade association for the aggregates, asphalt, cement, concrete, … QPANI, Quarry Products Association Northern Ireland. | How to focus on large deep field sites to significantly impact the decarbonisation targets.<br>Consideration of the main heat users.<br><br>Heat extraction and deployment<br><br>How to build and mutualise public and public-private commitment.<br><br>How geothermal projects can be developed within mines/quarries, like elsewhere.<br>A review of all active or disused mines and all quarries in Northern Ireland. |
| Geothermal as energy-efficiency-first and accomplishing environmental justice for community inclusion. Geothermal heat networks can put an energy-efficiency-first approach which will help consumers reduce the energy they use and therefore minimise their energy bills. | Act Now<br>Green Growth<br>Friends of the Earth NI<br>The Climate Coalition NI (CCNI)<br>Climate Action NI/ Climate Act Now<br>RSPB NI<br>Amesty Int' NI<br>Save Our Sperrins<br>Farming Carbon | How to create an inclusive energy-efficiency-first approach to geothermal energy and energy security. |
| Geothermal as enterprise generating. | Private investors, private-public consortia.<br>Land and property owners.<br>Supply chain, mining firms and quarry operators. Consultancy and other environmental and planning specialists.<br>Heat pump association | Consideration of the geothermal sector as entrepreneurship. Skills development, transfer and capacity programmes. Supply chain building.<br>Academy for installers, accreditation schemes. |

| | | |
|---|---|---|
| | Installation and maintenance | |
| Geothermal as network heating systems for regenerating urban centres through renewable house building schemes. | Northern Ireland Housing Executive.<br>Northern Ireland Federation of Housing Associations (NIFHA)<br>Social Housing Projects<br>National Energy Action (NEA) NI<br>Northern Ireland Council for Voluntary Action<br>Community Energy NI | Consideration of district heating systems in the regeneration of city centre zones for shared community living, meeting social, affordable and private housing needs. A geothermal heated system to include amenity spaces within all buildings for potential facilities such as a crèche, pharmacy, gym, flexible workspace, lounges, restaurants, shops, arts and community uses. Link in with City Deals and High Street regeneration policy. |

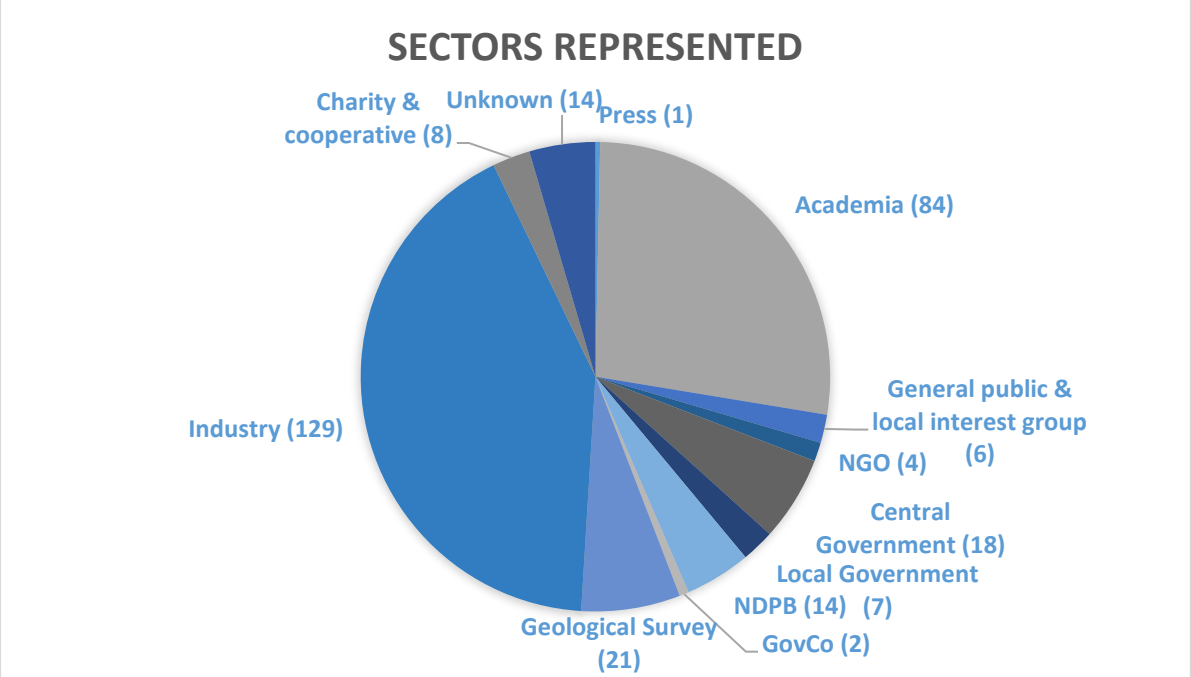
Source: Developed by the authors.

## Appendix 6: Emerging interest in the geothermal sector

Building Back Better – A Future for Geothermal in Northern Ireland

The purpose of the conference was to highlight and explore the future potential that geothermal technologies can play in Northern Ireland in building back our economy in a better, fairer, greener and more sustainable way after the Covid-19 pandemic. The table and chart below show the location of conference registrants and the sectors represented.

| | |
|---|---|
| Northern Ireland | 146 |
| Ireland | 39 |
| England | 53 |
| Wales | 5 |
| Scotland | 25 |
| Europe (other) | 19 |
| World (other) | 12 |
| Unknown location | 9 |
| | 308 |




The conference was officially opened by Jenny Pyper, the new interim Head of the NI Civil Service and took the form of a half-day of talks, arranged into three sessions with Q&A at the end of each session. The conference concluded with a panel session chaired by Steven

Agnew (Renewable NI). Speakers from a range of sectors presented aspects of geothermal, relevant to NI, including resource distribution and current geothermal research along with examples from other areas of geothermal business models, public engagement, policy and the performance of heat networks.

## Appendix 7: Transitioning markets with a Technology Roadmap

Technology Roadmaps reflect an attempt to develop and outline a vision for the sector. Activities and issues are scoped out, considerations and questions are debated and discussed, consensus reached where possible, hurdles facing the sector and time schedules to work toward overcoming them are outlined. A Technology Roadmap will scope out through a range of detailed discussions of the sector building plans and activities which could include:

• **Delivery actions** in relation to investment and financing, the evolution of societal or individual behaviours and leadership by key actors.

• **Timings**. The timespan over which delivery should be possible. Factors taken into account include timescales for the development and deployment of geothermal projects, infrastructure, and the timeline for formulation, development and implementation of policy.

• **Costs.** The costs associated with each individual option and in aggregate compared to a counterfactual with no action on cutting emissions.

• **Co-benefits.** The co-benefits of action to achieve net-zero emissions, such as those related to communities, human health and the environment.

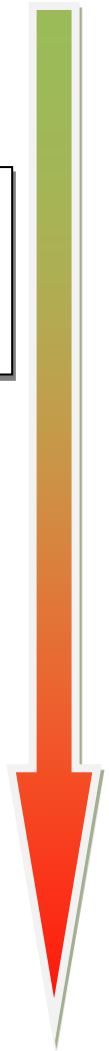
• **Challenge**. The scale of the challenge that each option presents in terms of, for example, new infrastructure that would be needed, the readiness of supply chains and any evolution of societal or individual behaviours that may need to occur.

• **Immediate priorities.** Actions that should be made a priority now, due to the length of time needed for implementation or the fact that they are a fundamental enabler of future options.

## Appendix 8: GRID framework for identifying potential regulatory tools

Intensity of intervention increases according to risk type

Intensity of intervention increases according to regulatee type



| Nature of the Regulatee | Nature of the low-risk site/activity | | | | Regulatory Activity & Intensity |
|---|---|---|---|---|---|
| | Inherent lower-risk – stable | Net lower-risk – stable | Inherent lower-risk – but may change or accumulate | Net lower-risk – but may change or accumulate | |
| Regulatees are well- motivated with high capacity to comply | | | | | Screening tools |
| | | | | | Monitoring tools |
| | | | | | Engagement & incentive mechanisms |
| | Low | Low | Low | Low | Regulatory intensity |
| Regulatees are well- motivated with low capacity to comply | | | | | Screening tools |
| | | | | | Monitoring tools |
| | | | | | Engagement & incentive mechanisms |
| | Low | Low | Medium-Low | Medium-Low | Regulatory intensity |
| | | | | | Screening tools |

| | | | | | |
|---|---|---|---|---|---|
| Regulatees are less motivated with high capacity to comply | | | | | Monitoring tools |
| | | | | | Engagement & incentives |
| | Medium | Medium | Medium | High | Regulatory intensity |
| Regulatees are less motivated with low capacity to comply | | | | | Screening tools |
| | | | | | Monitoring tools |
| | | | | | Engagement & incentive mechanisms |
| | Medium | Medium | High | High | Regulatory intensity |

Source: Black and Baldwin (2012).

Endnotes:

[i] Several trends are driving this transition. Policy and also society's desire for more sustainable ways to produce energy have driven viable commercial advances, and many technological advancements for DER applications, along with growing use of these systems across the UK, EU and further afield.

[ii] The concept of scaffolds describes the role of institutional structures in providing regulative, normative, cognitive support toward stronger understanding, skills and independence in the sector.

[iii] This research was tasked with understanding the scale of the UK geothermal opportunity; the barriers; how geothermal could bring down energy costs; how geothermal projects could be incentivised? How jobs in fossil fuel heating industries would be protected in the transition to renewable heat?

[iv] The Mine Energy Task Force published a white paper in May 2021 on unlocking deployment of geothermally heated energy in the UK's 23,000 abandoned coal mines – see https://www.northeastlep.co.uk/wp-content/uploads/2021/05/Mine-Energy-White-Paper_FINAL.pdf

[v] The research by Kerr (2017) discusses how uncertainty is used by both environmentalists and corporations in the debate in order to postpone regulation and stimulate status quo. Other research by Slovic et al. (2004) show how risk can be framed as analysis and risk as feelings.

[vi] COP, or "The Conference of the Parties," is a yearly conference that began in 1994 with 197 countries signing the UN Framework Convention on Climate Change. The conference gathers experts from around the world, from different sectors of society, stakeholders, governmental organizations, and experts from companies large and small.

[vii] The UK's Climate Change Act (2008) established a legally binding obligation to reduce the net UK carbon account for the year 2050 by at least 80% lower than the 1990 baseline. In 2019 the Climate Change Act was amended to increase this target to 100%, making the UK the first major economy to pass a net zero emissions law. https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

[viii] UKGEOS is a UK government capital investment to create world-class, subsurface energy-research test centres. The Glasgow Geothermal Energy Research Field Site (GGERFS) aims to study low-temperature geothermal energy from the flooded mine workings below Glasgow.

[ix] NERC convened at least one workshop on geothermal innovation in 2019 and we requested a copy of the workshop report for this research. Further information can be found at https://ukgeos.ac.uk/

[x] In the area of data sharing, key initiatives include the release in 2015 of the Transparency and Openness Promotion Guidelines (TOP guidelines) produced by the Center for Open Science, and the launch in 2016 of the FAIR Principles (Findability, Accessibility, Interoperability, Reusability). Open data practices are also a part of the EU's open science policy platform, for example in examining open data readiness in Europe.

[xi] The Sustainable Development Goals (SDGs) set out 17 goals and 169 targets aimed at ending poverty, protecting the planet, and ensuring prosperity for all and provided the basis of the Agenda 2030 and established paths to end extreme poverty, fight inequality and injustice and protect the environment on a global scale. Drawing on the Brundtland Commission's (World Commission on Environment and Development, 1987) landmark definition—meeting the needs of the present without compromising the ability of future generations to meet their needs— the United National General Assembly (UNGA) in 2015 set out the global institutional scaffolding for achieving planet sustainably. Within the SDGs, the energy-specific goal is #SDG 7 Affordable Clean Energy - but building the geothermal sector in Northern Ireland, we believe also addresses goals #9 Industry/Innovation and Infrastructure, #11Sustainable Cities and Communities, #12

Responsible Consumption and Production and # 13 Climate Action. Within this, there are social impacts that are not simply measured through financial metrics.

[xii] Arguments that governments should intervene often presuppose that governments can intervene effectively and the role of government in furthering the technology trajectory and creating the market. The policy work by Professor Mariana Mazzucato at the London School of Economics brings to the fore the way that national and regional governments can act in a leadership role for derisking and making markets (see https://marianamazzucato.com). Other recent market-making analysis shows how the government lays the market foundations that can then be deepened through practices of intermediation and capitalisation by private firms. See also the work of Sangeetha Chandrashekeran.

[xiii] Demski et al. (2015) identified 15 values that constitute what they call a "public value system for energy system change." According to the authors, understanding this value system enables anticipating and understanding public reactions to energy topics, paying attention to public values as a steppingstone to develop governance for just energy transitions. Some geothermal projects across the world have been associated with induced seismic events. Adding to the risk of induced seismicity associated with geothermal energy technology, other factors come into play that have implications on the public's view and acceptance of this technology, such as the financial risk related to the successful implementation of the technology, as well as more general issues linked to the siting, scale, and impact of individual projects. These issues must be debated publicly in relation to community expectations, with stakeholder engagement and value system analysis.

[xiv] However, only looking at a one-off pilot case where geothermal has been accomplished as a project, rather than more broadly as a pool of geothermal activities, is likely to lead to a skewed picture if there is partial failure and curtail the mutualisation of risk. The consultation evidence from EU geothermal projects is that derisking is accomplished with collaborative pooling of resources and mutualising geothermal resources and R&D activity, particularly at early stage niche development. See the reports on georisk. https://www.georisk-project.eu/wp-content/uploads/2020/03/D3.4-Proposal-for-a-transition-in-the-Risk-Mitigation-Schemes.pdf

[xv] An option for Northern Ireland geothermal resource base might be to consider mirroring the Netherlands small fields policy which has provided support for exploration and production of small fields.

[xvi] A Pareto effect analysis – 20% generates 80% carbon reduction – could allow for further sector prioritization within large industrial/commercial field sites in order to accomplish decarbonisation targets. (see https://en.wikipedia.org/wiki/Pareto_principle)

[xvii] Initial research on this activity shows approximately 2000 disused quarries in Northern Ireland and several existing boreholes, for example at Ballyinlea and Ballyymacilroy. Feasibility of heat demand and matching resource with demand could be reviewed.

[xviii] The geothermal sector is in a nascent stage of development. With these conditions project pioneers and investors typically act less in response to actual expressed market demand than by anticipating it (so called latent demand): they gauge where indirect heuristics and indicators are in terms of breakthrough technologies, organising activities and funding calls by national, regional and local governments, sector trends, potential and doability, thus determine what they can do that is similar and yet different enough to justify investment. Clusters of technology and industrial networks are usually found and co-located in science parks or a regional cluster, but when the institutions of the market have not yet been formed temporary clusters are a critical indirect indicator for positive expressions of interest, the latent demand, interest and sector potential.

[xix] Besides a one word reference notably on page 14, "…there are potentially significant but as yet, …[not]… fully explored and exploited geothermal heat resources in NI", geothermal was not discussed anywhere else in this 67-page report. In effect, geothermal technology as a source of heating and cooling is treated as a Cinderella stepchild in the heat decarbonisation for NI. This research conducted four thematic workshops and a final seminar, as well as a series of focus groups with NI consumers. Over 120 stakeholders from almost 100 organisations attended the project workshops. A full report is available at

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

[xx] Two authors of this report – Palmer and Zhang – supervised a Ph.D. research study on the RHI scheme and the reference to this work is as follows: Gharib, A., (2022) An institutional study of a government-led green technology innovation scheme, Queen's University Belfast.

[xxi] Design Science Research (DSR) aims to create better technology solutions that focus on user experiences and therefore enhance understanding of the experience. Improved geothermal application processes can emerge from a better understanding of user experience of that process and practice, and practical applicability to solve a problem is an essential requirement of DSR.

[xxii] In other markets we observe that the geofund can be complemented crowd geothermal funding or crowd funding. See the following URL: https://www.crowdthermalproject.eu and also the crowdthermal webinar:

https://www.youtube.com/watch?v=mXruEFBnmkU&list=PLxpzCdkdwTWD3MyEC0DIEwMe8ZVLkS_BV&index=34

[xxiii] Interviewees were mindful of the effect of any UK-wide Geothermal Incentive Scheme on costs within the sector. Others point to pressures and these accord with Campbell's law which highlights that the more any quantitative social indicator (or even some qualitative indicator) is used for social decision-making, the more subject it will be to pressures and the more apt it will be to distort the social processes it is intended to create or monitor.

[xxiv] Interviewees raise the issue of high upfront capital expenditure requirements and the role of the NI Department for the Economy in procuring that strategic capital funding – that could be called a geofund as is the case in other markets – for geothermal infrastructure-building. Elsewhere the Director of Environmental Policy at the Department of Agriculture, Environment and Rural Affairs (DAERA) in Northern Ireland has requested clarification on resource net zero funding in an open letter to Chris Stark, Chief Executive of the Climate Change Committee (see https://www.theccc.org.uk/publication/letter-costs-associated-with-achieving-net-zero-by-2050-in-northern-ireland). DAERA Question: "Will the up to £900 million costs (i.e. the additional costs of reaching net zero rather than the costs of getting to at least 82%) be borne by the Northern Ireland Executive alone or by both the public and private sectors." CCC Answer provided: "The question of who pays the additional costs required to reach Net Zero is a policy choice for the Northern Ireland Executive to make. While our pathways model the actions and costs required for emissions reductions, they do not determine how they will be funded, or how those costs might be split between the public and private sectors." All capital and resource funding schemes need approval by the NI Executive to action and deliver. It is assumed that this would apply to DfE Energy Action Plan. There are several national or international capital funding schemes in which the NI Executive or the Department for Finance might elicit advices from UK HM Treasury to build a geofund for mutualisation purposes, including;

(i) The Green Bond. See: https://openknowledge.worldbank.org/handle/10986/22791

(ii) UK Green Gilt. See https://www.ft.com/content/94d604a9-50b9-49f1-b377- a7b6e4083d01

(iii) UK Green Savings Bond. See https://www.ft.com/content/09587e4f16c3-41bb-8df8-bcb8100fda94

(iv) The EU Sustainable Finance Bonds. See https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance

(v)Energy Performance Contracts. While there are varying types of EPCs, the simplest is an agreement between the owner of a property portfolio (e.g. Government) and a specialised entity, referred to as an "Energy Service Company" (ESCO). The ESCO will design, fund and implement the energy conservation measures to reduce carbon emissions and achieve guaranteed annual energy resource savings. See https://sibni.org/app/uploads/2019/03/Energy-Management-Strategy-March-2019.pdf

For example, the Carbon and Energy Fund (CEF) was launched in 2011 and created by the NHS for the NHS and wider Public Sector. This funds, facilitates and project manages energy infrastructure upgrades. https://www.carbonandenergyfund.net

[xxv] Risk insurance funds for geothermal projects have been operating in specific European countries, namely France, Germany, Iceland, the Netherlands, Denmark, Switzerland and Turkey. The geothermal resource risk can take the form of: The short-term risk of not finding an economically sustainable geothermal resource after drilling; The long-term risk of the natural depletion of the geothermal resource, making its exploitation economically unprofitable. file:///I:/Geothermal%20Market/Policy%20documents%20on%20Geothermal/Final%20Report%201st%20Report/D-4.4-Study-on-risk-insurance-schemes-and-correctives-measures.pdf

[xxvi] Standards could apply to different aspects and/or parts of geothermal activity (for example, health and safety on drilling rigs, or environmental protection) and a full scoping appraisal is beyond the remit of the research report. The geothermal sector standards implemented could take different, stronger or weaker forms, e.g. enforceable rules or less binding codes of conduct. Geothermal standards could be produced by a variety of public and private actors, thus reinforcing governance processes.

[xxvii] Ad coelum doctrine relates to the common law rule that a landlord owns everything below and above the land, up to the sky and below the earth to its core. This doctrine applies to all minerals in the land as well.

[xxviii] The Extractive Industries Transparency Initiative (EITI, a worldwide initiative for transparency in the resource extraction sector (https://eiti.org/) might provide some useful guidance on this exploration, stakeholder review and consultation, but also evaluation.

[xxix] In early 2022, Northern Ireland's Department for Infrastructure (DfI) reported on the implementation of the Planning Act (NI) 2011. On foot, the Northern Ireland Audit Office published its report 'Planning in Northern Ireland' wherein the institutional outworkings of the decentralisation of planning was reported on. Within the context of that Audit Office report, we believe that the capacity of decentralised planning in Northern Ireland to undertake geothermal applications requires review and further consideration to ensure that there are sufficient resources for building the geothermal sector.

[xxx] We believe that a range of primary and secondary legislation provision could be reviewed including, but not limited to, the Northern Ireland Land Act 1925; Mineral Development Act (Northern Ireland) 1969, The Environmental Protection Act 1990; Criminal Justice and Public Order Act 1994 (Disruptive trespassers), The Water and Sewerage Services (Northern Ireland) Order 2006; Energy Act (Northern Ireland) 2011; The Planning Act (Northern Ireland) 2011.

[xxxi] It should be noted that presently the Director of the Geological Survey of Northern Ireland (GSNI) Chairs the Geothermal Advisory Committee each month, membership of which includes a diverse range of individual professions including planning representation. Further consultation on how planning and planners can institutionally support the efficient, effective and positive transition towards net zero through the deployment of LZC technologies might be necessary through transitional knowledge sharing workshops. DfE and DfI could both facilitate this temporary spatial clustering activity. Further consultation on the statutory role of the GSNI in the building of the geothermal sector in Northern Ireland may require consideration and review at those workshops.

[xxxii] An extensive literature on regulatory enforcement and on responses to regulation suggest that both compliance-orientated and enforcement activities(including for these purposes advice and assist visits, or education campaigns as well as formal enforcement action) should vary with the behaviour and compliance motivations of the regulate. Some regulators have gone a step further and grouped their regulated population according to their propensity to comply. Some develop mixes of strategies that are suitable for discharging the main tasks of regulation (notably of detection, enforcement, performance assessment and strategic adjustment) (Baldwin & Black, 2008).

[xxxiii] Introduction of streamlined procedures will be necessary in building the sector. This report invites the geothermal shaper community to backcast one geothermal shallow and deep application and then articulate the steps surrounding those applications, finding perspective in Leventhal's criteria of fair procedures including; Consistency, Bias-suppression, Accuracy, Representativity, Correctability and Ethicality.

[xxxiv] The specific terms of environmental assessment including Environment Impact Assessments (EIAs) and Strategic Environment Assessment (SEAs) are sometimes used interchangeably in reports. A useful summary and demarcation is available online at https://www.soas.ac.uk/cedep-demos/000_P507_EA_K3736-Demo/unit1/page_08.htm.

[xxxv] Press releases are an important platform for communicating and showcasing LZC technology in use, or plans for use. Despite this, we find little evidence that carbon in use or LZC technologies are highlighted as part of press releases on new capital build programmes in Northern Ireland. We believe that the communications PR sector is an important market actor for showcasing and normalising geothermal activities.

[xxxvi] The Energy Performance of Building Regulations (Northern Ireland) implement Articles 7 (energy performance certificate), 9 (inspections of air-conditioning systems) and 10 (independent experts) of EPBD. The main provisions are: Energy Performance Certificates ("EPCs") should be made available when buildings are constructed, sold or rented out; Display Energy Certificates (DECs) should be displayed in large public buildings(over 1000m2) providing public service. These institutions must also obtain an advisory report containing recommendations for the improvement of the energy performance of the building. The advisory report is valid for a period of 7 years from the date its was issued. The DEC should be no more than 12 months old (regulation 12).

[xxxvii] Research shows that storytelling is not just for lay audiences, but that elements of narrative make scientific articles more effective in communicating (Slater, 1997; Slater & Rouner, 2002; Green et al., 2004). All technologies and specifically the geothermal scientific research, R&D activity and all of its field activities require storytelling for building market acceptance.

[xxxviii] The interviewees suggest that financial short-termism and specific financial tools/metrics are harming what they perceive as long-run productivity savings arising from long run-type geothermal technology innovations. After emailing academic members of the UK Productivity Institute (https://www.productivity.ac.uk), it was reported by the academic leads at that institute that no research on this specific issue existed as far as they were aware. Joint research by Institute of Management Accountants (IMA) and the Association of Chartered Certified Accountants (ACCC) on the role of Chief Financial Officers in technology roadmapping, shows that the general view of R&D managers was that finance involvement in the early stages of project evaluation would stop or slow down the authorization of projects. The common viewpoint of R&D managers was that finance should not be invited to be involved in the early stages because they were less likely to encourage projects (Moll, 2017).

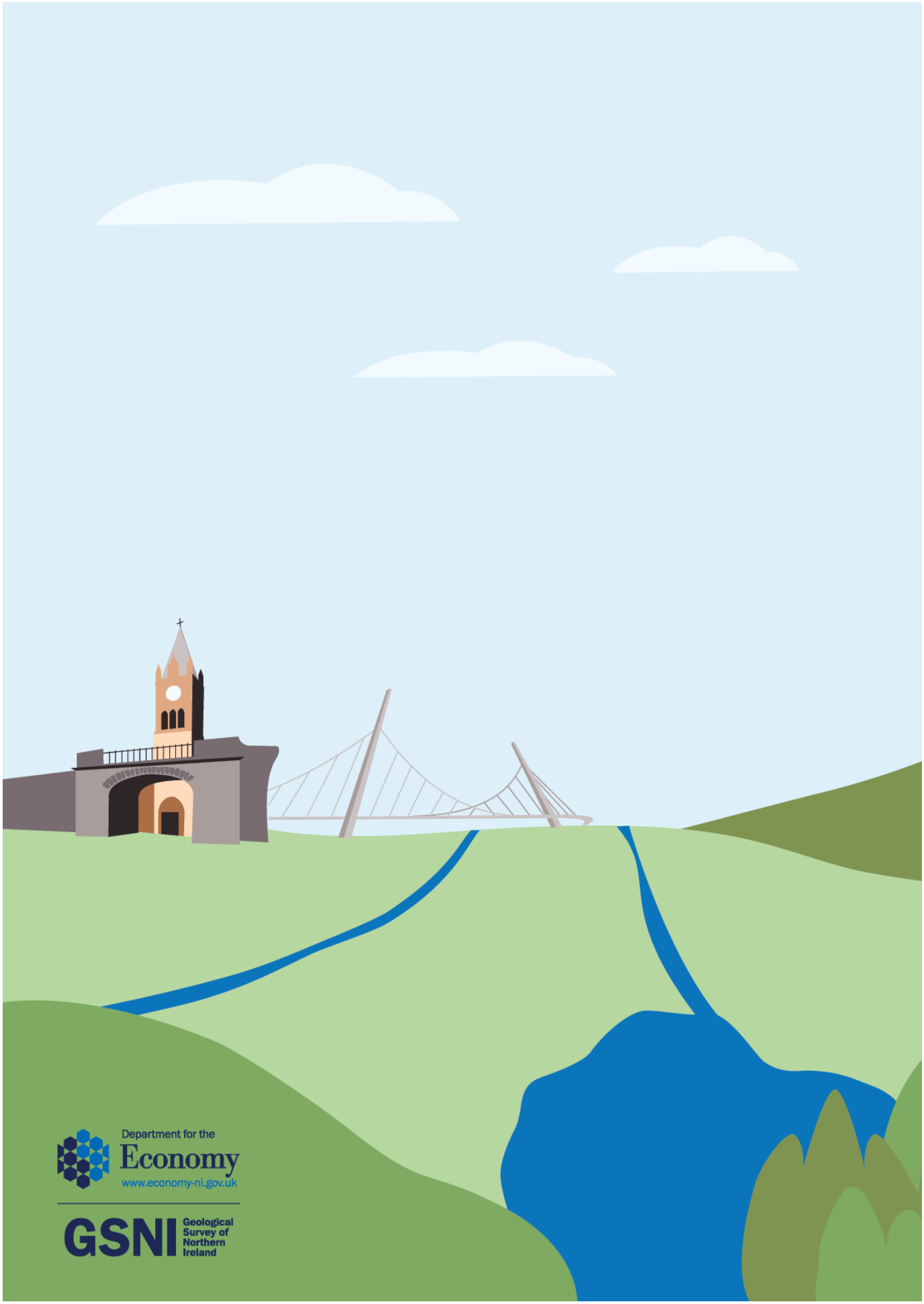
[xxxix] Philippe Dumas, Secretary General of European Geothermal Energy Council (EGEC) has written an open letter on 11th of April 2022 to the Commission President von der Leyen calling on the EU Commission to prepare and issue Europe's strategy on geothermal energy and sustainable raw materials extraction, by 2023. https://www.egec.org/wp-content/uploads/position_papers/2022-Geothermal-strategy-letter-FINAL-1.pdf

In USA state governments are bringing forward statutory provisions that level up LZC technologies and apply solar energy bill provisions so that they also apply to geothermal energy, for example, the State of Colorado.
Seefile:///I:/Geothermal%20Market/Policy%20documents%20on%20Geothermal/Final%20Report%201st%20Report/Bill%20in%20colorado%20geothermal.pdf

[xl] This report specifically shows that the role of InvestNI is to (i) Promote and raise awareness of supply chain opportunities in sustainable energy technologies both locally and further afield. (i) Support the growth of suitable manufacturing or tradeable service companies operating in the sustainable energy field. The interviewees are calling for a revision of this remit and, specifically, one that addresses the InvestNI appraisal green book and the governance of energy and carbon in capital investments.

[xli] Currently legislative responsibility for the promotion of energy efficiency is set out in the Energy Efficiency (NI) Order 1999 order. This was amended in December 1999 following a reorganisation of NI Departments by a Statutory Rule known as the Departments (Transfer and Assignment of Functions) Order (Northern Ireland) 1999, which resulted in placing statutory duties for the promotion on energy efficiency on three main Departments. In 2002 it was amended further through the Industrial Development Act (NI).

[xlii] The eleven Northern Ireland councils comprise: Antrim and Newtownabbey Borough Council, Ards and North Down Borough Council, Armagh City, Banbridge and Craigavon Borough Council, Belfast City Council, Causeway Coast and Glens Borough Council, Derry City and Strabane District Council, Fermanagh and Omagh District Council - Enniskillen Office, Lisburn and Castlereagh City Council, Mid and East Antrim Borough Council, Mid Ulster District Council – Dungannon, Newry, Mourne and Down District Council.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