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Pivoting the geoenergy nexuses

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Pivoting the Geoenergy Nexuses

Thermal Fabric | Heat Pumps | Built Environment | Geology
Heat Networks | Thermal Storage | Thermal Recycling
Renewable Technologies



Authors

Mark Palmer is a Professor of Marketing and Strategic Management at Queen's University Belfast.
Mr Andrew Frew is the Technical Innovation Manager at the Northern Ireland Housing Executive.
Dr Nicola Barron is an adjunct faculty member at Queen's University Belfast.
Mr Joseph Ireland is a Ph.D. candidate at Queen's University Belfast.
Dr Chaun Li is a Lecturer at Queen's University Belfast.

Corresponding author:
Professor Mark Palmer
Queen's University Belfast
Riddel Hall
185 Stranmillis Rd, Belfast BT9 5EE

This report reflects the views of academics at Queen's University Belfast and those in attendance at our workshop 'Building the Geothermal Energy Sector in Northern Ireland' held on 4th July 2023 at Riddel Hall.

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Geoenergy-Heated Queen's Business School

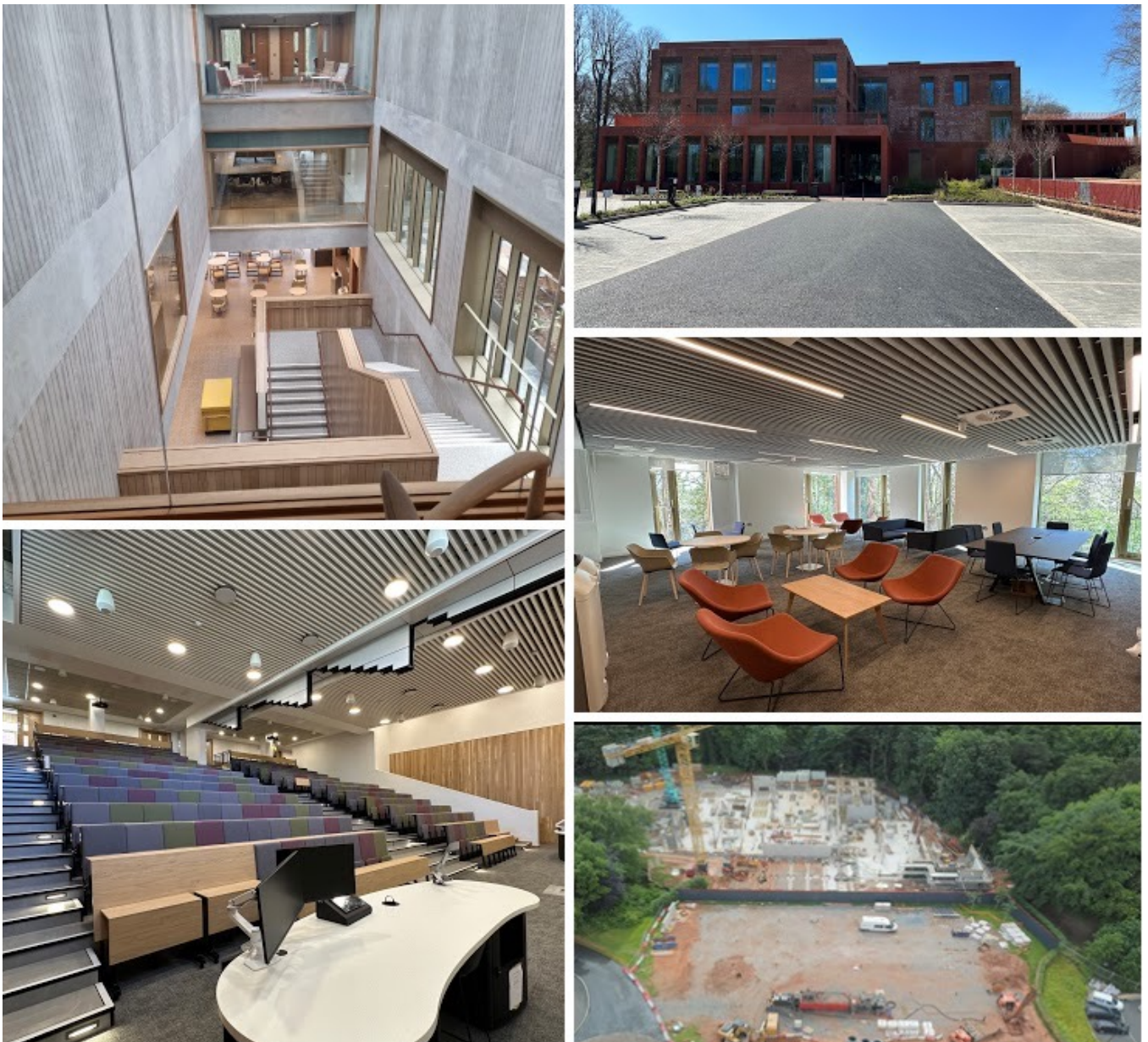


Figure 1 - Geoenergy-heated business school, QUB

Report Summary

Northern Ireland's natural resource environment is 'brimming with home grown' energy opportunities including; a diverse and thermally-rich geology, windy undulating drumlins, and maritime zones; moreover, an emerging array of renewable technology projects, some of which are under consideration, in-progress or completed. We are arguably in a time period when some of the greatest energy changes are a foot – 'a golden age', so to speak. Staying on top of, and up-to-date with, this ever-changing energy environment is no small task. Data repositories, reports, websites, and social media feeds all help. Organising workshops too can serve to inform, energise, and mobilise networks, further collective network goals, build confidence, kick-start collaborations, and hatch as well as spur project ideas and capital investments. This workshop briefing note reports on all of the above.

Held on the 4th July 2023 and entitled 'Building the Geothermal Energy Sector in Northern Ireland,' the workshop was co-organised and co-hosted by Queen's University Belfast with the Northern Ireland Housing Executive. It comprised multi-stakeholders, as well as keynote speakers, panel discussions, and question and answer sessions. Significantly, our workshop also marked the construction completion of the new Business School building at Riddel Hall, which, coincidentally has a geothermal heating system.

With 120 participants in attendance, our workshop aimed to provide practitioner-led project updates across the geoenergy nexuses. Richard Rodgers, Head of Energy and Deputy Secretary of the Department for the Economy opened our workshop, before keynote presentations by Dr Matt Trehwella, Chief Executive Officer, Kensa Group, and Sara Lynch, Head of Sustainability, Estates Directorate, Queen's University Belfast. The workshop activities overall generated a range of thoughtful conversations and discernible themes:

Theme 1 — More awareness of established geoenergy blueprint elsewhere in the United Kingdom and further afield. Kensa Heat Pumps Ltd demonstrated exemplary cases of geothermal and ground source heat pump (GSHP) applications from across the UK.

Theme 2 — Increase emphasis and overlap in both the quality and energy trilemma issues in the energy transition.

Theme 3 — Government subvention support, political engagement and big society conversations beyond the important strides made with the NI Energy Strategy Action Plan 2022, Heat Policy frameworks.

Theme 4 — Significant value co-creation and socialisation of costs by pivoting and collaboratively working across ecosystem nexuses. Integrated data fusion thinking between geology, front-end heating engineering and business models.

Theme 5 — Behavioural change among consumers will be an important component of the level of decarbonisation envisaged with retrofitting of homes, heat pump switching, heat demand optimisation, and heat network development.

Theme 6 — Leapfrog pathway development with general UK policy and the Energy Bill to close and progress the legislation gaps between the NI Utility Regulator and Ofgem. Also, increase the local Assembly or policy-makers' capacity to bring forward legislation commensurate with the other devolved UK governments.

Overall therefore, our main conclusion from the workshop is that sector-building efforts require the pivoting of the geoenergy nexuses towards multiple ecosystems. Developing the different geoenergy ecosystem perspectives and pivoting with the 10-point axis are additional key focus areas for sector-building and policy development.

Workshop Registration



Figure 2 - Workshop registration

1. Introducing the Workshop



Figure 3 - Workshop introduction, Mark Palmer, QUB

The workshop Chairs – Professor Mark Palmer (QUB) and Andrew Frew (NIHE) – welcomed participants to the workshop and outlined the agenda for the morning (see Figure 3). Professor Mark Palmer (QUB) noted that it was his pleasure to welcome everybody to Queen’s new Business School and to co-organise the workshop with the Northern Ireland Housing Executive (NIHE) on one of the most important topics today – the net zero transition to ensure a sustainable future. Mark reported that the initial plan was for only a small gathering of 15 or so persons, but that had snowballed quickly filling up the 120-seater Harvard-style room at Riddell Hall. Perhaps a lesson in striking the geoenery backcloth when the iron is hot? Mark indicated that there exists a strong local interest in all things geoenery – ground source heat pumps, thermal collector loops, geology, built environments, heat networks, thermal fabric, storage and recycling – and all with good reason. Geoenery can help

decarbonise our economy; deliver Sectoral Plans and Local Area Energy Plans on the ground; and spur Green Growth opportunities. While the location of the workshop at the new Business School afforded the opportunity to showcase the geothermal installation backcloth, the attendees could also see and hear about peers’ project successes, progresses and draw social comparisons.

Workshops are not unusual in the policy and business domains, yet most leave little or no visible trace behind. This report, then, traces out the workshop communications as a market organising activity (see Appendix 2 for the workshop itinerary)¹. In designing the workshop itinerary, we aimed to foreground practitioners’ voices and experiences, pivoting out and across multiple ecosystems in search of the energy nexuses (e.g. drilling, mechanical, electrical and plumbing operations, housing associations, and heat pump associations (GSHP), banks, legal, electricity grid, thermal-solar, Consumer Council, energy poverty associations, utilities etc.)². By way of a supplement to the practitioner conversations, interspersed throughout the report are vignettes – think boxes – from social science studies that amplify some of the discussion points with commentary and questions. Furthermore, this report also links in and builds on previous workshops by the authors before and after Northern Ireland Geothermal Energy Week in June 2022 on sector confidence-building measures, sector buildability scaffolding and collective vision-making practice with multi-stakeholder groups³. Notably, this geoenery workshop pivots from our proto Steering Wheel Vision for NI Geothermal Energy (see Appendix 3)⁴.

1 Orlikowski, W.J. Yates, J. (1994) Genre Repertoire: The Structuring of Communicative Practices in Organizations, *Administrative Science Quarterly*, 39, (4) p. 541-574.

2 In doing so, we follow Karen Barad’s stance in understanding sociomaterial to be an entanglement in ontological and onto-epistemological terms.

3 Palmer, M., Ireland, J., Ofterdinger, U., Zhang, M. (2022a), Net zero pathways: Building the geothermal energy sector in Northern Ireland. Department for the Economy. Technical Report, pp.1-137.

4 Palmer, M., Ireland, J., Ofterdinger, U., Zhang, M. (2022b). #NIgeothermalWeek: Defining the vision for geothermal energy in Northern Ireland. Department for the Economy. Technical Report, pp.1-54.



Figure 4 - Mr Andrew Frew, NIHE

Mr Andrew Frew, Technical Innovation Manager, from the Northern Ireland Housing Executive (NIHE), then outlined why geothermal solutions mattered for the Housing Executive's housing stock of 83,000 rented homes (see Figure 4). Andrew noted the scope of social and environmental impact opportunities to 'do good' with the NIHE housing portfolio, and the readiness of the NIHE to deploy a range of renewable technologies to decarbonise their built environment. Andrew noted a range of issues that the NIHE were working through, including Northern Ireland's reliance on oil heating burners, the challenges attributable to the distinct rural nature of its housing stock (e.g. the rural dwellings). Andrew also noted how the NIHE were presently seeking alternatives to using fossil fuel sources, with a focus more on integrated solutions. This approach includes; insulation cost abatement, 'fabric first' measures, considerations for fuel poverty, the affordability of heat pumps for their renters and the rural obligation. As Andrew explained, the Northern Ireland Housing Executive is interested in low carbon sources of heat and geothermal energy is a very interesting option under consideration,

"Fuel poverty has to be a concern for us and what we know is that if we put ground source heat pumps onto the grid, that has less of an impact than using lots of air source heat pumps, particularly at critical peak winter demand periods. That helps our underinvested grid and for our renters, that's less of a cost to go onto their electricity bills and therefore less of an impact on fuel poverty."



Figure 5 - Mr Richard Rodgers, DfE

Opening, Mr Richard Rodgers, Head of Energy and Deputy Secretary of the Department for the Economy (see Figure 5) drew upon the Belfast Energy Summit speech by his colleague, Ms. Jayne Brady, Head of the Northern Ireland Civil Service, and reiterated the importance of collaboratively working together to open the door to multiple renewable opportunities –

to open the nexuses between the energy ecosystems. In essence, collaborative approaches set the scene for the subsequent workshop conversations. Drawing on a resonant framework in the energy community – the energy trilemma⁵ – Richard Rodgers called for more actions on 'institutionally breaking down' the dependence on the import of fossil fuels in Northern Ireland to deliver inter-generational change through collaborative innovation, as he reminds us,

"The energy strategy landed in December 2021 and in one line it's self-sufficiency in affordable renewable energy. Self-sufficiency means we're going to stop importing fossil fuels. For almost 100 years and, more recently, over the past 30 or 40 years, energy policy has let us down because we've been a price taker, therefore we've been subject to the volatility of global cost shocks. Crucially, we need to be affordably heating our homes and our businesses that means breaking the link with global commodity prices of energy... The geothermal sector is in our hands. You are the innovators and collaboration is a challenge we must overcome to seize this golden opportunity to deliver inter-generational change."

Energy permeates all parts of the Northern Ireland 10X economy vision foci. Foregrounding the linkage of the energy transition with the 10X economy vision, Richard highlighted that geothermal energy transitions can bring;

- (i) innovation opportunities – harnessing our industrial and technological base,
- (ii) sustainability opportunities – harnessing the heat beneath our feet,
- (iii) inclusion opportunities – skilling up local population to bring about an affordable energy supply.

Richard concluded his address reaffirming the Department for the Economy's policy support and commitment with the geoenergy RD&D projects in transitioning the energy sources and vectors, reiterating that,

"We need to work collaboratively together to ensure a balance in the energy transition and that is challenging and requires leadership. Second, the government-funded geoenergy RD&D can provide a catalyst for informing evidence-based decision-making. Finally, there is a need for more urgency to deliver the Climate Change targets and the time for talking is over, solutions are needed."

The net zero-driven transition is redrawing the energy connections and 'crucibles of ecosystem relations' of energy boundaries, yet also drawing in resources and constraints. Balancing the physical energy systems and social ecosystems is seen to be a central consideration to the energy system transition. Collaboratively working together, as Richard Rodgers and Jayne Brady note, holds so much sway in this work not least because it ensures that any movements of adjoining systems parts and ecosystems are not stretched to the point of impairment and any focal strain pressures can be managed accordingly. That is not an easy task, as Think Box A below suggests.

⁵ The 'energy trilemma' is a framework of three objectives that energy policymakers need to balance, and which is often used as a guide in designing energy policy. The trilemma comprises: Sustainability: decarbonising energy. Security: ensuring the security and reliability of energy supplies. Affordability: minimising the cost of energy to consumers.

1.1 Think Box A

Think Box A: Working collaboratively together across the geoenergy nexus chasms

Social identity theory articulates and explains away, in part, why working together is challenging. Professor Clayton Alderfer showed the importance of physical and psychological boundaries to social identities. Clayton Alderfer noted that the permeability of boundaries, i.e., the ease with which they can be crossed, regulates transactions among groups. Boundary permeability is shaped by the compatibility of vested interests between groups of ecosystems (e.g. policy-makers, academia, environmental groups, engineers, geologists). When vested interests are compatible, boundaries between groups loosen, as members expand their ideas of who is inside the groups (i.e., who 'we' are). The perception of incompatible interests leads to relatively impermeable boundaries, as groups close off from perceived 'others'. Boundary permeability is also shaped by group differences in power dynamics and rent-seeking behaviours to control the market spoils.

Thinking outside the think box questions

What is the meaning of a nexus in the energy transition? In this context, we use the term nexus as a liminal connection, link or corridor between ecosystems⁶. Studies find an 'ecosystem churn' of complementors in and out of an ecosystem and so we know that entry and exits exist⁷. This nexus perspective is not only valid for thinking about how innovation happens, but also it is equally valid for developing sustainable business models through the socialisation of costs and benefits in geoenergy. Clayton Alderfer explains why the chasm of the nexus is difficult to cross. So why are we perfectly happy to stay nested within our own ecosystem? Is it simply a case of 'birds of a feather flock together?' Do you think your profession cleaves to ecosystem identities for security? When identities are threatened, do members return back to their core ecosystem? What makes someone travel the nexus? How do you pivot towards nexuses and enter other energy ecosystems?⁸

Source: Alderfer (1987)⁹

1.2 Workshop Organising Observations

A selection of the workshop observations are shown below.

Observation 1 – workshop organising as solution-finding

"... geothermal can provide low-temperature heat of approximately 20-30°C and fed into a pipeline heat system that connects individual homes or network clusters of buildings, with each building having its own heat pump to upgrade the heat to the required temperatures. NIHE manage over 83,000 homes and over 25-high rise flats across Northern Ireland, and we are considering many solutions to ensure that the energy transition is a just one for all of society."

Andrew Frew, Technical Innovation Manager, Northern Ireland Housing Executive

Observation 2 – workshop organising as socialisation

"We know from studies the value of temporary spatial clusters like this workshop insofar as they provide the 'social glue' for opening and renewing conversations, producing social comparisons and intensifying exchanges of information with presentations, question and answers (Q&A) panels on projects and project considerations. All of this activity helps in the socialisation of the technology and the conditions for ideation, network goals, projects, plans, opportunity-making as well as kick-starting reform."¹⁰

Professor Mark Palmer, Queen's University Belfast

Observation 3 - workshop organising as network-forming

"Within today's Energy Institute workshop we can gain insight into what others are doing, enlarge and maximise the common ground. It can also deepen our understanding about how renewable technologies can accelerate the energy transition. It can help to harmonise renewable technology within our institutional systems, energy systems and other technologies. It can also bring an understanding of what others are doing and to learn about those projects, even if they are at the consideration or aspiration stage."

Mark Welsh, Chair, Energy Institute, Northern Ireland Branch workshop. Riddell Hall, 28th June 2023

⁶ Throughout our report we draw attention to the plurality of nexus practice, acknowledging the energy system is systemic in nature with multiple ecosystems. This report alerts the reader to those important connective institutional corridors in market-making and market-shaping.

⁷ Boudreau, K. (2010) Open platform strategies and innovation: Granting access vs. devolving control, *Management Science*, 56(10), p. 1849-1872.

⁸ Didonet, S. Simmons, G. Diaz-Villavicencio, G., Palmer, M. (2016), "Market orientation's boundary-spanning role to support innovation in SMEs", *Journal of Small Business Management*, 54 (1), p. 216-233.

⁹ Alderfer, C. P. (1987). An intergroup perspective on group dynamics. In J. Lorsch (Ed.), *Handbook of organizational behavior*, Englewood Cliffs, NJ:Prentice-Hall. p. 190-222.

¹⁰ See 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.

Workshop Opening



Figure 6 - Workshop opening

2. Keynote Presentations



Figure 7 - Dr Matt Trewhella, Kensa Group, Key Note

This part of the morning comprised of two keynote speakers. Andrew Frew from the NIHE welcomed and introduced Dr Matt Trewhella, Chief Executive Officer of one of the most formidable firms in the geoenergy landscape – Kensa Group (see Figure 7). The Kensa Group comprises three companies;

- (i) ground source heat pump (GSHP) manufacturer,
- (ii) heat pump contracting installation of large scale domestic and non-domestic buildings, and
- (iii) Kensa Utilities, capital-enabling supplier of street-by-street heat networks infrastructures¹¹.

Presently, the Kensa Group are the leading manufacturer of ground source heat pumps (GSHPs) in the UK. Dr Trewhella informed us of his work with ongoing ground source heat pump installations, highlighting the affordability of geothermal energy as a heat resource in domestic and non-domestic built environments¹². In opening his presentation, Dr

Trewhella reminded us of the importance of finding perspective in a customer orientation,

“As much as you get caught up with the ground source heat pump engineering, or geology, or the business models with the subsidy and government policy and all of that design and money, there is nothing more pleasing for myself than when you walk into someone’s house and they say, ‘I was paying £60 per week, last week, and now I’m paying £30 per week, this week,’ because of what you’ve put in here. So you’ve got to bear that in mind the whole way through.”

A recurring theme from Dr Trewhella’s keynote was in the way that Kensa has established ‘how-to blueprint’ operating elsewhere in the UK market. That is, it is not a question of first-to-market mover blueprint, or waiting for a dominant geothermal blueprint to be completely established. As stated during the keynote presentation,

“...there is no need to reinvent the wheel in Northern Ireland. It is about realigning the wheel to your existing energy demands and transiting those against the existing blueprints. Benchmark with some of the GSHP schemes across the UK and learn from others organisations that have deployed, like Wirral Council or Enfield Council. Save your energy, the groundwork design templates are already there on the desk and can be shared.”

The keynote presentation outlined numerous built environment archetype project cases, examples of ground source heat pump (GSHP) installations, and geothermal energy designs which could be utilised in an array of built environments. Think Box B sheds some insights into the dominant blueprint phenomenon with technological discontinuities.

¹¹ Throughout this report we do not distinguish between these divisions but refer to said company as ‘Kensa’.

¹² Ground source heat pumps are also sometimes referred to as geothermal heat pumps and/or ground coupled pumps.

2.1 Think Box B

Think Box B: Technological discontinuities and the dominant design

Harvard University Professor Michael Tushman along with his colleagues Johann Murmann and Philip Anderson have provided several interrelated studies into how technological evolution happens through cycles. Technology cycles are composed of technological discontinuities that trigger periods of technological and competitive ferment. For practitioners, ‘reading the wind’ in terms of the timing and emergent nature of the dominant design or blueprint during these discontinuities is crucial for progression within the cycle. These periods end with the emergence of a sector or what some refer to a standard code or dominant design. The dominant design is assumed to be ‘selected’ in the sense that it is the only design that is able to survive the competition for resources. When there are fragmented designs, rarely do technology cycles push on. The emergence of a dominant design ushers in a period of incremental, as well as architectural, technological change and that, at some point, is broken by the next substitute design.

Thinking outside the think box questions

The Stormont and CAFRE RD&D projects hold genuine promise of supporting the geoenergy blueprint. At one stage of our careers, most of us

asked for a precedence or “just an example” of the previous application or plan. Having a blueprint is a commonplace human practice in markets that exist. But what happens if the blueprint does not exist (it is ab initio)? Not to put too fine a point on it, nothing much, or mistakes. Of course, there are merits in having ‘a blank slate’ - tabula rasa so to speak – with mistakes shaping, but that assumes that the blueprint for ‘the wheel’ does not exist elsewhere and there are no time constraints in this activity.

And what do you do when there are multiple blueprints and, moreover, if they are partial, unconnected and sometimes making competing points? Michael Tushman, among others, show how and why technology and also business model blueprints matter. Consider what blueprint(s) does your organisation need to accelerate your energy transition? Did you know that there exists Sectoral Plans or Local Area Energy Plan blueprints at the UK Catapult website that can support your energy transition?¹³ What technological discontinuity have you observed recently in your organisation or sector? Is the idea of an industry or sector always firmly rooted in a central product (e.g., the ‘VCR industry’ or the ‘PC industry’)? Consider also if such a blueprint can lead to a narrow view of the market – what Theodore Levitt referred to as market myopic practice. How do vested interests shape the technology cycling between exploratory work and the goal of market commercialisation?

Source: Tushman and Murmann (1998)^{14,15}

Kensa’s experiences provided a ‘show and tell’ flavour of the project examples from across the UK built environment. Each case project was presented in a range of geothermal heating scheme contexts, which had variations in size and design application depending on the heat load requirements and the configuration of geothermal and ground source heat pump (GSHP) applications. Dr Trehwella outlined a number of cases as social housing retrofit in Trent and Dover Housing, which comprised 5 sites around Burton-upon-Trent, and which had been undertaken between January and May 2015. This project comprised 133 properties and the drilling of 62 boreholes to 130 metres depth. This project was made financially possible through support from the non-domestic Renewable Heat Incentive Scheme (RHI). In that case, annual bill savings of £500-700 in 2015 were reported by residents.

One quite telling point had been the need to ‘shift spatial perceptions’ on geoenergy concerning

whether it can still be used effectively in urban areas with limited space. As exemplified by Kensa’s social housing initiative hi-rise flats located in north London and led by the Enfield Council, this project comprised a total of 8 tower blocks, with 402 flats and was undertaken over a 12-month period. Suitably, our Keynote Speaker explained that,

“...some try to say that there is not enough space for the geothermal boreholes, but when you get a bit creative in the design around the park green areas and car parks, there’s a lot of space for boreholes. Our Enfield Council project shows what is possible in a comparatively small area surrounding the high-rise flats...”

These examples are not unusual in the densely populous GB urban city environment. A further case in point shown in the project delivered by Kensa which included the tower blocks in Elland, Halifax and Blackburn. New Build Developments in Wilmott-Dixon and Bristol City Council comprising 133 new

¹³ <https://es.catapult.org.uk/tools-and-labs/local-area-energy-planning>

¹⁴ Tushman, M., & Murmann, J. (1998). Dominant designs, technology cycles, and organizational outcomes. *Research in Organizational Behavior*, 20, 231 – 266.

¹⁵ Anderson, P., & Tushman, M. (1997). Managing through cycles of technological change. In M. Tushman, & P. Anderson (Eds.), *Managing strategic innovation and change: a collection of readings* New York: Oxford University Press. (pp. 45 – 53).

properties developed between July 2019 and March 2022. This was enabled by planning policy, using Bristol City Council's heat hierarchy and an example of Shared Ground Array Projects.

Non-domestic buildings also formed a contrasting project case focus. Plymouth Marjon University was funded by Public Sector Decarbonisation Scheme (PSDS). This involved the drilling of 98 boreholes and 55 heat pumps across the campus. Community retrofit Heat the Streets at Stithians, and off-gas village in Cornwall was also highlighted as the world first deployment of boreholes in the public street. This included socially and privately owned properties being connected to the same network. Financially, property owners are required to pay a monthly fee for ground array access.

The different threads running through the presentation draw the same conclusion on the direction of travel – a phasing-out of oil and gas boilers, the emergence of alternative low to zero carbon solutions such as ground source and air source heat pump installations, along with retrofitting of thermal insulation, the collective scaling of heat networks and also thermal recycling. Notwithstanding the enormous amount of research effort and the many constraints to this transition, yet there are also windows of opportunity. The technology and its cycle is only part of the picture. Equally significant, business models are an important carrier as well as diffuser of practice. As noted in the Kensa keynote presentation,

“...this is a policy and business model challenge, not a geology one. We are starting to see the business model pivot beyond the public sector, for example the local councils. We've got a concept called 'heat the streets' where you put

the infrastructure in the street as a utility and then people can connect to it and pay a standard charge for access to that infrastructure. So rather than trying to persuade a street of 100 people, they can club together and buy by 100th of a ground array that they share. The utility supplier comes in and funds it, and then the customers just finance that over 40 years. The properties are connected up so the homeowner is now just paying a simple monthly fee for their heat.”

Whatever way you look at it, the replication blueprint is sought after and saves management having to design a new blueprint from a blank slate (i.e. ab initio). But this blueprint will require fine-tuning. The blueprint is typically conceived as the repeated 'doing' in the application of a simple formula or recipe. As Sidney Winter and Gabriel Szulanski accurately note,

“The formula is assumed to be known perfectly to the replicator and reproduced accurately each time that a replication occurs. The formula is thought to be the clever implementation of an insight into consumer needs, and it is anticipated that little effort will be required to replicate it or to maintain its operation. The formula or business model, far from being a quantum of information that is revealed in a flash, is typically a complex set of interdependent routines that is discovered, adjusted, and fine-tuned by 'doing.' Growth by replicating such a 'formula' requires the capability to recreate complex, imperfectly understood, and partly tacit productive processes in carefully selected sites, with different human resources every time, facing in many cases resistance from proud, locally autonomous agents. For this reason, replication requires effort, and naturally takes time.”¹⁶

Almost inevitably, this blueprint debate cycles around to the debate in Think Box C on the merits of the first-to-market or fast-followers. Here, urgency is a hallmark of the first-to-the-market point.

2.2 Think Box C

Think Box C: First-movers and fast-followers in the energy transition

The idea of the first-to-market or fast-followers has been a topic of much interest with books such as 'copycats' or 'fast second' revered and reviled in almost equal measure. The widespread use of the idioms, “the early bird gets the worm”, and, “the second mouse gets the cheese”, often cloud practitioner stances on this topic. This question, moreover, is often framed in bellicose terms – in other words as a winner and a loser. The academic evidence is more nuanced, however. Professors Constantinos Markides and Paul Geroski, along with other researchers have increasingly recognized that there are usually

at least two facets to this and that neither 'first mover' nor 'fast follower' are able to fully explain market domination, or the mechanisms behind market evolution and time needed for change to happen.¹⁷

Absolutist and binary thinking behind this question are misleading and thus must be qualified with an 'in part explanation.' In part, both can accrue rent-seeking benefits. Fast followers can benefit with minimising the energy and costs of the learning curve for project and technology design blueprints; mitigating against the risks of project failure; learning from the first to market mistakes; and appropriating and adding value to the existing design blueprints. But fast followers with a blueprint still need resources, infrastructure

¹⁶ Winter, S.G. and Szulanski, G. (2001) Replication as Strategy, *Organization Science*, 12 (6), p. 730-743.

¹⁷ Markides, C. Sosa, L. (2013), Pioneering and first mover advantages: the importance of business models, *Long range planning* 46 (4-5), 325-334.

and strong ties to adjoining ecosystems. First movers – and linked with the ideas of the ‘Blue Ocean’ strategy and institutional pioneers – can tie up patents and copy rights, set standards and the ‘rules of the game’, build strong alliances, create brand differentiation and visibility with opportunities for driving market share.¹⁸ The two schools of thought are perhaps less important than finding a holistic and evolutionary way of thinking about this question. Moving beyond this question, other research studies look at the question with a different angle: finding common characteristics, overlapping ecosystems, institutional lineages and family market-product influences¹⁹. For example, the related concept of ‘family tree’ is often used to illustrate the co-evolution of markets with the key idea market concepts often derive from earlier market concepts.

Thinking outside the think box questions

Why is it quite common to hear this ‘mover question’ at energy summits? Where do you sit on the first-to-market question? As is oft-said, “no fence sitting permitted, as one begets splinters sitting/resting on the fence(!)” Perhaps our industrial heritage can answer that question? You can definitely see the family tree pattern in our industrial past with the Belfast ship building nexuses overlapping with the linen fabric, which together, aligned with the farming nexus of flax – ‘our wee blue blossom’ – as well as the chemistry nexus in chlorine production for the cleaning of that linen. Do you agree that Northern Ireland can be a fast follower? Should we be framing this question with a different angle? Perhaps it is a question of how markets co-evolve collectively moving and adopting different first-mover, fast-follower, slow laggard stances?

Source: Geroksi and Markides (2004)²⁰

The second keynote presentation was delivered by Ms. Sara Lynch, Head of Sustainability, Estates Directorate, Queen’s University Belfast (see Figure 8). This keynote presentation provided an overview of the implementation of geothermal energy and ground source heat pump technology at Queen’s University’s new Business School building. The presentation didn’t stop there, though. Sara went into the wider University’s Net Zero strategy, linking it into the wider decarbonisation process and the pursuit of UN Sustainable Development Goals. The seemingly simple task of the net zero target is hard work, yet as Sara reminded us in her presentation, a reduction in carbon emissions is something that both “its staff and students want to see.” It is worthwhile restating this, the agency of staff and students matters. Downstream demand matters. The net zero side of things was illustrated across the university estates built environment, with BREEAM accreditation, the adoption of solar PV panels, water borewells, ground source heat pumps, along with a range of biodiversity and transport scheme measures. Sara explained that,

“...with our new Business School building, the jewel in the crown, so to speak, is the geothermal system, yet there is little visible pictures of that system to stand here and show.”

Aside from a small collector manifold cover in the green lawn for maintenance access purposes (see image of the central manifold in Figure 9), there is no visible trace of the 40 x 125 metre boreholes, or any visible evidence of the extensive 10km of collector pipework fitted that feeds the ground source heat pump system for the 6500 sq. metre building. The



Figure 8 - Ms Sara Lynch, QUB Estates, Keynote

high thermal conductivity is harnessed from within the Sherwood Sandstone formation which runs under large parts of Belfast and elsewhere across the province. Sara highlighted the role that the university could play in using the Riddel Hall building as a Living Lab. Living Labs are environments for involving users in innovation and developments in real-use and real time contexts (See Think Box D overleaf). Sara invited the attendees to bring forward any living lab data recommendations to the University so that the Riddel Hall project could aid with evaluation, determine value, organize information, knowledge and ideas relating to the geoenergy systems. The Riddel Hall living lab approach promises rich potential to strengthen the energy transition twin interconnected challenges. First, for building appropriate solutions to address greenhouse gas emissions challenges, and second, in scaling that model to other built environment facilities. A living lab, by implication, is established within a real-use context, and with a need for organisational absorption to ensure the building delivers on its goals. The living lab data collection could relate to, but is not limited to;

18 Palmer, M. Toral-Manson, I. Truong, Y. Lowe, F. (2022) Institutional pioneers and articulation work in digital platform infrastructure-building, *Journal of Business Research*, 142, p. 930-945.

19 Buisson, B. Silberzahn, P. (2010) Blue Ocean or fast-second innovation? A four-breakthrough model to explain successful market domination, *International Journal of Innovation Management* 14 (03):359-378.

20 Markides, C. Geroksi, P. (2004) Fast second: How smart companies bypass radical innovation to enter and dominate new markets, *Jossey Bass Inc.*

- Energy use kWh/yr covering the annualised heat demand over a calendar period.
- Fuel costs covering the electricity bill to run the ground source heat pumps.
- Opex covering the cost of maintaining the heat pumps including in-house maintenance training and third-party maintenance.
- Annualised capex covering the cost of replacing the ground source heat pump after its life and annualising it.
- Energy KPI or metrics covering energy efficiency and optimisation any kind of energy relevant processes.
- Building carbon footprint covering all life-cycle stages and operational GHG emissions.
- Maintenance team perceptions covering the views and opinions on the ease of maintenance.
- Staff and student user perceptions covering building real life usage.
- CO2 savings covering annualised data and opportunity costs savings.

We know that entrepreneurs and small firms are notoriously reluctant to ‘stump up’ for consultancy services and the production of any blueprint. Previously we outlined the four-principle guidance in relation to energy reform²¹ and from speaking with

the attendees we find that there is a rent-seeking norm that expects government subvention and grants²². Yet, universities can also help support small, medium-sized enterprises and public sector decision-making in the energy transition with the idea of the real-use living lab. During Sara’s presentation, she invited workshop attendees to bring forward data capture points to establish the living lab parameters,

“So we are really interested in collecting data points from the geothermal heated building here at Riddell Hall and sharing the findings with you in a living lab format way. If you have any suggestions, please let us know. Maybe if you can have a think about that and let us know, certainly we will be working with Mark Palmer and Joseph Ireland around when we get the carbon emission data from it.”



Figure 9 - Central manifold

2.3 Think Box D

Think Box D: Navigating institutional traps with real-use living labs

Professors Gautam Ahuja and Curba Lampert identify three organisational pathologies that inhibit the adoption of technology; (i) familiarity trap – favouring the familiar; (ii) the maturity trap – favouring the old technology; and (iii) the propinquity trap – favouring search for solutions near to existing solutions. Transitioning built environment GHG emissions requires considerable skill to navigate the ‘traps’, not least the impact on human and financial resources and the effect on institutional routines, processes and practices.

Absorptive capacity is found to be central here in this navigation process. Living labs can bring the ‘golden links’ needed to institutionally break down organisational pathologies: these links being: knowledge creation; knowledge

application; and knowledge storage and retrieval. In essence, the three ‘golden links’ are the primary conduits of knowledge which form the building blocks of an organisation’s absorptive capacity.

Thinking outside the think box questions

Everybody has fallen into a trap at some point, particularly the online just-click-here-baiting-variety. The institutional traps, as Professors Gautam Ahuja and Curba Lampert, outline chime with most of us. What other institutional traps have you found from your experience in the energy transition? Would you consider how particular trajectories or commonplace metrics can entrap (e.g., the market share)? Which parts of your organisation would you open up as a living lab? Does that question go to the kernel of human vulnerability?

Source: Ahuja and Lampert (2001)²³

²¹ Palmer, M., Ireland, J., Ofterdinger, U., Zhang, M. (2022a). Net zero pathways: Building the geothermal energy sector in Northern Ireland. Department for the Economy. Technical Report, pp.1-137.

²² This is an age-old policy question and remains a difficult task, particularly when faced with international comparisons (e.g., the Inflation Reduction Act in the US). Recent research suggests that the opportunity cost of seeking

²³ Ahuja, G. Lampert, C.M. (2001) Entrepreneurship in the Large Corporation: A Longitudinal Study of How Established Firms Create Breakthrough Inventions, Strategic Management Journal. 22(6-7). 521-543. grants is higher for

2.4 Q&A Session

The Q&A session shown in Figure 10 was led and moderated by Jamie Delargy (Enirgy) and Orla Hanna (DWF). Jamie Delargy started the panel off noting that geothermal has been the Cinderella of the renewable energy industry, while wind and solar have been sharing the limelight, so my question is has its time arrived, and is it going to the ball? Is it the answer to some of our carbon problems? What share of heat demand do you think it eventually could supply? What do you think? In answering this, Richard Rodgers quite tellingly stated that,

“...it was as much as anything a test of the business economics and also a test of the technical capacity. The litmus test is the cost and that is fundamentally important because in making any change to the energy system, we need to simultaneously keep a stable price for energy. The 40-year models that were talked about in the presentation earlier are really, really important because this is about a long-term regulated return. There are also examples from around the world of not-for-profit opportunities where communities get involved and it’s the development of community wealth. I think we can piece together the tapestry, but we need we need to get on and do things.”



Figure 10 – Introductory Q & A session

Orla Hanna (DWF) put two simple, yet incisive, questions to the panel – what do we need to do to kickstart things off? Who should take the lead in this progress? In response, Dr Matt Trehwella from Kensa confidently answered and suggested that strength of consumer appetite for ground source heat pump installation had been “really strong elsewhere in the UK.” He continued,

“We’ve just invested £42 million into growing the Kensa Group, so get ready. So in a Cinderellian sense, we’ve bought the frock and the shoes and we’re ready to go to the ball, but we’re not sure exactly when the ball is going to start yet. There is work to be done in terms of building national awareness.”

A further question was answered by Sara Lynch - What are the most challenging areas that you finding in your decarbonisation journey at Queen’s University? Sara

highlighted that there were a number of installation impediments including the price curve, not least,

“...the costs associated with installing a new heating system as a university, and also to invest more money in improving the insulation in our buildings and retrofitting our buildings. But one of the biggest challenges for us is the Scope 3 emissions in terms of decarbonising supply chains and travel and how far supply chain partners are prepared to go on the net zero journey with us?”

Sara emphasised the importance of the long-term view and succinctly captured this point,

“...somewhere like a university has that opportunity to think about the long-run whereas other people might not; private homes tend to think about those five year cycles. Most people ask, is geothermal the most expensive heating system? But actually when you model it over 40 years, it isn’t. It’s actually the cheapest. But what you’ve got to do is put all of that infrastructure in on day one. So you’ve bought your 100 years worth of energy supply in the first week, so capital costs, is higher, but you are taking a long term view.”

Questions during this panel drew attention to the deficiencies of “the energy legislation lagging behind” which suggested that Northern Ireland had “a lot of catching up to do” on the geoenergy transition in particular, and in the decarbonisation of the built environment more generally. Adopting a clear roadmap and bringing a ‘leapfrogging mindset’ could ensure that the legislation is ‘ready-at-the-door’ and ‘ready-to-go’ for the scrutiny of the Assembly, or Westminster, if necessary. As Orla Hanna (DWF) cogently put it (see Figure 11),

“As a finance lawyer by background, one of the one of the advantages of being the second mover is that we have good legislation in England and Wales with the Insolvency Act and the solvency order, we can potentially use that, copy that and follow a good lead, so that’s a positive.”

An additional question from the audience illustrated the interesting case of Edenderry Village, which had formed a community energy group and that activity had demonstrated interest in installing ground source heat pumps. Its lead – Dr Rónán Davison-Kernan – indicated that, **“at present there were no business case frameworks and sustainable business model and governance data readily available.”**

This point again reinforces the holistic approach needed to enable data fusion practice in day-to-day practice. The issue of governance is central to innovation,²⁴ and more in particular, to the development of distributed and microgenerational energy communities. Not to put too fine of point on this, it perhaps suggests that the Department for the Economy and the Centre for Advanced Sustainable Energy (CASE) must work closely together and level up the behavioural science practice in the energy

transition for decision-making support.²⁵ Like other universities, the Business School at Queen’s University is now the largest School and is thriving – and for good reason. Developing the business case for geoenergy merits more attention. During the Q&A, not surprisingly, there were calls for pivoting actions across the nexuses of regulatory frameworks and policy, heat pumps, built environment energy performance, heat networks, thermal storage, thermal recycling and various nexus interfaces with other renewable technologies such as thermal PV, wind and hydrogen energy sources and vectors. Think Box E provides a theoretical example of the likely effects of singular geoenergy nexus approach.



Figure 11 - Orla Hanna, DWF, Introductory Q&A

2.5 Think Box E

Think Box E:

If ...[geoenergy]...is only seen as ...the result can be

Strong geology R&D data capability	One-off project. Geoscience data survey knowledge creation, without market and/or business model knowledge fusion and application and insufficient technology market acceptance and general uptake practice.
An upstream activity	Downstream data deserts. Undermine cocreated solutions and the service dominant logic. Technology fixes which fail to meet downstream user, needs, commercialisation and may not be accepted in communities.
The province of subsurface specialism	Epistemic market myopia and a lack of involvement by other specialists and a lack of key knowledge. Unilateral-driven approach.
Building strong geoscience skills	Lop-sided supply without the market demand and need for skills. Skills gaps across the supply chain.
One ecosystem	Higher capital expenditure and higher operational expenditure costs. Gross fixed capital formation costs remain high. Financial cost abatement remains high. Limited socialisation of costs and benefits. Limited sustainable business models and innovation.
Frontier advances in deeper borewells and/or in sedimentary aquifer exploration	Academic projects for academic publication with insufficient technology cycling between exploration and exploitation/ commercialisation.

Thinking outside the think box questions

Consider the collective way that the social entrepreneurs, institutional entrepreneurs, policy entrepreneurs and market rent-seeking entrepreneurs and others, navigate the institutional traps. So how, then, can all institutional members pivot in harmony with a collective vision and the development of the

sector? Do all institutional members share the spoils? How can the RD&D project pivot beyond a specific member’s vested interest? How does the RD&D project shore up the institutional links between broader geoenergy vision, roadmap and pivot across energy nexuses?²⁶ Are those nexus links visible and in plain sight? If not, why not?

Source: Adapted from Tidd (2006)²⁷

²⁵ <https://www.case-research.net>

²⁶ Simmons, G. Palmer, M. and Troung, Y. (2013), Inscripting Value on Business Model Innovations: Insights into Projects focused on Disruptive Digital Innovations, *Industrial Marketing Management*. 42 (5). p. 744–754

²⁷ Tidd, J. (2006) A review of innovation models. University of Sussex. p.1-17.

Within the Northern Ireland context, geoenergy energy is comparatively under-developed or at a nascent market stage²⁸. Internationally, by contrast, geothermal energy has enjoyed some more traction – although that still remains comparatively small relative to other renewable technologies and fossil fuels – and there is an obvious upside capacity that could contribute significantly more to self-sufficient and sustainable energy systems. What is interesting from observing the international developments, there are more microgeneration energy policy frameworks emerging.²⁹ That is, the distributed energy sources for use at the level of individual buildings, or in small rural local communities. This might include, for example, the configuration of wind curtailment, thermal solar and thermal storage for distribution across a heat network, or the configuration of wind curtailment, hydrogen production at water and sewage treatment plants. But who is doing this in this energy market? Thinking about how to practically regulate such micro-energy zones would perhaps merit attention in respect to geoenergy and other renewable technologies. Compared to the traditional central electricity system (e.g., Kilroot power station), microgeneration can in many circumstances reduce carbon dioxide (CO₂) emissions when it replaces fossil fuels by renewable fuels, and also by increasing total efficiency through the combined configurations.

Internationally, we also observe how governments have been leading out on this activity. Indeed, the launch of the GeoEnergy NI RD&D project led by the NI Department for the Economy has the opportunity to enable the pivoting of geoenergy nexuses. This RD&D project is set to explore the potential of shallow and deep geothermal at the Stormont Estate and at the College of Agriculture, Food and Rural Enterprise, Greenmount Campus in Antrim³⁰. As indicated from the Edenderry Village project feedback at the workshop, data fusion between the governance, the built environment, the geology and the front-end heating engineering and business models is needed. In other words, pooling and integrating the data streams. Quite tellingly, the ‘show and tell’ experiential dimension will be critical whereby

consumers can actually ‘touch and feel’ the heat from radiators and express their emotions openly and cathartically in relation to the heat beneath their feet. The Energy Bill makes provision on a range or portfolio of energy production and security and the regulation of the energy market³¹. Attendees of the workshop were conscious of the dynamics of the Red Queen effect – that is, the notion that staying in the same place is still falling behind when change is the hallmark everywhere else³².

Tellingly, attendees posed the question, how do the Department for the Economy ensure Northern Ireland, is included within the Energy Bill provisions? Considerations of the leapfrog effects might include learning on the following issues;

- (i) Collective proximal effects between thermal fabric, heat pumps, built environments, geology, heat networks, thermal storage, thermal recycling and renewable technology system interfaces (see Figure 12).
- (ii) Optimisation practice from thermal dynamics, heat networks, heat pump regulation and policy based on the Stormont and CAFRE RD&Ds.
- (iii) Consumer protection, technical standards, network zoning locales and ‘step in/step out requirements’ from the Ofgem (England), the NI Utility Regulator and the Consumer Council experiences.



Figure 12 – Experiential heat experiences

28 Palmer, M., Ireland, J., Ofterdinger, U., Zhang, M. (2022a), Net zero pathways: Building the geothermal energy sector in Northern Ireland. Department for the Economy. Technical Report, pp.1-137.

29 <https://www.naruc.org>

30 <https://geoenergyni.org>

31 <https://bills.parliament.uk/bills/3311>

32 Barnett, W. P., Hansen, M. T. (1996). The Red Queen in Organizational Evolution. *Strategic Management Journal*, 17, pp: 139-157.

2.6 Think Box F

Think Box F: Leapfrogging practice and effects

Any progress on geoenergy market-building will require a Herculean effort. Yet all technology is dynamic. Professor Wanda Orlikowski at Sloan School of Management, Massachusetts Institute of Technology (and visiting professor at Cambridge University), notes that the nature of all technology exhibits ‘interpretive flexibility’, that is, it is open to much interpretation before any sense of ‘closure’ is possible. Technology cannot be assumed to be fixed, complete and that it has ‘won the race’ – it is always conditional because new materials are invented, different features added, functions fail and are corrected, new standards are set, users adapt it for new and different purposes. By virtue, the leapfrogging opportunity coexists. Professor Jim Watson and colleagues at Sussex University’s Energy Group provide an excellent review of leapfrogging practice in environments. This research distinguished three types:

- (i) leapfrogging work within overall development pathways.
- (ii) leapfrogging work within industrial development.
- (iii) leapfrogging work in the adoption and use of technologies.

His study covers four case studies that show technology and environmental leapfrogging. An important condition for successful leapfrogging is institutional absorptive capacity – i.e., the capacity to sense-make on technological capabilities, knowledge, and skills as well as supportive institutions.

The interesting conclusion drawn from reviewing the evidence in this report underlines

that key factors for success in leapfrogging are different in each case. It is therefore not possible to generalise on whole markets regarding leapfrogging to a large degree. This echoes the result of earlier studies of the ‘Asian tiger’ economies which concluded that there is no standard model of development or catching-up. Instead a country’s distinctive resources need to be taken into consideration, and trial-and-error learning needs to be accepted as part of leapfrogging strategies.

Thinking outside the think box reflections and questions

Do you agree that leapfrogging effects are the exception, not the rule? How is leapfrogging linked to first mover and fast follower approaches? Why did DVD leapfrog Blu-ray in the high-definition optical disc format race? Does leapfrogging only apply to technology or can it apply to business model leapfrogging in the commercialisation process?³³ What happens if projects in the market leapfrog the RD&D demonstrators? Why do policy-makers speak of certain locations as being more suitable for leapfrogging? Can you think of other examples of technology leap-frogging and what lessons can be drawn for the geoenergy transition?

Source: Watson and Sauter (2011)³⁴



Figure 13 - Image of Leapfrogging practice and effect

In as much as leapfrogging capacity can be improved, or perhaps situated in locations, an important consideration could be a leapfrogging institutional mechanism for ‘development pathways’ in legislation, regulation and policy across the UK devolved governments to ensure any gaps do not persist. This Q&A ended with the workshop participants calling for legislative gaps between the NI Utility Regulator and Ofgem to be closed (i.e., some have noted that this gap includes 15 pieces of

energy legislation) and also consideration in relation to how to increase the local Assembly capacity to bring forward legislation commensurate with devolved UK governments. That ‘increase imperative’ had been pragmatically reframed as an ‘institutional workaround’ given that the local Assembly is not sitting. The keynote Q&A concluded with both moderators thanking the keynote presenters for an interesting and vibrant discussion.

³³ 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), p.306-321.

³⁴ Watson, J. Sauter, R. (2011) Sustainable innovation through leapfrogging: A review of the evidence, *International Journal of Technology and Globalisation*, 5(3/4). P.170-189.

Introductory Q&A



Figure 13 - Introductory Q & A

3. Panel Discussions

In the next part of the morning, we organised the conversations around three panel discussions which comprised three themes;

- (i) project delivery updates.
- (ii) project consideration updates.
- (iii) project drilling, MEP and utilities updates.

3.1 Panel 1: Project Delivery Updates

The first panel comprised project updates and we heard from Dr David Connolly (Irish District Energy Association and District Heating), Dr Simon Todd (Causeway Energies), Riccardo Pasquali (Terra GeoServ Ltd.), Conor Lydon (Tetra Tech Inc), Bobbie Milligan (District Energy, Ramboll Consulting) and Dr Matt Trewhella (Chief Executive Officer, Kensa Group). The lively Q&A was led and moderated by Andy Frew (Northern Ireland Housing Executive) and Dr Aoife Braiden (Geological Survey Ireland) as shown in Figure 14.

During this panel discussion a number of interesting points were raised, for example the benefits of heat network scalability and their capacity to decarbonise



Figure 15 - Dr David Connolly, IDEA, Panel 1

the built environment and how heat networks can be linked to thermal recycling. The panel highlighted the example of South Dublin County Council's (SDCC) heat network project which involved thermal recycling of waste heat from the Amazon Web Services (AWS) data centre. The panel raised some interesting points about the governance of the heating network, which is owned by a not-for-profit energy company, trading as Heatworks. The project again illustrates the importance of collectively working together with multiple partners including Fortum, SDCC, AWS and Dublin-based Energy Agency, Codema³⁵. Commenting on this completed heat network project, Dr David Connolly insightfully remarked that (see Figure 15),

"...none of this is a technology issue. All of this is an implementation challenge. It's just about how you do it, how you fund it, how you get paid for it, how you derisk it. You need paperwork to put heat network pipes in the street, and no one has ever looked for the paperwork to put a heated water pipe in the street before. So that means there was new paper required and that of course creates headaches. So I think the challenge there wasn't so much the diggers and the trenches. It was the paperwork."



Figure 14 - Panel 1, Project delivery updates

³⁵ In the first phase, the approximately 1.5 kilometre long heating network will heat 32,800 m² of public buildings. In 2024, 133 apartments will be connected to the network. It is planned to connect more public buildings to heat network in the same and the following year, adding further economies of scale and scope.

“...the big energy source we have in Ireland is wind energy and we have more of it in winter. Do you know are people looking at storing some of that heat in the ground, perhaps multiplying it up with the heat pump first?”

Drilling cost factors were also raised and the compound cost effects of purchasing a heat pump, alongside drilling costs and electricity needed to drive the heat pump. Reflecting on how costs can be absorbed within geothermal Dr Simon Todd (Causeway Energies) provided an insight into the configurations and sector coupling required (see Figure 16),

“What we’ve been observing is that when you combine it with industrial scale heat pumps, it then starts to become a balancing act between the capital costs of drilling and the heat pumps and the operating costs of electricity within the heat pump system and that can be usefully optimised by maximising the use of electricity when it’s cheapest, like at night. And it can be maximised by things like on site generation, which is where solar thermal PV comes in, so that’s what we’re learning.”



Figure 16 - Dr. Simon Todd, Causeway Energies, Panel 1

“In addition to this, there’s an opportunity, for example, to recover summer heat that would be otherwise waste. Store underground and recover again in the winter and the modelling that we’ve done again as part of that CASE project suggests that the efficiencies are over 80% in terms of recovery. So a wonderful circular opportunity that makes the economics and the carbon footprint.”

Conor Lydon (Tetra Tech Inc.) drew upon his experience from the project underway at the Stormont estate and he indicated that more clarity on legislation is needed and cited the timescales for major planning applications which have to “run their course through the planning system”. Conor made some suggestions where lessons could be learned, and legislation effectively grafted from the mineral exploration sector as well as the groundwater abstraction sector. Both of those have permitted development rights here in Northern Ireland,

“...we’ve had some lessons learned on the project in terms of what legislation we need in the future, what policy we

need to try and help unlock the market. At the minute we are proposing to drill 5 boreholes within the Stormont estate to explore the potential. Within that system, there will be bore holes down to between 200 metre, 250 metres and 500 metre depths. So it will be categorised as sort of a shallow geothermal system, but we do need to seek planning permission for those boreholes and in order to adopt a level of flexibility as to where exactly those boreholes will be positioned. The route of a major planning application does take time.”

In terms of skill gaps, it was highlighted that there are experienced drillers available in Ireland, however, their skills lie within water type scenarios rather than boreholes. Therefore, the drilling sector needs to adapt to set up for the future. Reflecting on the turnkey design and build service for the geothermal collector side, Riccardo Pasquali, (Terra GeoServ Ltd.) provided a summary project update (Figure 17),

“Our current project pipeline, there is a lot of design, there’s a lot of feasibility work. There’s a lot of interest, particularly in public sector buildings such as hospitals, and the leisure centres. Projects are mostly shallow closed loop geothermal. The issue we see is not the energy demand analysis, or the heat loss calculations, or the installing the pipe work. It’s actually about the delivery process of the project to the client. So at the moment, we see two things. First, the driver is always the client because in any large construction project that I’m involved in, it’s always on a cost benefit analysis approach. It’s never on a sustainability approach, and that’s one of the big problems. Second, how does the delivery structure of the project work from the very early design phase to actually putting boots on the ground. By the time you get to boots on the ground, the hard work is already done because you’re in production mode.”

Additional questions from the floor raised concerns over the environmental impact under the ground from geothermal drilling and the design process, best practice guidelines and projection modelling to predict future underground temperatures over a 50-year period. In summary, pivoting work is needed across the energy nexuses (See Think Box G).



Figure 17 - Ric Pasquali, Terra Geoserv Ltd, Panel 1

3.2 Think Box G

Think Box G: Pivoting the geoenergy nexuses

Professors Yuliya Snihur (Toulouse Business School) and Bart Clarysse (Imperial College London) have illuminated how entrepreneurs rework their identity through pivoting when faced with unexpected events.

Pivoting, or the substantive transformation that new ventures undertake in search of competitive advantage has been identified as a possible key to success for ventures in nascent markets. The pivot is often attributable to the enterprise in the ‘jockeying’ of a nascent field, but also has been applied in other areas (e.g., environment pivots or policy pivots).

There are often good reasons for pivoting – it is shown in studies that it enables better competitive market positioning and scaling potential, helps rework initial ideas following the detection of new opportunities, allows for a new carbon footprint environmental stance to be taken, shift identities that are linked to traditional stances, or for survival. The question of identity foregrounded in Snihur and Clarysse’s research links back to Think Box A and how ‘loosening’ that identity is central to transitioning boundaries, working together and making change happen. Interestingly, their research shows that stakeholder constraints can give rise to diminishing returns from pivoting, particularly if there is a continuing identification with a lingering organisational identity that is misaligned with the updated business model. In other words, the remnants of identity can harm pivoting efforts.

Thinking outside the think box questions

There are many examples in the literature of pivoting practice relating to entrepreneurs,

although much less is known about how nascent markets pivot and the nexus mechanisms through which this happens. For example, the global PIVOT conference series launched in 2020 aims to pivot from hydrocarbons to geoenergy by building momentum and traction within the oil and gas industry for geothermal development³⁶. This suggests that the pivoting is not a uni-directional practice. The elephant in the room remains if, or when, the established oil and gas firms will pivot towards geoenergy.

Curiously, Google’s initial search engine was called ‘backrub’ and academic research has reported on how Google’s founding members attended the one-week-long anti-market Burning Man event – an event focused on community, art, self-expression, and self-reliance held annually – just before Google pivoted and rebranded³⁷. Yet pivoting is no easy task with most studies reporting on the tumultuous nature of this change. For example, in the energy transition, why is it difficult to pivot from a financial project assessment to one that where projects are also assessed on carbon reduction merit? Does InvestNI’s ‘green book’ on investment rules ignore the triple bottom line? What public sector limitations exist in decision-making? Perhaps it is a case of the non-obvious pivoting and finding the obvious or vice versa?

Source: Watson and Sauter (2011)³⁸



Figure 18 - Image of the Burning Man Event, Black Rock Desert, Pershing County, Nevada

The central theme emerging from this panel was that geothermal energy is more than simply one source or one vector – it is as series of thermal nexuses across multiple sources and vector geographies. It is, moreover, configured across different well depths (i.e. horizontal and vertical, shallow and deep), and can be coupled with different hydro sources (i.e. aquifers, rivers, surface and waste water), thermal storage and thermal recycling (e.g. waste water or waste heat from

waste incinerators). This is geoenergy. The geoenergy system is systemic in nature, which means that commercialising part involves changing, adapting and co-specialising multiple assets to align them. Considering geothermal in a narrow nexus way can result in market myopia³⁹ and stifle the emergence of viable business models. This panel concluded with both moderators thanking the panellists for an interesting and vibrant discussion.

36 <https://www.texasgeo.org/pivot-conference>

37 Kozinets, R.V. (2002) Can Consumers Escape the Market? Emancipatory Illuminations from Burning Man, *Journal of Consumer Research*, Vol. 29, (1), p. 20-38.

38 Snihur, Y. Clarysse, B. (2022), Sowing the Seeds of Failure: Organizational Identity Dynamics in New Venture Pivoting, *Journal of Business Venturing*, 37(1). Online first.

39 https://en.wikipedia.org/wiki/Theodore_Levitt

3.3 Panel 2: Project Consideration Updates

The second panel comprised project considerations and we heard from George McCracken (Belfast Trust), Bob Barbour (Smart Grid Ireland), Robert Clements (Northern Ireland Housing Executive), Debbie Caldwell (Climate Commissioner, Belfast City Council), Terry Waugh (Action Renewables) and Peter McClenaghan (Consumer Council). The Q&A was led and moderated by Dr Marie Cowan (Geological Survey Northern Ireland) and Sara Lynch (Queen's University Belfast) as shown in Figure 19.

The second panel involved a discussion of project consideration updates. Following an introduction by Dr Marie Cowan (GSNI), George McCracken, Head of the Estates and Environment at the Belfast Trust indicated that he had been “dabbling with geothermal on various fronts for many years now” – but is presently looking at taking the new adult in-patient mental health unit based at the Belfast City Hospital site onto geothermal energy. Reflecting on the role of ecosystem nexuses in terms of the parallel work between sources, vectors and retrofit work within a hospital setting, George quite tellingly noted that,

“... we can't afford to pay for the health service we all demand at the minute and require. And any money that can be saved from energy efficiency and new sources can be put back into the system to improve healthcare is always a big advantage. Belfast Trust are probably the biggest carbon emissions polluter in Belfast. The Belfast Trust's gas and electricity bill last year I think was £44 million. There has to be parallel work ongoing with your energy source work. So if you have a new energy source for buildings, you will need to be thinking about a fabric first approach as well. If your buildings are old and aren't efficient, then you're just pumping more energy into an inefficient building. So it's about thermal fabric and everything else follows. We've done a scheme in the Matter Hospital and with Building Management System analytics we estimate that it'll take up to 20 percent off the gas bill just by simply adjusting our BMS strategy.”

Reflecting on his experience, George suggested that, more often than not, architects were not always the best placed to start eliciting advice, as the following excerpt indicates,

“Of course we need the architect, but it's not always the best person to talk to. You need to talk to the guy who's going to build the building because that's where the experience is. And if anybody's thinking of the project to look at people who actually who drill the holes, who know what's going to happen, who have actually completed projects of this nature. So tapping into that experience, construction related experience, drilling related experience, I would say is an absolute must as well as your design experience

and moving forward and we have to deliver for health and social care in Belfast.”

Bob Barber, the Secretariat for Smart Grid Ireland, which is part of the Centre for Competitiveness, succinctly highlighted another important nexus-ecosystem consideration – the electricity grid, while attending to the related behavioural, environmental and policy considerations,

“Technology is not the answer, of course, for everything. There's the whole issue of the behaviours, culture, the environment and policy. And sometimes we tend to work with these in separate silos.”



Figure 19 – Panel 2, Project Consideration Updates

There is more than meets the eye with this point. Bob draws attention to the fact that whenever emergent technologies are discussed, there is a tendency to foreground the technical aspects (i.e., the engineer heuristic bias). The question of ‘what works’ is sometimes drowned out by those enamoured by ‘the technology fix’ solution⁴⁰. Not far from this conversational point is the issue of ‘silo working’ which, again, resonates with the broader theme of pivoting towards the nexuses of ecosystems. From the perspective of the grid, Bob asked how geoenergy could fit and bring synergies for local microgeneration grids? Another panel member, Robert Clements from the Northern Ireland Housing Executive (NIHE) shared some of the in-progress project work (see Figure 20). Pivoting from the NIHE Sustainable Development Strategy launched in November 2022, a road map had been articulated for the Housing Executive to achieve net zero by 2050 and to have substantial improvement by 2030. In that



Figure 20 – Robert Clements, NIHE, Panel 2

⁴⁰ This approach stems from physicist Professor Alvin M Weinberg, who in a book entitled Reflections on Big Science in 1967, made the case for technology's potential to offer cheap and effective solutions to problems ranging from population growth, poverty, energy needs and water shortages. This became known as the ‘technology fix’ approach.

respect, Robert mentioned that the NIHE is presently looking at doing a geoenergy demonstrator pilot and is also undertaking a scoping study with the multi-agency Strategic Advisory Board (SAB). Noting that social, economic and environmental considerations all need to be taken into account as we move forward, Robert expanded on this salient point,

“Decarbonisation practice is not just a cost-benefit analysis equation. We need to look at the social and environmental. And economic is part of it. I do believe carbon will be a currency in the future and we are looking at that and heat with a 40-year capital expenditure outlay with heat pumps switching, heat demand and optimisation, joining heat networks and retrofitting of homes.”

Reflecting on NIHE’s significant estate of housing stock and the management of cohort of engineers, mechanical, electrical, plumbing, Robert further pointed to the ‘skills challenges’ in the energy transition,

“Skills are one of our amber, red areas. We have done a certain amount of retrofitting with the RDF funding to develop extra capacity rotation. Our plan for future retrofitting (which aim to deliver at scale from 2026) involves (i) a whole house retrofit, (ii) low carbon heating, (iii) education, tower change and adding renewables capacity to the housing stock such as thermal storage and PV. But all of that requires the skill set of people. So again, our view is that we need to provide surety to the market and to provide clear contracts to allow the construction industry to generate and build up capacity for this transition. We’re also looking with the SAB to try and deliver a centre of excellence to work with all our ecosystems. In this project, we are sharing knowledge with our tenants, staff and contractors on what retrofitting means, how it involves changing heat sources and what that heat looks like in their house. Our plan is to put in up to 5000 heating systems per year, year on year from 2026 onwards.”

Debbie Caldwell, Climate Commissioner, Belfast City Council, outlined the in-progress project work on Belfast City’s Local Energy Area Planning (LAEP), which modelled the energy demands for housing, transport and energy networks in order to improve investment into decarbonisation projects across the city (see Figure 21). Debbie succinctly explained,



Figure 21 – Robert Clements, NIHE, Panel 2

...one project is at the citywide level. The LAEP models the whole energy system for Belfast across buildings, the transport system and the energy distribution network. We want to use that information to shape investments into decarbonisation pathways over the next few years. So it’s a collaborative process and we’re at the point now where we’ve modelled the energy system. We’ve represented the energy system, and we are at the stage now where we’re running scenarios and each scenario (Catapult are helping us). We’re running four different scenarios and one of the scenarios is capturing geothermal and Catapult built that into their model. The second project under consideration is the potential for a district heat network in the city centre and we are really keen to tap in to the waste sources of heat, but also looking at perhaps seasonal geothermal storage as being part of that heat network...”

Behavioural change among the institutional ecosystems will be an important component of the level of decarbonisation envisaged. Therefore, Peter McClenaghan from Consumer Council (see Figure 22) brought a consumer protection side to the fore, reflecting the significant agency of consumers in the energy transition. Peter outlined that the Consumer Council is the statutory consumer body for Northern Ireland with a focus on decarbonisation and also a focus on the cost of living – fuel poverty – issues such as energy, water and transport. Peter noted,



Figure 22 – Debbie Caldwell, BCC, Panel 2

“...we’re tasked with doing five main remits on behalf of consumers. We’re tasked to educate and empower consumers. We’re tasked to protect consumers in the existing energy landscape in relation to complaints against unfair charges. We’re also tasked to understand consumers and then advocate on behalf of those consumers and those two last things are really key for what we’re talking about today.”

Indeed Peter quite tellingly noted the importance of sampling and tracking local consumer attitudes and experiences of fuel poverty and the potential that decarbonisation strategies could have upon consumers. Reporting that the Consumer Council published its first ‘Attitudes to the energy transition’ report which tracks consumer attitudes towards the energy transition annually⁴¹. Drawing on key insights from that first-of-its-kind report, Peter informed us that,

⁴¹ <https://www.consumerCouncil.org.uk/sites/default/files/202306/Attitudes%20to%20the%20Energy%20Transition.pdf>

“...people are broadly on board with the energy transition and that’s a really good thing. But people are nervous. And when you dig down into those research findings, it’s because they don’t have enough information. Consumers are looking for direction and particularly in relation to heat networks, what we find is that less than 20 percent of people actually say that they understand or have any good awareness of low carbon heating technologies. So we’ve a long way to go to bring the average person on the street up to speed with this.”

This baseline 20 percent awareness finding is quite revealing for those seeking to build awareness and shift behaviours. The annual report can be a useful dashboard barometer of market attitudes towards geoenergy. A further panel perspective was derived from Terry Waugh from Action Renewables. Reconnecting with the geoenergy nexus, Terry informed us of the historical linkage with Action Renewables and geoenergy. Reflecting on the registered charity and a not-for-profit status of Action Renewables, he posed the question –

“...why did they set us up? They set us up to go out and tell people about renewables. So one of the first pieces of work that the Department asked us to produce was a report into the potential for shallow geothermal in Northern Ireland in 2003.”

Terry then reminded us of the two key recommendations from his report,

“The first one was the promotion of the significant potential for development of shallow geothermal energy resources in private offices, utilities, industrial agricultural enterprises for both heating and cooling. Secondly, carry out information campaigns with architects and other building design representatives in influential positions.”

Moving swiftly on – before any quibbles about delays, gaps or oversights cross your mind – pivoting towards the nexuses invariably means reopening old conversations (perhaps also scripts and reminiscing about 400-strong Stormont Hotel events) of yesteryear in order to look forward and align with the present energy transition and market pivoting. Indeed, Dr Trewhella at Kensa pointed out that consumers would require protection and need to be able to trust the geoenergy technologies, the suppliers and operators, the installers and also have a complaint mechanism in place. Dr Trewhella hinted that the nascent geoenergy market is pivoting,

“More recently, over the last five or six years, Kensa Heat Pumps have been working with large, non-domestic buildings. Until that, social housing in retrofit has been ‘our bread and butter’ since 2013, but more and more the installations are new build housing. Unbelievably, new build housing installation in the UK is still dominated by natural gas but gradually low carbon heating is starting to pick up. And from 2025, you are not allowed to be able to put a fossil fuel heating in new build in the UK or in England, Wales, and in Scotland.”

3.4 Think Box H

Think Box H: Ecosystem leadership

Professor Nicolai Foss at Copenhagen Business School, Denmark, and his colleagues, provide insights on building ecosystem leadership. The term ecosystem featured prominently in policy quarters more recently because firms such as Apple have become ‘bellwethers’ and their ability to successfully develop, orchestrate, and manage ecosystems for value creation and value capture⁴². Ecosystem changes are systemic in nature. As such, ecosystems are often beset by problems of both coordination (i.e., who should do what, when, in which quantities, etc.) and cooperation (i.e., how are actors motivated to engage in (coordinated) innovative efforts?). One remedy is ecosystem leadership and that includes;

Collective shared vision-making - on boarding. The emergence of an ecosystem is facilitated when the relevant set of ecosystem participants shares a sufficiently common view or shared vision about the ecosystem, which prompts them to embark on the joint

effort of creating the ecosystem. A shared vision serves as a coordinating device by which the different ecosystem participants match their complementary investment plans⁴³.

Commitments to the joint ecosystem effort.

Members need to subjugate themselves to mutually agreed upon rules and standards, which include agreements about the blueprint, and the technical interfaces that ensure compatibility among components provided by different ecosystem members, or the specific requirements concerning quality or features imposed on organisations and agreed-upon measurements.

Step-in/step-out governance. In order for the ecosystem to be able to be agile and adapt to unforeseen events, a continuing ‘adder’ governance mechanism is needed in the coordination of joint problem-solving activities. This can be facilitated by the existence of relational governance mechanisms (e.g., oversight committees, workshops), ecosystem-wide standards of communication as well as standard procedures and problem-solving routines among members within the ecosystem.

⁴² Adner (2017) defined an ecosystem as groups of (mostly) legally independent but interdependent economic actors that invest in complementary and possibly ecosystem-specific assets and abide by mutually agreed-upon rules and agreements necessary for an innovative joint value proposition to materialize. See Adner, R. (2017) Ecosystem as Structure: An Actionable Construct for Strategy, *Journal of Management*, 43 (1). p. 39-58.

⁴³ This vision may be course and subject to change (i.e., what some call a provotision).

Thinking outside the think box questions

When idealism of collective vision-making meets the pragmatism of the vested interest, there is always a question mark over whether ‘a rising tide lifts all boats.’ Professor Nicolai Foss outlines leadership within one ecosystem. What is the nexus leadership required in the connection between the geogeneity ecosystems?

Working together with a collective vision, harness commitment and ensure circular governance requires an agile mindset with ‘step in, step out’ governance mechanisms. For example, panellists called for a comprehensive home energy retrofit scheme, but how would a retrofit ecosystem link or connect with heat pump ecosystems?

Source: Foss, Schmidt and Teece (2023)⁴⁴

Echoing Robert Clements at the NIHE, Debbie Caldwell from Belfast City Council adamantly claimed that “we must send market signals.” Adding to this excellent point, one clear signal needed is the structure of the regulatory framework, as Dr Trehwella of Kensa put it,

“...the consumer protection piece is a lot lighter with the ambient networked heat pumps approach and we still

welcome it actually. It could be an enabler, if it’s done right. So for instance, it took us something like 11 months to get permission to put those boreholes in the street at Stithians in Cornwall. Whereas a gas company could have just walked up and done it. So in regulation terms, yes, you’re regulating the returns. You’re regulating the way people can be charged, but also you’re giving powers and permissions to speed up the whole thing.”

3.5 Think Box I

Think Box I: Mirrors, signals and the isomorphic manoeuvres

Both Debbie Caldwell (Belfast City Council) and Robert Clements (NIHE) spoke of the need to send clear market signals and surety to the market and also to all their colleagues as well in education in terms of what they are planning on doing and when then are planning on doing this work. An insight into pivoting nexus phenomenon is the way that members of ecosystems relate to one another through language mirroring, signalling and isomorphic manoeuvres – the mirrors, signal and manoeuvre practice. The tale of Baron de Rothschild provides a glimpse into the different types of signalling within the ‘old world’ institutional environments. In response to a petitioner’s request for a loan, he reputedly replied: “I won’t give you a loan myself; but I will walk arm-in-arm with you across the floor of the [London] Stock Exchange, and you soon shall have willing lenders to spare.” But there is a growing number of studies showing that ‘the old’ and ‘new worlds’ are not as far apart as some would make out and try to make us believe (e.g., claims to arms-length agencies, or the digital world). Research studies provide some further insights

into this isomorphic phenomenon⁴⁵, with work by Dr Jeremy Cole finding that on word adoption in an analysis of the Reddit communities, the majority of new words are created/first adopted in larger communities. Such practice can be seen as an interactive form of ‘stepping-in-out’ isomorphic language and this can take the form of appropriation, association and importation.

(i) Appropriation of vocabularies.

Members in the socialisation process embrace appropriation, adopting similar words and sometimes appropriating those words, turns of phrases, or visuals.

(ii) Association between local, national and international agendas. Members shift between institutional settings to escalate their local context agenda, switching back and forth between the non-local and the local, the social and the economic, emphasising sometimes the past and sometimes the present.

(iii) Importation of multiple ‘outsider’ vocabularies. Members import vocabularies when ‘entering’ and immediate social field to gain external validity. That might transmit and signal across academia and government or be imported from the business media via prose and ‘sound bites’.

⁴⁴ Foss, N. J., Schmidt, J., & Teece, D. J. (2023). Ecosystem Leadership as a Dynamic Capability. *Long Range Planning*, 56(1). Online first, no page numbers designated, as yet.

⁴⁵ 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. p.214–225.

Thinking outside the think box questions

There are over 200 species of Old World lizards chameleons or chameleons in the world. They are extremely adept at fitting into new environments. They pivot quickly based on the environment

conditions. Is chameleon-like behaviour necessary for transitioning across the energy ecosystems? How do members of institutions do this when crossing energy ecosystems?

Source: Palmer, Simmons and Mason (2014)⁴⁶

The questions around the capital funding of the energy infrastructure in terms of heat network supplier and the heat network operations, operators, remained an area of moot debate (e.g. the question of who's responsible), and discussion at the workshop, with different management governance considerations. Dr Trehwella of Kensa outlined his company's stance towards the issue,

“Who manages the heat network? In theory, it could be anybody. It could be the community group themselves, it could be local council authority, a water utility such as NI Water, or it could be privately financed, or combinations. So we've set up an arm of Kensa Group called Kensa Utilities. That is to fund, own and operate the heat network when those other sources aren't available to do this. So we now can get financed from Legal and General and from Octopus Energy through Kensa Utilities to pay for the infrastructural networks. The cost of capital is a little bit too high in some projects. So if there's another way of getting it, then definitely look at that. For instance, local council authorities can do more on borrowing and that's the way we see this evolving.”

Debbie Caldwell, Climate Commissioner, Belfast City Council, highlighted the need to support the development of business models and consider the need for funding or other support mechanisms. Capturing the essence of the need for balanced data, Debbie noted,

“I do think it's not the technology that is the challenging part. I do think it's really the business model and the financial structuring. The question of the business model determining how viable the projects are, and that's what we're looking into at the moment. And, then, finally just to say we have a new building - the Belfast stories building - and we're hoping that will be an exemplar net zero building.”

A recurring workshop theme, no less. It seems that to make low carbon geoenergy heat more attractive to consumers, the business model engine is needed as the market growth driver. The business model driver could explore, among other things, types (e.g. heat-as-a-service, pay-as-you-save models, heat meters, and so on), roles (e.g. local government as energy providers, alongside traditional providers, heat network operators, heat network suppliers, heat-metering services, thermal storage providers), systems (e.g. circular models of thermal recycling and waste water providers), tools (e.g. digital tools,

AI and brokering matching services) and governance structure and mechanisms (e.g. community, private, public, private-public).

Reflecting more on the changes and progress made so far in Belfast City Council projects, Debbie pointed to the importance of having a pipeline of projects in place with a LAEP. The LAEP's value and importance can be seen in the granular spatial data-driven road map for the city and that which actually could underpin a series of business cases, not only for Belfast City Council to invest in, but for other private investors across the city as well. Debbie informed us that one of the issues had been capital investment, as the following excerpt suggests,

“Certainly the conversations we've had indicate that there is a lot of appetite out there from investors and that the money is there. We've had some really good conversations with the UK Infrastructure Bank and the Municipal Bonds Agency. And they're very willing and able to invest to City Councils, but in Northern Ireland because of the kind of structure of Councils versus Central Government we are not a Transport Authority or a Housing Authority.”

Trust, according to Peter McClenaghan from Consumer Council, strongly resonated with the reported consumers' attitudes towards the energy transition, particularly in respect to stepping into and stepping across the various energy nexuses of the energy ecosystems. A tangible commitment on the part of those working in and between the geoenergy ecosystems,

“Consumers seek protection in relation to the energy transition and what they mean by that is they want to be able to trust the technologies they've been asked to take on. Consumers want to be able to trust the installers and know that the installers are registered. Consumers want to be sure that installers have the skill-set that's required. Consumers want to be able to have trusted finance sources and consumers also want to have someone to complain to if it all goes wrong. And there's a big job here to undertake regulation that both enables the industry to grow, but also provides consumer protection and having early conversations with the regulator about that, particularly in relation to heat pumps and heat networks.”

This panel concluded with both moderators thanking the panellists for an interesting and vibrant discussion.

3.6 Panel 3: Project Drilling, MEP and Utilities

The third and final panel of the morning comprised drilling, mechanical, electrical, plumbing (MEP) and utilities (see Figure 23). We heard from Riccardo Pasquali, VC of GAI and CEO, Terra GeoServ Ltd, Paddy McGuinness, CEO, Colloide Ltd, Karl Farrow, CEO, CeraPhi Energy Ltd, Connel McMullan, CEO, Alternative Heat Ltd and Jeff Meehan, CEO, Meehan Drilling Ltd and Dr Matt Trehwella of Kensa Group. The Q&A was led and moderated by Dr Simon Todd (Causeway Energies) and Joseph Ireland (Queen's University Belfast).

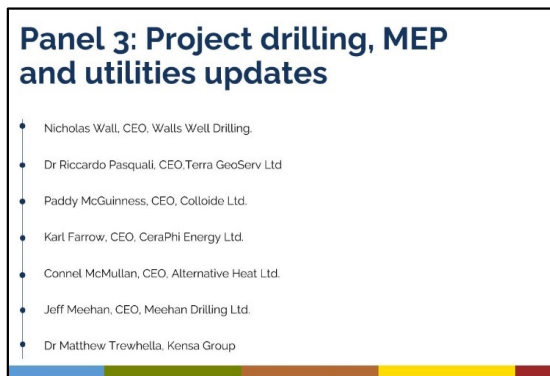


Figure 23 - Panel 3 members

In this panel, conversations centred on costs, innovation and continuous improvement and in developing the competitiveness of geenergy projects. The panel conversations highlighted that a spectrum of stances existed on targeting the cost of capital hurdle rates. That spectrum of views ranged in the following ways:

- (i) Power of practice (e.g., replication cost reduction strategy, economies of scale and scope).
- (ii) Number of rigs and driller surety on the 'gross fixed capital formation' point on the drilling rig machinery (e.g., amount of and visibility in project work).
- (iii) Socialisation of cost of equipment (e.g., the socialised portion of the total costs of production, sharing rigs and other equipment).
- (iv) Socialisation of cost of project (e.g., the socialised portion of the total costs of production such as ground loop, thermal storage, thermal recycling).
- (v) Subventions and grants to kickstart economic activity and human skills (e.g., government incentives)⁴⁷.
- (vi) Abatement project costs (e.g., removing negative byproducts created during projects).
- (vii) Hybrid technological solutions (e.g., propinquity search for cost reduction solutions near to existing solutions, leveraging curtailment and microgeneration grids).
- (viii) Chemical innovation, thermal dynamics and technological advancements (i.e., the refrigerant).

The spectrum of cost conversations perhaps reflects the systemic nature of energy ecosystems. For example, the costs associated with the heat pumps are not necessarily a standalone household cost. This is extensively outlined elsewhere, but includes for example the characteristics of the built environment which is shown to impact operational costs⁴⁸. There is generally one heat pump per building required for both ASHP and GSHP technologies. But for ground source heat pumps (GSHP), the ground loop can be shared between buildings. The economies of scale from shared ground loop represent a capital cost reduction as well as mitigating operational costs of the Seasonal Performance Factor (SPF) with the grid peak demands, particularly if coupled with thermal storage. A further noteworthy cost issue on this panel discussion concerned the behavioural change need among consumers – the so-called cost of abatement issue. Most homes in Northern Ireland use fossil fuel burners, with the gas networks comparatively newly installed. The rural nature of the dwellings in the province poses a significant cost challenge.

Bringing the conversation back onto drilling costs, Dr Simon Todd (Causeway Energies) invited the panellists to suggest possible solutions to this drilling issue (see Figure 24). The promise of the power of practice was highlighted in terms of replication of the drilling rigs working on the ground and operating routinely 365 days a year enables a learning curve. The panels discussed some ideas on what needs to happen here on the island of Ireland to get that learning curve going. The promise of successful replication does not inhere in all, as Jeff Meehan, CEO, Meehan Drilling Ltd, pointed out,

“...to try and drive down the costs, I think its purely down to repetitiveness, drilling more holes. But, it comes back to no projects, no industry, no market. So how do we kick start that?”

Karl Farrow, CeraPhi Energy Ltd added that,

“...we need to get large manufacturers to start investing more in this area. They can sell steam turbines all day long, so getting the GE Mitsubishi to turn their attention to this problem. They can bring scale and another dimension.”



Figure 24 - Dr Simon Todd, Causeway Energies, Panel 3

⁴⁷ Gustafsson, A. Tingvall. P.G.Halvarsson, D. (2020) Subsidy Entrepreneurs: an Inquiry into Firms Seeking Public Grants, 20, p. 439–478.

⁴⁸ See the work of Professor Neil Hewitt at Ulster University. To cite a couple of moderator cost; the size of existing radiators and pipework, or the age or heritage status of the building.

Local circumstances may also account for drilling costs (see local example of drilling operations at the new Business School project, QUB in Figure 25).



Figure 25 – Drilling operations at the new Business School

There is more to replication than meets the eye, however. Targeting the heterogeneity corollary follows this replication strategy. Replication leveraging spreads the idiosyncratic resources thin across different locations and each location may bring new demands (e.g., heterogeneity of geology, built environment dynamics etc.). Local factors affect the viability of options including, heritage status, heat demand, dwelling type, proximity to thermal recycling, noise and space constraints and so on. Dr Trewhella of Kensa echoed Jeff Meehan's point (see example Kensa drilling project in Figure 26), drawing

in more economies of scale as well as economies of scope issues and stating that,

“About 60 percent of our bore holes are drilled by one company and that firm is based in County Durham. I've seen them on site from Devon to Scotland and every time they turn up there, the first week or so it's a bit slow and then by the third week they've probably gone through four different drill bits before they've found the perfect one for that geology. Then, they really speed up and they're running at twice the efficiency by the time they get through week three of the project. And when you are only travelling 10 miles to the drill location because there's so many projects going on all over the country, then you're not adding on all the travel and accommodation costs. The whole cost of financing comes down because your rigs are running better.”

Example – New Build Development
Wilmott-Dixon & Bristol City Council

- 133 new properties – 2, 3 and 4 beds
- 16 shared arrays
- 2-4 boreholes of 177m deep per array
- Each array serves 4-9 properties
- Constructed July 2019 – March 2022
- Enabled by planning policy – using Bristol City Council's heat hierarchy



Kensa Group
National Geothermal Energy

Figure 26 - Example of Kensa drilling project

3.7 Think Box J

Think Box J: **The power law of practice and 'quick wins'**

Professor Nick Chater (Warwick Business School) report for the Climate Change Committee provides an insight into the pivoting nexus phenomenon. Specifically he outlines the 'power law of practice' which governs the rate at which new skills, methods of work, or activities of all kinds are acquired, whether for individuals, organisations, or entire industries. The theory explains that new tasks are generally slow and ineffective. So the assumption is that the more times a new task is performed with measures of how well it is done: if a task is performed, say, twice as many times, there will be a fixed percentage decrease in how long it takes, how much it costs to do, and related measures. This phenomenon is well-known in the technology

sector with the blueprint assumption (See Think Box B) and applies to technologies directly related to low-carbon (e.g. learning curves for wind, solar, batteries).

Nick Chater outlines the implication of the power law is that individuals, businesses, and governments focused on the short-term are likely often to be unwilling to switch to 'better' ways of working – the initial costs of switching will appear daunting, creating a friction which will impede change. A second implication is that the 'up front' cost might, nonetheless, be worth it in the longer term, as the benefits of practice start to bite. In terms of the power law of practice, the question is whether the 'slope' of the power law of practice is steep or shallow; and, moreover, there may be 'hard' limits beyond which performance cannot improve (e.g., human cycling speed).

Thinking outside the think box questions

“Engagement campaign that focuses on reducing energy demand. This should be aimed at both businesses and households and its effectiveness would be strengthened by combining informing ‘quick win’ bill-saving measures with programmes supporting longer-term actions.”⁴⁹

Why do policymakers and entrepreneurs often talk about ‘low hanging fruit’, ‘quick wins’ or ‘the paths of the least resistance’? Are they speaking to the power law of practice or does it hint at a broader status quo effect? Evidence on the failure rates of new technology and more generally, in the successful implementation of infrastructure projects are fairly grim (i.e., 90 percent of all new technology fails in the first year and 80 percent in the first five years). This journey is often referred to as the Valley of Death - and for good reason. However, rarely are those technology project statistics ever reversed and framed positively (i.e., 90 percent of the time, institutions succeed at maintaining the status quo). The question is one of *cui bono* – in who’s interest is the status quo? In established markets, incumbents uphold and maintain the current field provisions not least because these already meet relevant needs, and therefore are reluctant to alter ‘the way things are’ and thus the status quo (e.g., oil and gas). The status quo effect has also been shown in numerous lab experiments. As Nick Chatter illustrates, when given one of two possible objects (e.g., a mug or a chocolate bar), people tend to prefer to ‘stick’ with what they are originally given rather than swap to the other object.

The power law of practice individualises the behaviour, however. It downplays the social influence of the institutions and nexuses. The

workshop panellists spoke of the ‘red tape’ paperwork in the installation of heat network pipes in the road infrastructures. Institutions can dwarf the expectations of individuals and halt changes. Metaphorically, with technical proceduralism, institutions can throw a very large 15-tog duvet over any project with a chorus of ‘no’ or ‘ah but’ voices, not to mention the cycles of the silences and inaction marching on. If the ‘blue hour’ actually happens, then progress can become stop-start slow as it enters a prolonged cycle of the institutional waltzing down the long institutional corridors (e.g., in manager parlance, ‘kicking the can down the road’ or ensuring things ‘fall off the desk’). But before one draws the wrong conclusion that institutions are ‘all bad and ugly’, so to speak; they are not. Far from it. Institutions ultimately preserve the status quo and for good reason; maintaining much-needed stability with energy-saving routines, conventions, rules and auto-habits brings the benefits of power law of practice. Curiously enough, local and regional planning offices are often called out as being ‘too tight’ in the renewable technology transition. However, evidence from mature markets show that ‘tight planning systems’ work in the interests of firms in terms of the protection of profit margins.

Overall, then, technology and RD&D deployment projects must travel the all-important ‘institutional corridors’ to organise, transmit and reproduce the existing ‘institutional codes’ of the market. For some technologies, we have seen the power law of practice becoming steeper and almost vertical-like. What, then, survives in the institutional corridors often depends on who does the shaping and what remains from the ‘institutional codes’ to meet the needs of the present. What, then, are the limits of institutional codes absorbing the power law of practice?

Source: Chatter (2020)⁵⁰

The panel discussion also leaned into the economic question of the ‘gross fixed capital formation’; essentially the drilling plant rigs, related machinery, and equipment and the cycle of needing the work before the committing to capacity. Karl Farrow explained that,

“We are coming from the oil and gas sector with 25 years in drilling exploration side. The biggest challenge in this space is really trying to drive down the cost of drilling and trying to get it to a point where we can get a ‘plug and play solution’, whether it’s shallow, whether it’s deep geothermal borewells. There’s lots of things we can look at with the oil and gas sector to actually add benefits to this space, but we can’t look at it as an oil and gas business.”

In developing this economies of scale point, Dr Trehwella of Kensa noted that the scope across the country can also reduce costs, particularly with respect to travel and accommodation of the rig operative crews,

“Last November ...[2022]... in a meeting with the British Drilling Association we worked out that there’s around 60 rigs across the whole of Great Britain that are working in some sort of ground source, geothermal drilling and some quick back of the envelope stuff says we’re going to need around 700, so it’s pretty easy to see once you’ve gone from 60 to 700, how you become much more local, how you can see those cost curves coming down..”

In a lively exchange of views, Karl Farrow (CEO, CeraPhi Energy Ltd), brought the conversation back around to risk and the view of the investor,

“The problem with that triple bottom line philosophy, and I totally get what you’re saying is OK in the world of where we live in, but from the investment world they look at it totally different. They look at the costs and the risk is in the drilling. So more cost in the risk prevents them from entering that market and that’s one of the challenges we see in the big scale of stuff is the investment cost.”

A further issue raised during the panel discussion concerned moving beyond the ‘demonstrator mode’ of thinking in relation to the ‘scaling up mode’ and Dr Trehwella of Kensa again shared his thoughts on this issue,

“...it’s time for us to move away from demonstrating projects really and start doing. Yes, it might be the first of a kind. This [Business School] building wasn’t called a demonstrator, but it is being used to demonstrate what can be done. If we’re going to demonstrate projects, let’s demonstrate where we want to be in the future. We still get contacted by Housing Associations saying ‘we want to run a pilot project for 6 houses.’ In response, we say we’ve already done 900 houses across Yorkshire, probably you want to go and look at those first and see them working. Think about demonstrating 1000 or 2000 rather than going back to doing another six. It’s just because it’s new to them. It is tried and tested. You can do it and we just need to start doing more. That’s the way we want to go.”

Ric Pasquali suggested that multiple demonstrators are important from a social B2B market readiness interaction point of view,

“... not because they’re bore holes in the ground and heat pumps in the plant room, but because of this type of workshop social interaction with all the various stakeholders and the end users. That’s why they’re important today. They’re not new, there are hundreds of examples across Ireland, Cliffs of Moher Visitor Centre, 200 kilowatts heating and cooling Castletroy in Limerick. One MW geoenergy plant cooling the largest manufacturer of contact lenses on these islands – Johnson and Johnson. So there is a sliding scale from houses to industrial pharma and small healthcare applications that that can be looked at on the island.”

Connel McMullan (Managing Director, Alternative Heat Ltd), echoed Matt’s point on the ongoing talk of demonstrations. Connel suggested moving on from this and instead focusing on solutions to do with the socialisation of costs as a way to target the cost of capital of the projects. His perspective attempts to shift the thinking beyond the ‘Going Dutch’ logic and socialising the costs across the ecosystems. In doing so, Connel suggested using combinations and hybrid solutions. Both air source heat pumps (ASHP) and ground source heat pumps (GSHP) operate using a wet heating system (air-to-water and ground-to-water heat

exchange) and require a hot water solution. Both can work together in different configurations. Working in the design, integration and operation of low carbon heating systems since 2003, Connel pointed out that in terms of the total project capital costs, there are different levers to pull,

“Having installed a number of systems, including one in 2016 just up the road from us in the Girdwood’s leisure and community space in Belfast, as well as Eglinton Primary School in Eglinton, we need to move the conversation on. Both Girdwood and Eglinton were designed specifically as demonstrators, with a mixture of horizontal collectors and vertical collectors to demonstrate the differences in the compatibility to run those systems together, or in tandem. The target challenge for those demonstrators was against the capital cost that we know there is in this industry. There’s a lot of very efficient ways that we can integrate low carbon solutions to base load heating systems and massively reduced gas consumption by over 80 or 90 percent.”

Following the same line of thought the conversation shifted towards how to target the capital cost. One avenue discussed involved pivoting towards the geoenergy nexuses. Pivoting towards the thermal recycling ecosystem, Paddy McGuinness from Tyrone company Colloide Ltd outlined its general role as design build contractor for water and wastewater treatment, but also renewable energy schemes. Paddy also highlighted his work with Islington Council’s (London) Bunhill Heat and Power Network (BHPN) which had been the first scheme in the world to take waste heat from an underground train network and use it to provide lower cost, greener heat to local homes, schools and leisure centres. This project highlights the potential of thermal recycling from waste water and water treatment in any city with waste heat sources (e.g. incineration plants, manufacturing plants such as mills, such as Thompsons Feeding Innovation – Belfast which could off-set large carbon emission footprints). The panel discussion generated a continuum of views with some seeking more hybrid solutions in the transition, while others emphasised the need to move down the cost curve with drilling, retrofit and installation to be part of enabling supply chains and not creating a secondary cost imprinting trap from the oil and gas sector. As we see from Wind and PV solar, this does not automatically mean an immediate transition or short-term savings, but long-term value creation and carbon reduction.

Discussion ideas also noted the possibility of developing ‘light rigs’ for private small-scale residential dwellings focusing on closed-loop systems. Issues around security in work and projection of geothermal borehole demand were discussed, when considering training and upskilling. Others point to regulatory mechanisms needed to increase the competitiveness in the installation process – in the operational drilling, systems installation, and utilities, as Dr Trehwella’s viewpoint makes clear,

“So if it becomes regulated, yes, you’re regulating the returns. You’re regulating the way people can be charged, but also you’re giving powers and permissions to speed up the whole thing. So done, right, we’d welcome it and bring it in.”

Costs were not only related to the drilling, however. Viewpoints highlighted the broader complexity of the systems of costs, particularly with respect to the built environment including;

- (i) the retrofitting costs of homes with the ‘fabric first’ approach,
- (ii) thermal storage costs (e.g., hot water tank and how that might be upsized or oversized for rural dwellings and communities),
- (iii) point of use hot water systems, radiator upgrades and boiler decommissioning.

The cost of capital question remained linked across the conversations. Some of the panellists indicated that having multiple sources and vectors for the source of heat (including waste heat-source and water-source) for the heat networks and even a mix of heat pumps, could reduce the overall capital expenditure costs. Linked to this discussion was the need for more enabling tools to increase interaction of consumers with their heating systems – the nexus of digital and artificial intelligence solutions to improve the thermal dynamics of the built environment and also ease of use. Price comparative tools can drive down costs, but as some indicated, were missing in the solutions for cost reduction. Another side to the cost of capital question reflected a need for mandatory energy standards and carbon emissions reporting of existing businesses to shift the dial on collective economies, market surety and proximal effects. Connel McMullan of Alternative Heat added,

“I could probably be the most unpopular man in the room for my next comment. We’ve talked about the energy ‘beneath our feet’, but the energy is around us too. So

thinking about solutions that couple ground source with air source systems should be on the table. It is also a process that we’ve been trying to test and to help target that capital cost reduction and lower the initial investment and maximise the operational efficiency. The average temperature outside in Northern Ireland is 7 °C all year round and for many parts it is higher than what you will extract from the ground, whether it is shallow or deep. New build is very important for showcasing, but it equates to less than 7 percent of the carbon. The larger portion – over 90 percent – comes from existing buildings and there’s a large challenge there with tried and tested experience on how we can target that from a carbon perspective.”

Pointing to the client-driven approach, Connel articulated the complexity of the technology trade-offs and the company’s ‘propinquity search’ for cost reduction solutions near to existing solutions,

“I suppose in the early days we were looking at heat pumps. Heat pumps are designed to go at a low temperature. That’s the most efficient way to run them, which is ideal and perfectly possible. The technology has evolved where there is capacity on various different refrigerants to lift from an incoming temperature, say at 10 °C and multiply that. It puts the control of their asset directly into the hands of the client in that they are free to the approach the solutions. We have found that very effective over the last five or seven years where if we sit back and wait for the perfect solution for a lot of the sites, it’s not just there. But if the client is in control of the solution, they can integrate the technology and remove their gas dependency and the carbon associated with it over time. They might sacrifice their efficiency at the front end, but they’re in control of how long they sacrifice that efficiency for. And if they tie that into their plant replacement strategies for their estate or their buildings, they can target that and continue to target that long after the technologies are in and operating. So it’s quite an important point in relation to the advances in the technology, which I think opens up much, much wider, the opportunity for existing estate buildings as well as new builds for that matter.”

3.8 Think Box K

Think Box K: Proximal effects, readiness and hard selling

There are many models that help explain the dynamics of how receptive or open individuals are to persuasion. One interesting model is the elaboration likelihood model developed by Richard E. Petty and John Cacioppo in 1980. The ELM model proposes two major routes to persuasion: the central route and the peripheral route. The peripheral route can carry important indirect market signals without imparting much detail of the information (e.g., some individuals

use that proximal as a signal or an indicator). The upside of the proximal effect is that it can generate spillover or spill forward attention. For example, heat networks can act as a proxy for geoenergy, despite heat networks having multiple energy sources. Or, for example, the Sherwood Sandstone formation can generate a proximal effect for thermal conductivity, despite closed loop systems being agnostic to geology. Other studies point to the importance and degree of readiness – that is, readiness as much a function of people’s beliefs and feelings about an issue. For example, the degree to which someone is optimistic. Readiness examples abound but include;

- Optimism: Positive view and belief that it offers increased value, control, flexibility and efficiency.
- Innovativeness: Tendency to be a pioneer and thought leader.
- Discomfort: Perceived lack of control and a feeling of being overwhelmed by it.
- Insecurity: Distrust and scepticism about it working properly.

Therefore, the receptive or landing conditions can be hostile and harsh. The oil and gas sector, for example, may not be responsive but others are attempting to pivot towards this with a project called Project Innerspace and the global PIVOT conference series⁵¹.

Trevor Pinch and Colin Clark conducted studies on of a number of markets in the North of England on ‘hard selling’ by ‘pitchers’ describing how market-pitchers both build and solicit commitments from audiences. Nick Llewellyn and Robin Burrow in a study published in The British Journal of Sociology offers a penetrating insight into how Big Issue vendors approached passers-by, how they responded, and how recognisable courses of social and economic activity were interactionally produced from initiation through to conclusions.

Thinking outside the think box questions

If you can, find geoenergy’s market share – the key KPI driver – for markets. Based on that market share data, how much could geoenergy contribute to the baseload energy provision? How could the oil and gas sector pivot to contribute to this market share? A cursory glance at the local market suggests that geoenergy presently sits at the bottom of the market share footing of renewables technologies. More generally, UK heat pump sales languish at the bottom of the European countries too. As Terry Waugh at NI Action Renewables noted during our workshop, the wisdom of our predecessors was ignored for the nirvana of the cheap fossil fuel proposition.

Does geoenergy face encounters that are familiar to that of the ‘street seller’ who must find ways of converting expressions of interest from individuals who have ‘stubbornly entrenched’ attitudes to costs? Are there ‘stubbornly entrenched’ attitudes towards the use of domestic heat oil fire burners? So maybe there is something to learn in the proximal hard selling markets when there are hardline economic cost stances? Should there be both ‘a carrot’ as well as ‘a stick’ of built environment emissions polluters? Perhaps the top 50 carbon polluters should pay for that and help bring the costs down? Perhaps policy could enable the oil and gas super majors to pivot their skill set to geoenergy?

Following on, Joseph Ireland turned the conversation onto skills. Paddy McGuinness from Colloide Ltd explained that in designing the thermal systems he found it was difficult to recruit,

“...from a building service, or overall project delivery, basic skills we need are for mechanical electrical engineers, process engineers and building services engineers. But we advertised and couldn’t get anybody at all to apply and we’re continually looking for people with those skill sets.”

Turning the skills question back onto the client needs, Connel McMullan of Alternative Heat added that a strong area for any focus in the future,

“Yes we need skills from a solution providers and designers side, but we also need skills from the clients’ perspectives and what they’re trying to achieve. So I think a strong focus on data from the client base to understand how their buildings are performing. Over 90 percent of the carbon is coming from existing properties, so we need to understand that data. Capturing that data and mapping that out

provides a unique starting point for any client in the room looking to plan how they’re going to decarbonise their estate or their sector.”

For enterprises like Jeff Meehan’s Meehan Drilling, the issue of market surety is a significant issue for investing and developing in the drilling skill sets. He explained that market surety issue,

“The market isn’t there, or it’s very slow compared to the UK and we went through a period of time there were we couldn’t get bad help, never mind good help. How can I attract somebody to come and work for me if let’s say we do get one pilot project going and it’s only going to last three months. So we need continuity of work for building the skills base.”

This panel concluded with both moderators thanking the panellists for an interesting and vibrant discussion. Professor Palmer then pithily closed the workshop, thanking all of the participants and attendees. He ended on a positive – lunch was ready and served(!).

⁵¹ <https://www.projectinnerspace.org/>

Inter-semiotic Reflections



Building Back Better – A 1 for Geothermal Energy Northern Ireland

This online conference is the first in a series of the future for Geothermal Energy in Northern Ireland we look toward our recovery from a global pandemic take a fresh and renewed approach to build greener and more resilient economy. Geothermal can play a fundamental role in this as we build better.

Date: Friday 11th December 2020.
 Time: 9:00am to 1:30pm.
 Hosts: Centre for Sustainability, Equality and Action (SECA) at Queen's University, Belfast and Geological Survey of Northern Ireland (GSNI).

Location: Zoom Video Conference.
 Register here: <https://www.geothermal-energy-uk.org/back-better-a-future-for-geothermal-energy-uk/ireland-tickets-127852984302>

Northern Ireland Geothermal Webinar Series

Unlocking the True Potential of Clean Geothermal Energy

Matt Houde
 Co-Founder and Project Manager
 Quaise Energy

To scale geothermal to terawatts we must drill deeper, hence Quaise Energy's millimeter wave drilling technology hopes to unlock a powerful and clean energy source on Earth by allowing us to drill deeper.

QUAISE Thursday 12th January 2023
 16:00-17:00 GMT

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Figure 27 - Semiotic Reflections

3.9 Synoptic Reflection - Alert to the Undertows

Workshops are active perceptual systems (see Figure 28). This section offers a synoptic reflection on the workshop practitioner communications (i.e., the keynote presentations and the panel discussions). As might be expected, the participants were very upbeat about the geoenergy transition possibilities of furthering the Steering Wheel Vision for NI Geothermal Energy (see Appendix 3) and the Northern Ireland 10X economic vision.



Figure 28 - Workshop

Yet there is more to the industrial workshop than meets the eye. The ‘precious objects’⁵² are always at work in organising workshops. The institutional codes – or put slightly differently, the taken-for-granted street codes – become much more pronounced when the members of different ecosystems socially interact at workshops. Like the ocean waves, then, the geoenergy wave comprises more than the sustained forward motion evident on the surface. As metaphorically pointed out elsewhere, ‘waves also, always and everywhere, entail an undertow’⁵³. We detect the undertow waves at our workshop in the institutional ‘diffractive bending’ when members pass through the narrow openings of the panel peer discussions and Q&As.

One strong undertow wave concerns the actual footing of the ‘demonstrator mode’ phase. In the workshop discussions, there were strong voices that contested any notion of the ‘demonstrator mode’ footing, but rather instead asserted a different transitional scaling-up mode. On closer inspection, this undertow is not surprising given that there is an established geoenergy blueprint elsewhere in the UK and further afield. This undertow wave hints at status preservation, vested interests, or market signalling. Either way, commercialisation invariably overtakes demonstrability. Perhaps this undertow wave marks the permanence and inseparability of the doing and showing and indeed the ongoing search for

multidisciplinary data to do energy transition work.

Another undertow wave surfacing concerned the issues of cost of capital that demanded answers and solutions, none of which are addressed individually. What is needed, therefore, are complementors to pivot and enter the ecosystems, inter alia, thermal fabric, heat pumps, built environment, geology, heat networks, thermal storage, thermal recycling and interfacing with other renewable technologies. We detect undertow around role-specificity issues (e.g., councils, utilities), with financing, public-private partnering, infrastructure-build issues (e.g., thermal recycling, microgeneration grids, heat networks), and around capital and revenue-raising authority and the hallmark questions of who pays for the energy transition more generally. It reveals, moreover, the undertow in the member’s differences in socialising the technology (e.g. pure versus more applied, subsurface versus above-the-ground, separate versus more integrated hybrid approaches) as well as targeting the institutionally stubborn capital and operational expenditure costs with business model innovations.

Data collection seems to be a further undertow. Some members believe that data collection efforts are presently too narrow and are not elucidating, generating, or adding fusion between the geoscience, front-end heating engineering, consumer behaviours, governance and business models data. There are therefore limits in ‘cutting together, apart’⁵⁴. In sum, reflecting on the undertows offers an opportunity to rethink the nature of geoenergy institutional relationships beyond one ecosystem and toward multiple geoenergy nexuses as outlined in Figure 29 below.

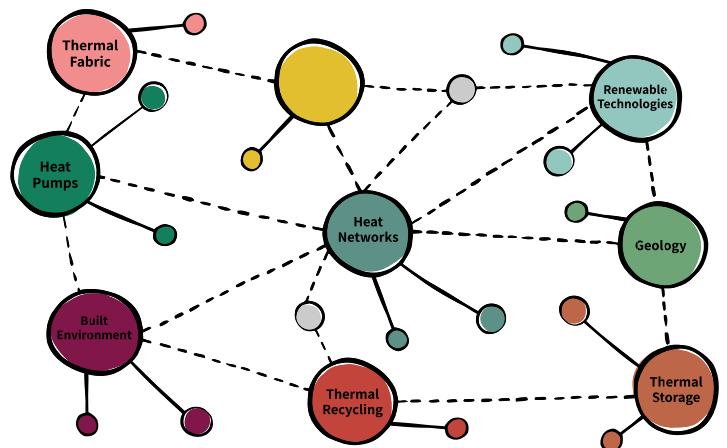


Figure 29 - Pivoting the geoenergy nexuses

52 See Bruno Latour’s research on ‘precious objects’.

53 Orlikowski, W.J. Scott, S.V. (2023) The digital undertow and institutional displacement: a sociomaterial approach, *Organization Theory*, 4 (2), p.1-16.

54 Barad, K. (2013). *Ma(r)king time: Material entanglements and re-memberings: Cutting together apart*. In P. R. Carile, D. Nicolini, A. Langley, & H. Tsoukas (Eds.), *How matter matters: Objects, artifacts, and materiality in organization studies*, (pp. 16–31) Oxford University Press.

Building Traditions

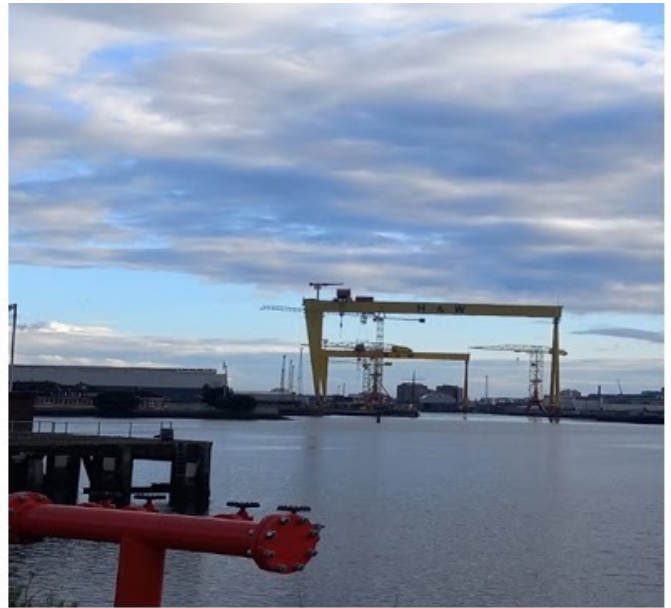


Figure 30 – Belfast harbour and the cranes in the shipyard

4. Conclusions

We are arguably in a time period when some of the greatest energy changes driven by the low carbon agenda and achievements are a foot – a ‘golden age.’ Indeed some of the participants during our workshop draw parallels of today’s energy transition with the ‘build-build-build Victorian’ environment of yesteryear. That era paints a certain picture, one which industrially resonates with Belfast lough, its harbour and the cranes towering over the shipyard. That industrial proximal effect left its mark widely on the city, commerce, and adjacent industries. While there may well be a striking familiarity with those industrial times, arguably the global scale and scope of the contemporary net zero challenge surpasses even that era. The present must also leave its mark on the future.

All challenges invariably find work. The work of our workshop draws attention to the some of the project work in-progress, project considerations and project aspirations, and raises important themes and poses questions, which have considerable significance for the energy transition more generally, and geothermal energy in particular. Should any further proof be required, our keynote presenter Dr Matt Trehwella, Chief Executive Officer, Kensa Group, exemplifies the range of project applications across GB and testifies to that much-searched-for blueprint. Sara Lynch invites us to create a living lab following the new Queen’s University Business School building. Another opportunity. Richard Rodgers cogently points to the importance of collaboratively working together.

Overall therefore, our main conclusion from the insights from our workshop is that more emphasis should be placed on pivoting the geoenergy nexuses of the ecosystems of thermal fabrics, heat pumps, geology, heat networks, thermal storage, thermal recycling and with other renewable technologies. This pivoting of the nexuses is crucial for ensuring that each ecosystem is marching in time and in the same direction. This is a challenging market-making and market-shaping task, requiring capacity-building steps in regulatory frameworks and policy, finance, law, planning, drilling, community engagement and collaboration, mechanical, electrical and plumbing operations and consumer protection as well as data generation and the fusion of data to inform behaviours. It requires much transition work and indeed many hands. The role of organising conversations and working collaboratively together across the nested ecosystems cannot be underestimated in making this change happen. This collective organising practice must be inclusive, integrated and ongoing to ensure that geoenergy projects pique interest and ecosystem members remain

curious, engaged and committed.

Our workshop follows on from a series of ongoing steps. It marks the opening of the geothermal heated Business School building. It raises important themes and poses important but unanswered questions and these conclude our report (see illustration in Figure 31:

Theme 1 — More awareness of established geoenergy blueprint elsewhere in the UK and further afield.

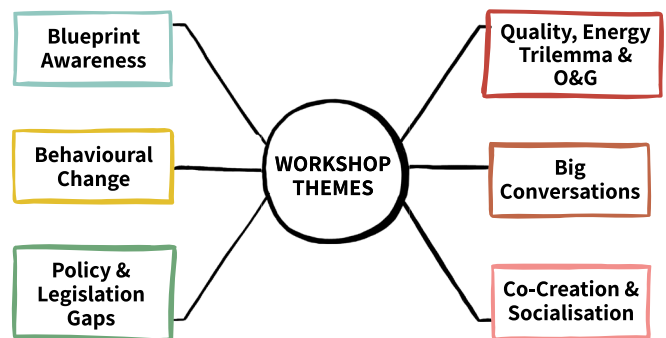
Theme 2 — Increase emphasis and overlap in the quality and energy trilemma issues of the energy transition.

Theme 3 — Government subvention support, political engagement and big society conversations.

Theme 4 — Significant value co-creation and socialisation of costs can be realised by pivoting and collaboratively working across ecosystem nexuses. Integrated data fusion thinking between geology, front-end heating engineering and business models is needed to prevent crimping effects.

Theme 5 — Behavioural change among consumers will be an important component of the level of decarbonisation.

Theme 6 — Leapfrog pathway development with UK policy and the Energy Bill to close and progress the legislation gaps.



Someone once stated that the secret of making and progressing conversation is to get started with a question or several. In sum, we have many more questions than answers, perhaps a characteristic of a lively workshop. Will the next ten years see a portfolio-driven shift in baseload energy provision in Northern Ireland? Who will pay for the baseload transition? How will the oil and gas sector pivot its energy agenda? How will the triple line be protected – the economic, environmental and social considerations? How will the consumer journey be managed in the energy transition? How should the costs and benefits be socialised across society? How does all of society benefit from our natural energy resources? Who will report on and pay for the built environment carbon emissions? And, ultimately, what can geoenergy do to enable a portfolio-driven approach in the energy transition?

5. Ways Forward – a 10-Point AXIS

It is hard not to be sanguine about the prospects and challenges that the Northern Ireland natural resource environment affords. The good news is that much progress has made in the energy transition so far, notably in PV solar and onshore wind. The baseload energy point remains, however. But there are ways forward, regardless of setbacks or institutional constraints. Previously we put forward 50:200 actions and sub actions and a further two-step platform, as outlined in the ‘Net zero pathways: Building the geothermal energy sector in Northern Ireland’ and in the ‘Defining the vision for geothermal energy in Northern Ireland’ respectively. Those actions need to be fully implemented. With the insight from our workshop project updates, the pivoting 10-point axis are additional key focus areas for sector-building and policy development, and these are now outlined below:

1. Pivoting reciprocally from the multi-stakeholder-informed geothermal sector vision as outlined at Geothermal Week in June 2022, developing and shoring up roadmaps and explicitly linking the RD&D projects, regulation, incentives and policy.

2. Pivoting across the geoenergy nexuses to promote ‘joined up’ approaches, positive proximity spill-over effects, sector couplings between heat pumps, built environment, geology, heat networks, thermal storage, thermal recycling, other renewable technologies vectors.

3. Pivoting from the Stormont RD&D and other geoenergy projects elsewhere on optimisation practice and business case validation from energy generation, network infrastructures and customer interfaces.

4. Pivoting with assessments of consumer protection, technical standards, network zoning locales and ‘step in/step out requirements’ drawing in from the experience of Ofgem (England), The Department for Energy Security and Net Zero (DESNZ), the NI Utility Regulator and the Consumer Council respectively.

5. Pivoting through nurturing a balanced, equitable and holistic approach in data knowledge

creation, knowledge application, and knowledge storage and retrieval. This could explore and marry geoscience data with sustainable business model energy sources, vectors and geographic characteristics (e.g., rural dwellings and housing stock). There is also a need to pivot between the cost benefit analysis approach, which prevails in decision-making, towards one that considers the opportunity costs of the polluter paying for CO₂ building emissions (e.g., new gas boilers, mandated reporting of CO₂ building emissions) to reflect the cost of direct air capture and storage of carbon⁵⁵.

6. Pivoting towards micro-generation regulatory frameworks and policy zones in the production of electricity at the level of individual buildings or small local communities. Pivots towards more decentralized or distributed electricity generation system could contribute to a transition towards a more sustainable energy system. There are pivoting opportunities with winter peak moderation and thermal storage, counter-balancing systems and dispersed management (e.g., with Air Source Heat Pumps).

7. Pivoting commensurately with regulatory structural frameworks, policy positions and incentive schemes elsewhere in the United Kingdom (e.g., heat pumps, geothermal feasibility, heat networks feasibility and infrastructure-building).

8. Pivoting alongside the circular economy policy (e.g., thermal recycling with waste heat, surface water and water treatment facilities) and couple with other renewable technologies (e.g., wind and heat pumps, thermal PV, heat networks and thermal storage, geothermal and hydrogen production) to unlock the conditions for ‘home grown’ energy sources.

9. Pivoting with energy systems optimisation (e.g., matching apps, storage, AI, digital technologies), leveraging economies of scale and economies of scope in the pursuit of the low carbon agenda.

10. Pivoting through a resource mechanism such as a Northern Ireland or cross border sovereign wealth fund that harnesses the natural resource benefits for all of society.

⁵⁵ See NYC Local Law 97 as an example. <https://www.nyc.gov/site/sustainablebuildings/l197/local-law-97.page>

Acknowledgements

We are very grateful for our keynote presenters, the panellists, moderators and for all of the attendee contributions and participation. We would like to thank Sharon Clements, the Department for the Economy, as well as Professor Neil Hewitt, Ulster University, and Professor Aoife Foley, University of Manchester, for their ongoing feedback. Also, a word of thanks to Dr Alice Neeson at QUB's central Research Office for the institutional support, along with the Business School's Dean and Head of School, Professor Ravishankar for his ongoing support with our work. A final note of thanks to Lauren within the Business School Research Office, Thomas and Brian from the catering services for ensuring one of most important ingredients for good conversations – the teas, coffees and lunches – were delivered on time and tasted delicious!

Appendix 1 Workshop Slides Summary

Building the Geothermal Energy Sector in Northern Ireland

Tuesday 4th July 2023, 9.00am – 12.30pm BST
Registration from 9.00am, lunch provided

Queen's Management School, Riddell Hall, Queen's University Belfast, 135 Stranmillis Road, Belfast, BT9 5EX

Keynote presentation by Dr Matt Trevellick, Chief Executive Officer of Kensa Heat Pumps

Chair's Professor Mark Palmer (QUB) and Andy Frew (HWE) Co-Chairs, Joseph Ireland, Dr Nicola Barron and Dr Ulrich Offenberg (QUB)

Queen's University Belfast and the Northern Ireland Housing Executive

Following Northern Ireland Geothermal Energy Years (IUGY) 2022 and governmental sector project update workshop in October 2022, the purpose of this workshop is to provide a platform to discuss key project developments in the geothermal sector, particularly as they relate to accelerating the built environment and the implementation of Sector Plans and Local Area Energy Plans.

Co-organised by Queen's University Belfast and the Northern Ireland Housing Executive, and hosted at Queen's Management School, this geothermal energy focused building, the event is for business, public authorities, government, MCR and community groups with an interest in accelerating the built environment and we look forward to welcoming you.

Building the Geothermal Energy Sector in Northern Ireland

Project update workshop II, 4th of July, 2023

Professor Mark Palmer (QUB) & Andy Frew (HWE)

Co-organisers: Joseph Ireland, Professor Min Zhang, Dr Nicola Barron, Dr Ulrich Offenberg, Dr Charles Li (QUB)

Integrating Net Zero - Riddell Hall Business School

04 July 2023
Building the geothermal energy sector in Northern Ireland

Shared Ground Array Projects

- Kensa Contracting has been installing properties onto shared ground arrays since 2013
- To date there are 4,559 properties connected to these
- None in Northern Ireland but
 - technology is being deployed at scale
 - Across many types of geology
 - Wide range of property type and tenure
 - Northern Irish geology is suitable

Building the geothermal energy sector in Northern Ireland: Closing

Thank you

Heating source

Geothermal

- 40 vertical piles bored to a depth of 125m
- Over 10km of pipework

Example – Social Housing Retrofit Trent and Dover Housing

- 15 sites around Burton-upon-Trent
- 133 properties
- 42 boreholes – c130m deep
- Constructed January – May 2015
- Replacing Night Storage Heaters
- Annual bill savings of £500-700 – in 2015!
- Financially possible through support from the non-domestic RHI

<https://www.youtube.com/watch?v=z74MvnH6StI&t=36s>

Our carbon footprint

What are our emissions?

2018/19 ~105,000 tCO2e

Appendix 2

Workshop

Agenda

9:00 am - Tea and coffee

9.30 am - Welcome and introduction (Professor Mark Palmer, QUB and Andrew Frew, NIHE)

9.35 am - Opening (Richard Rodgers, Head of Energy, Department for the Economy)

Keynote presentations

9.45 am - Keynote speaker Dr Matt Trehwella (Chief Executive Officer, Kensa Heat Pumps) - Building the Geothermal Sector in Northern Ireland Practical considerations and examples

10.10 am - Sara Lynch (Head of Sustainability, QUB Estates) - Integrating Net Zero - Riddell Hall Business School

10.20 am - Q&A led by Jamie Delargy (Enirgy) and Orla Hanna (DWF) and floor

Panel dialogues

10.35 am - Panel 1: Project delivery updates

- Dr David Connolly, District Heating.ie, Dr Simon Todd, Causeway Energy Riccardo Pasquali, Terra GeoServ Ltd Dr Matt Trehwella, Kensa Ground Source Heat Pumps Conor Lydon, Tetra Tech, Bobbie Milligan, District Energy, Ramboll Consulting

11.05 am - Q&A led by Andy Frew (NIHE), Dr Aoife Braiden (GSI) and floor

11.15 am - Panel 2: Project consideration updates

- George McCracken, Belfast Trust. Bob Barbour, Smart Grid Ireland. Robert Clements, NIHE. Debbie Caldwell, Belfast City Council. Terry Waugh, Action Renewables, Peter McClenaghan, Consumer Council

11.45 am - Q&A led by Dr Marie Cowan (GSNI), Sara Lynch (QUB) and floor

11.55 am - Panel 3: Project drilling, MEP and utilities updates

- Nicholas Wall, CEO, Walls Well Drilling. Riccardo Pasquali, Terra GeoServ Ltd Paddy McGuinness, CEO, Colloide Ltd. Karl Farrow, CEO, CeraPhi Energy Ltd. Connel McMullan, CEO, Alternative Heat Ltd. Jeff Meehan, CEO, Meehan Drilling Ltd

12.25 pm - Q&A led by Dr Simon Todd, Joseph Ireland (QUB) and floor Close

Appendix 3 Collective Vision Making Steering Wheel

