Imaginaries of Development, Economy and Place: A Minewater Thermal Energy Industry in Scotland

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Abstract

Scotland's existing energy economy grapples with a legacy of fossil fuels and a governance regime which produces unsustainable environmental, climate and social burdens. In order to meet ecological need and empower communities, a democratic and just energy system transition is the focus of much debate. Minewater Thermal Energy (MWT) is an undeveloped resource grounded in the material and cultural legacy of deindustrialisation, with the potential to contribute to a just energy transition in Scotland.

In this thesis an imagined MWT industry is explored through an analytical framework that integrates theories from sociotechnical imaginaries, political economy and energy justice to develop understanding of how MWT can contribute to a just transition in Scotland. I demonstrate how this novel framework provides a suitable lens through which a future energy industry such as MWT can be explored. One of the challenges of this thesis is that the object of study - MWT in Scotland - does not yet exist. For this reason, the development landscape and wider energy economy were vitally important in understanding the visions of MWT development, as well as the material realities shaping such visions.

The empirical element of this thesis consisted of a wider sectoral interview approach as well an in-depth case study of a former mining community. The analytical framework was applied through a reflexive methodology, built upon critical realist and interpretivist approaches to knowledge. Qualitative methods were used, including semi-structured interviews (n=29) with sectoral professionals and a community case study consisting of two workshops (n=19).

This thesis finds that the process of imagining and implementing alternative MWT futures is shaped by hegemonic political economy forces embedded in socio-technical energy regimes and landscapes. Significantly, it finds that MWT can serve various collective imaginaries, which range from technocratic-led visions to bottom-up approaches in opposition to neoliberalism, aligned instead with alternative economic approaches.

The case study demonstrates that for MWT, the characteristics of place are critical, and the legacy of deindustrialisation plays a role in shaping MWT futures. Participants prioritised fairness and meaningful partnership rather than opposition to the changes brought about by MWT and an energy transition. It has demonstrated the potential of alternative policy and practitioner approaches which are place-based, involve the state working strategically for public benefit and to empower communities, and the role of hegemonic and counter hegemonic ideas in shaping the imaginaries and implementation of alternative energy governance.

Acknowledgements – 15/10/2025

Having completed writing this PhD, I would like to preface it with a few reflections for the reader. First, as challenging a journey a PhD can be, I want to state how much of a privilege I consider it to be able to earn a living in this contemporary world by undertaking research. Pursuing knowledge relating to ideas and realities important to me is the fundamental drive behind this work, and I am under no naivety as to the difficulties facing the purity of this pursuit today.

I would like to thank everyone in my life and the many faceless comrades in society who all contribute to the creation and renewal of opportunities to learn such as this PhD. It would be an impossible task to qualify or quantify all the contributions to this thesis and my own development, but I will absolutely give a name to those I feel deserve thanks.

First, a thanks to all the participants who engaged with this PhD, particularly those who were involved directly in the data collection and the people of Cardenden. The research would not have been possible without your openness, endurance, and commitment to share your time.

I would also thank my academic supervisors Professor Matthew Hannon and Dr Iain Cairns for the depth and breadth of your wisdom, support and guidance throughout and for having a profound impact upon my life and this project.

To all my family, friends and loved ones who helped make this PhD possible, the school teachers and educators who sacrifice towards making further education a reality. I never considered that I would undertake a PhD until about the moment I applied for one, and that open mindset of enquiry I treasure is down to you all, thank you.

If this PhD is the only public print I ever produce with space for such reflections, then I want to say that my parents Janice Bain and James Kerr are the most incredible and beautiful humans I have ever known, and have impacted countless lives in the quietest and most admirable of ways. They are my eternal inspiration.

Finally, I'd like to emphasise that my goal at all times is the reduction of suffering in the world and the advancement of wellbeing for all creatures on earth. If one is to take a macro perspective, I hope this PhD is a worthy effort in attempting to do so in our small (and massive) area of energy social science research.

Declaration

I, Finlay Bain Kerr, confirm that the work presented in this thesis is my own and no part of the work has been used in the context of any other application for a degree or other qualification with this or any other university or other institute of learning.

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List of Acronyms and Abbreviations

MWT Minewater Thermal Energy

CWB Community Wealth Building

SEPA Scottish Environmental Protection Agency

BEIS Department for Business Energy & Industrial Strategy

GDP Gross Domestic Product

STS Sociotechnical System

STT Sociotechnical Transition

STI Sociotechnical Imaginaries

MLP Multi-level Perspective

PE Political Economy

GPE Geographical Political Economy

OECD Organisation for Economic Co-operation and Development

UNEP United Nations Environmental Programme

IMF International Monetary Fund

MMT Modern Monetary Theory

MEL Midlothian Energy Limited

Chapter 1 - Introduction

> "…the ultimate, hidden truth of the world is that it is something that we make, and could just as easily make differently" – David Graeber in The Utopia of Rules: On Technology, Stupidity, and the Secret Joys of Bureaucracy, 2013, pg54

This thesis explores the conditions of development for a Minewater Thermal Energy (MWT) industry in Scotland. MWT is the thermal energy found within former coal mining infrastructures including shafts and pits, where the water level has recovered. The existing thermal energy found within mines can be used to provide heating services, in addition to its potential as an energy storage vessel, where excess energy from elsewhere can be stored and utilised when needed. The scientific and engineering dimensions of the implementation of MWT technologies is briefly explored in more detail within this thesis. However, it is the social, economic, political and cultural dimensions relating to its development which are the primary focus here.

This thesis sets out to engage with realities and complexities of global and local energy transitions, a post-coal mining Scotland, as well as the hegemony of neoliberal energy markets. Therefore, a rigorous exploration of material, historical and critical forces is a requisite. The line of enquiry taken in this thesis has been adopted because there is little research that explores MWT industries from a critical social science perspective, or explores how former coalmining communities and their imaginaries intersect with the current energy transition. The research is important for our understanding of the energy transition, Scotland's energy economy, and former mining communities, such as the village of Cardenden, the case study used in this thesis. As an industry yet to exist as part of the energy transition in Scotland, imaginaries and the process of imagining play a critical role in the shaping of MWT energy futures, where power structures observed across different scales and spaces underpin this process in varying ways. Therefore, as mentioned, a case study was undertaken alongside wider sectoral data collection to illicit understanding of how place-based approaches to transition are situated within a wider energy political economy.

The research takes a critical perspective, drawing from scholarship on sociotechnical imaginaries, neo-Gramscian political economy and energy justice. Conceptions of wellbeing, democracy and justice are explored in relation to the energy economy, with a particular effort made to digest the function of community inclusive energy governance. An integrated analytical framework is presented later in Chapter 5 which unites the critical perspectives mentioned here.

This introductory chapter guides the reader towards the research questions with an exploration of the major contextual information, framing the research focus. It begins by discussing the wider energy transition that MWT may contribute to, from global sustainability transitions to local and heating sector considerations in Scotland. Socioeconomic issues are then examined including both fuel poverty and deindustrialisation, before a discussion of relevant policy developments such as the just transition. The chapter ends by setting out the research focus and the structure this thesis follows.

1.1 Framing sustainability transitions

Minewater energy systems developing today will enter into an energy system and economy reckoning with environmental and societal challenges on the path towards sustainable futures. In this first section, the nature of the challenges facing modern societies relevant to MWT development are explored, in order to provide crucial framing and context for any future industry.

The nature of ecological tensions and environmental boundaries are better understood and more pressing than at any time of human history (Lenton et al. 2019). As a response, sustainability discourse has become a mainstay of societal governance, politics, and behaviour. Conventional sustainability philosophies have been around for centuries, where individuals and collectives have highlighted the importance of conserving environmental materialities for human benefit, as well as a recognition of the damaging effect of environmental destruction to long-term human existence (Gibbons 2020). However, it is the relative failure of the historical and contemporary sustainability paradigm that must be confronted in the face of the severe ecological breakdown if human activity carries on as present. Indeed, human induced climate change and biodiversity loss has been understood for a significant period. Despite this, scientific and technocratic-led solutions have not been able to drive sufficient transformation to address environmental challenges (Ives et al. 2020). The sustainability lens has shifted in recent years beyond environmental issues, bringing together social, health and economic dimensions, in which all societal trajectories are in focus, with the aim to move beyond solely surviving, into a more transformative agenda for holistic planetary wellbeing (Gibbons 2020). Yet to date, this renewed, and more dynamic sustainability agenda, has failed to stop continuing environmental degradation and widening socio-economic inequality.

Transitions or transformations in human society conducted through narrow or singular perspectives have the potential to cause harm, exclusion and produce greater inequality (Bennett et al. 2019). Any narrowly focussed environmental or climate transition poses the

same risks. Technocratic and top-down solutions have yet to enable a just transition , and where they are implemented, concern lingers over long-term suitability and sustainability. Thus, a radically different democratic form of sustainable development is crucial in meeting the challenges of the 21st century. An appropriate and necessary sustainability transformation effects all aspects of society, from basic services and needs such as transport and food, to social and organisational approaches in governance and politics. A crucial dimension of this programme is the energy transition, which is unfolding across all geographic scales and is firmly embedded in human ecological activities it is the focus of the following section

1.1.1 Energy Transitions

With the central theme of this thesis being the interconnected nature of energy systems, it is important to define why the focus is a worthy one. As Dagget (2019, 12) states, how we define and mobilize energy in many ways “shapes the possibilities of life on earth”. In some ways, the societal need for, and relationship with, energy has been taken for granted. However, it has emerged as a major area of study across the social sciences (Shove and Walker 2014). As a fundamental resource that allows us ‘to do’, energy systems and their evolution have a direct impact on social order and livelihoods, on both a collective and individual level. In some interpretations of this energy-societal relation, energy resource use and development is one of, if not the most critical element that can determine societal progress (White 1943).

It is possible to get lost in different framings and conceptions of societal, technological progress and behaviours in relation to the usage of energy resources, but what is abundantly clear is that the most fundamental and basic aspects of daily life require energy; to eat, move, stay in good health, work, engage in leisure and comfort. As such, it is important to reemphasis the central provisions of an energy system; it should work to enable social practices, it works with material realities of consumption and demand, transmission and networks, and should not create burdens which threaten the fundamental elements of life.

Shifts in the energy system have the potential to cause huge change to societies, at the everyday level through to national politics and global relations (Bridge et al. 2013). Across the majority of human history, energy transitions would have been made at local or individual levels, with little coordination as a response to contextual impacts such as availability and practicality (Solomon and Krishna 2011). The transition between fuel and technology has underpinned many of the most influential social, economic and geographical transformations, with a rudimentary linking of wood to coal, and coal to oil providing a

simplistic but striking snapshot of human development and history (Smil 2010). With our modern society and variations of democracy intrinsically linked to recent rapid development of fossil fuel extraction and usage (Mitchell 2009).

The time in which we live, and the first half of the 21st century is widely acknowledged as a period of seismic transition in energy systems, with an important distinction to previous energy-societal changes; that current energy systems are interconnected, reliant and impactful on an array of globalised features. The importance of long-term strategic energy planning in national and global governance contexts has been evident since the 1970s oil crisis, recognised as the first globalised energy crisis.

1.1.2 The energy trilemma

In recent times, and in light of the aforementioned sustainability challenges, the management and purpose of energy systems has been viewed as a trilemma which meets the needs of human welfare along with planetary ecosystems, see Figure 1.

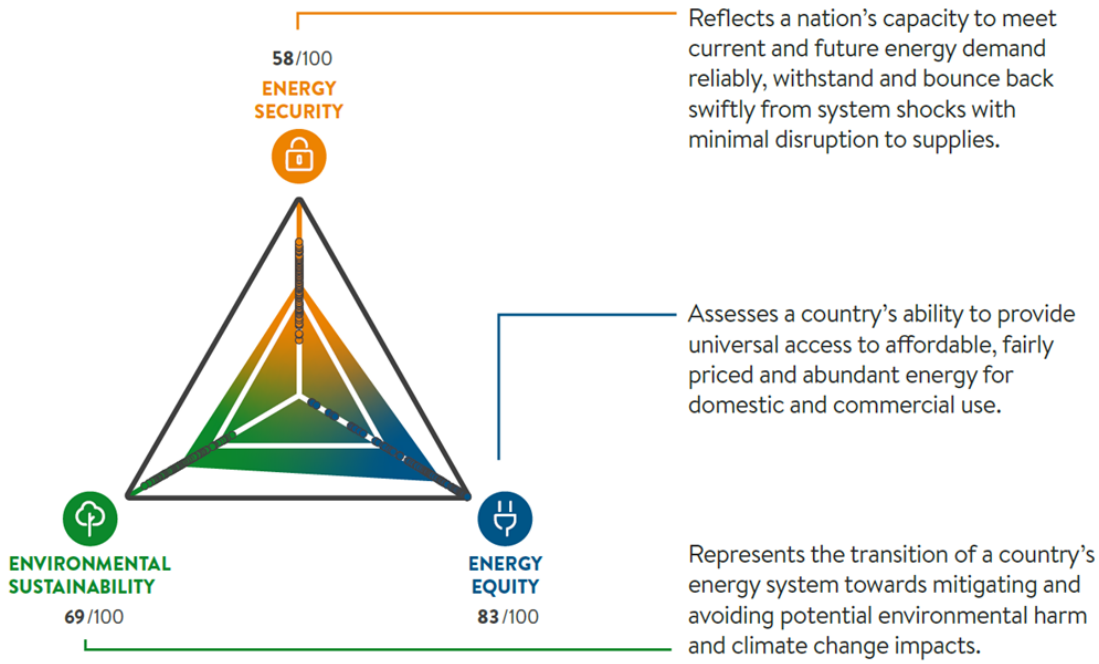

Figure 1 World Energy Trilemma Index (WEC 2023)

The energy trilemma is designed around pillars of an appropriate energy system through providing affordability, security of supply and environmental sustainability. Whilst there are criticisms of the usefulness of this framing (Liu et al. 2022), it does provide a useful foundation upon which to build a deeper understanding of the driving forces behind energy system change. The environmental sustainability aims of the energy transition are driven by a range of challenges, climate change chief amongst them, as one of the major human-induced changes to life on earth. Any MWT system is placed directly in the centre of these

energy transition challenges and in a broad sense must address energy security, energy equity and environmental sustainability.

Climate change & environmental sustainability

Climate change presents a unique and central driving force for the intense changes experienced and planned within the energy sector, with the Paris Climate Agreement signed in 2015 obligating all parties to limit global temperature rises to 2^0C above pre-industrial levels. Building upon previous legislation such as the Kyoto protocol, which put prices on greenhouse gases, and subsequently built on at following COPs, national and international commitment to tackling the wide range of environmental issues of the present is established. Beyond emissions contributing to climate change, it is also well understood that the extractive nature of the current energy system can have a range of ecological impacts.

The environmental damage from direct fossil fuel extraction and usage, the minerals and materials required for energy technologies, and the extended supply chain of energy related products and services are represented by many cases of oil spillage, mining disaster, habitat destruction and material pollution from products and waste. It is also important to note that new forms of renewable or ‘green’ energy are not exempt from environmental impact, despite their emission reducing potential, the rare earth metals required for electrification and difficulty in recycling parts of modern systems are well documented.

The case for aligning energy systems with environmental sustainability and addressing climate change is scientifically well understood and has been robustly made for some time. Ultimately the evidence continuously points towards severe scenarios if rapid and wide change in the energy sector is not made, from climate change impacts such as drought, sea level rise and famine to biodiversity collapse and a mass extinction event. This thesis emphasises and takes such claims with seriousness, though equally acknowledges the limitations of current approaches to tackling the environmental challenges and that transformative solutions lie in addressing interconnected societal, cultural and political phenomena which drive systemic behaviours.

Energy equity

The central role of energy in people’s lives and its ability to severely impact health, well-being, economic security and socialisation is well documented, and recognised by different states and organisations globally (UN 2018). Any MWT must be recognisant of its central role in affecting equity and quality of life through the provision of energy. Poverty is often defined in economic terms, with those living on less than $2.15 a day classified as being in

extreme poverty, rather disparagingly this accounts for about 8.5% of the global population (Development Initiatives 2023). However, non-income dimensions are increasingly acknowledged as being as important, whether its education, health or general living conditions and the sequence of issues that can follow from deprivation of life's basic needs.

Energy in the form of electricity and fuel, are essential world-over for daily activities including cooking, heating, transport and lighting to name a few. Beyond necessity and practicality, access to affordable, reliant and adequate forms of energy impacts productive opportunities, enterprising capabilities and cascading health impacts resulting in numerous feedback cycles of persistent and entrenched poverty (Pachauri and Rao 2013). To presume such cycles occur naturally would be extremely simplistic, and in fact the relationship between energy poverty and social dimensions such as class, gender and geography leads to a political economy understanding of energy inequalities (Bracking 2003; Sovacool 2012). Further disempowerment of the already disadvantaged is a serious risk, as inequalities widen between these different groups under altering political and economic climates, as witnessed in the energy crisis period from 2021.

Whilst the energy transition presents opportunities for democratisation, due to the socio-technical nature of emerging technologies and the entry level of skills, time and material capability required to benefit and engage means that those struggling and without are more likely to be left behind as other sections of society benefit (McGee and Greiner 2019; Stewart 2023). Therefore, genuine sustainable and regenerative human development demands a reckoning with the wide-ranging impacts of energy systems.

With a globalised energy supply chain particularly reliant on fossil fuels, volatility in the market and record prices for gas, oil and electricity has been observed. Energy prices have been on the rise globally for decades and though increases are geographically uneven, UK prices as shown in Figure 2 provide a snapshot of the picture. At its core, energy equity is the acknowledgment of the primary function of energy to fulfil basic needs and services and that no humans, regardless of their material wealth, should be prevented from benefitting from it. Energy inequalities will go on to be discussed at length as a primary concern which this thesis aims to analyse and address.

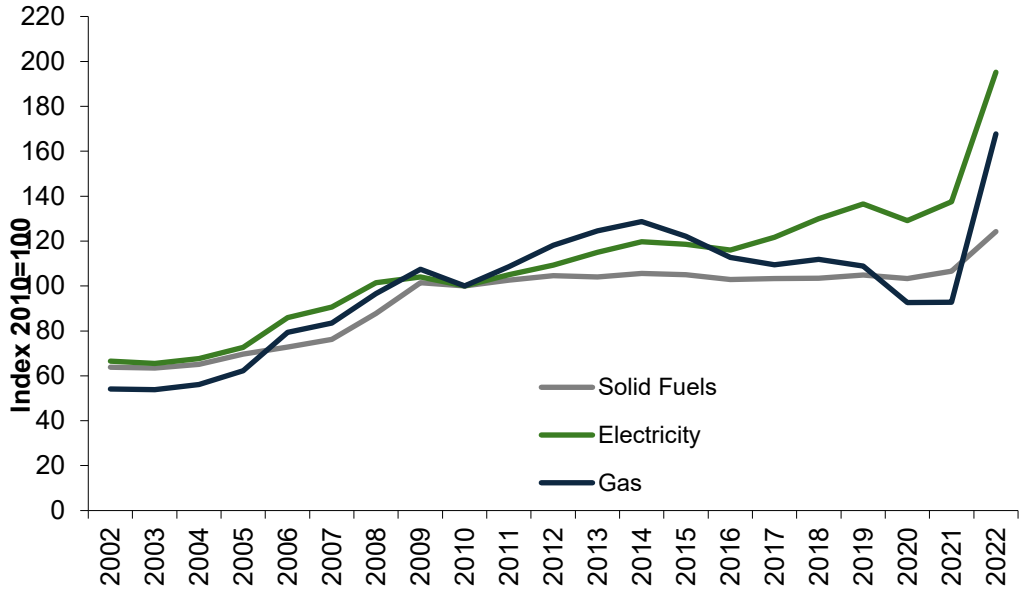

Figure 2 Fuel price indices in the UK's domestic sector in real terms (BEIS 2023)

Energy security

Security of supply has also risen to the fore in developed nations in ways not seen for decades. Responses to an over reliance on oil and gas from governments have included new national strategies, demands for behaviour change from citizens and infrastructure measures to guard against power and fuel shortages. The recent developments in the global energy system linked to Ukraine and fossil fuel markets have brought current energy systems into public attention and prominence in policy making circles. Thus, demonstrating the degree to which the trilemma challenges and balance is insufficiently served. It also has illustrated the contested and geopolitical nature of energy resources as the balance of importers and exporters is thrown into contention with political instability. Further, as energy resources form the backbone of some national economies, and are a socially and culturally contested phenomena, reliance on and the ability to change energy source in a globally connected system is significant challenge. Whilst this may appear a primary characteristic of the age of oil, renewable energy resources as well as the technology to access them may also suffer from similar geographical insecurities.

Longer-term trends also provide concern over the need to transition to more sustainable energy systems. Fundamentally, fossil fuel reserves are finite, and energy usage continues to grow across the world as varying development pathways are followed. Therefore, longer-term solutions are required to address energy generation and usage demands. Though the intermittency of some forms of renewable technology is a serious issue to overcome on the

scale required, a move to localised, indigenous energy sources where possible, whilst reducing demand through efficiency and behavioural changes, is essential as part of a transition to a secure energy future.

1.2 The UK's transition

Having provided an overview of the energy transition from a global perspective, this section zones in on the UK and Scotland's transitions, which have characteristics and context that present unique challenges for any MWT industry. To understand the energy sector landscape and the policy challenges of today, there are several key stages of development worth examining. Beginning with the 1970s oil crisis, which impacted energy security policy in countries across the world, leading some to invest in alternative energy resources and technologies, such as wind power in Denmark and district heating in many parts of Europe. An alternative approach was taken in the UK which focused on domestic coal and natural gas reserves (Millar et al. 2019). This transition from oil boilers to coal and gas utilisation was more disruptive and transformative than the response in other nations and set the scene for the heavily fossil-fuel dependent and household level residential heating configuration seen today. The lock-in effect of fossil fuel domestic heating solutions felt today can be traced to this period and is worth unpacking.

During the 1980s, the political decision was made to decouple the generation, transmission, distribution, and supply by privatising the publicly owned institutions previously responsible for all undertakings and to open up energy markets to liberalisation (M. J. Hannon et al. 2013). This period began with the Gas Act 1986 and the Electricity Act 1989, and the process of liberalisation continued with speed through the 1990s, producing a range of distinct private actors and legislative mechanisms in the energy sector (Pollitt 2012). The so called "dash for gas", coupled with the market changes over this period produced a period of low prices and supply abundance, meaning that changes to the energy sector at the systemic and individual level were of low priority, producing a "lock-in" effect still felt today. The mandating of condensing boilers in 2003 represented the most significant intervention and development in the UK heat policy over this period (M. J. Hannon et al. 2013). Towards the end of the 2000s the situation changed, with the UK becoming a net importer of both gas and energy overall, in part due to diminish north sea reserves. Further, the Climate Change Act in 2008 committed to a transition away from fossil fuels. General economic uncertainty looming from the financial crisis along with rising gas and electricity prices pushed millions into fuel poverty ('House of Commons - Fuel Poverty - Energy and Climate Change', n.d.). This combination of critical factors exposed the incumbent energy system and policy apparatus as un-fit for purpose in meeting emerging objectives.

The basis of the UK's energy transition is similar to that outlined in the previous section, facing challenges relating to affordability, security and environmental sustainability. As well as having global obligations to emission reductions under the Paris Agreement, the UK has its own targets under the Climate Change Act (2008). It includes five-year period carbon budgets, which incrementally map the pathway in meeting the updated 2050 net-zero emissions target. 2021's net-zero strategy sets out the UK Government plans to attain that target, as well as an emissions reduction of 78% by 2035 from 1990 levels. The progression of the UK's energy transition from the selected baseline of 1990 can largely be attributed to the switching from coal power generation to natural gas, and the increase in renewable power generation with territorial emissions in 2021 being 48% lower than 1990 levels. However, within this measurement, there is discrepancy in accounting terms between consumption based and territorial emissions. Figure 3 demonstrates the UK territorial emissions by sector, including buildings which accounts for heat emissions. The scale of the challenge to meet net-zero by 2050 is significant and according to the Committee on Climate Change (2024), the independent advisory body to the UK Government, the progress necessary has not been seen. Particular challenges remain in key areas around transport, buildings, agriculture and construction.

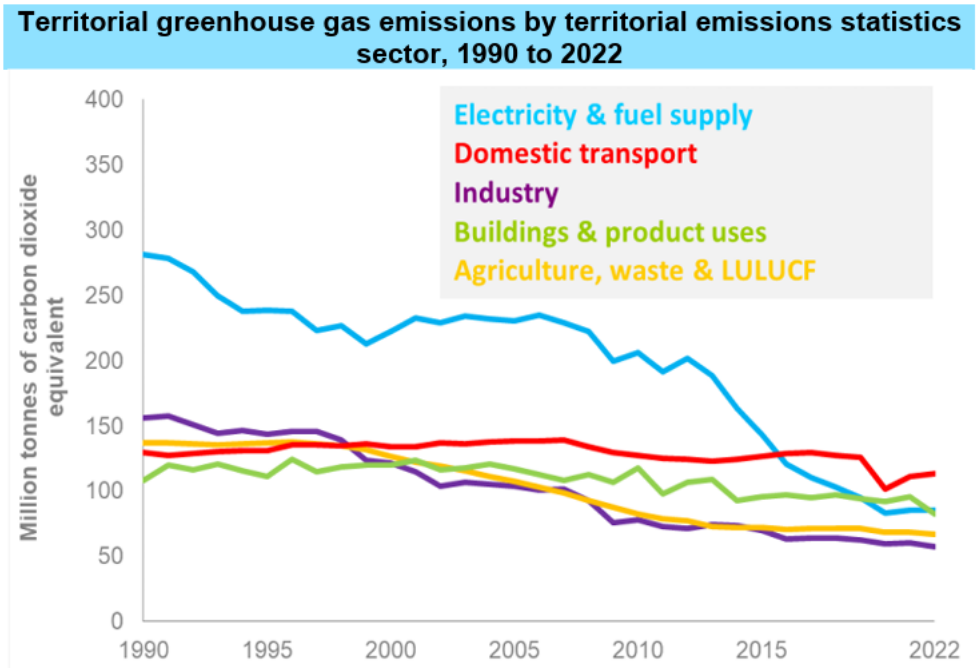

Figure 3 UK energy emissions by source (UK Energy in Brief 2024)

The energy crisis period beginning in 2021 has had a profound impact on energy systems and policy, acutely felt in the UK. Though energy prices have been on the rise over a significant period and the UK has been a net importer of energy for several years, in 2022 energy security and energy equity were under intense scrutiny and arguably became the

primary concerns of energy policymaking and wider discussion. Though invariably connected to net-zero developments, as new clean generation and energy efficiency remain two of the most effective ways of tackling all aspects of the trilemma, climate concerns were somewhat side-lined and, in some cases, criticised for their role in the energy crisis. However, during this period the UK Government produced a new Energy Security Strategy and a new department for Energy Security and Net zero, recommitting to growth in indigenous renewable energy generation as a way of tackling insecurities. This was reinforced by the UK's biggest ever net zero review, which delivered wide recommendations to the Government underlining the positive relationship between net zero and economic growth (BEIS 2023). Over-reliance on volatile international markets is strongly identified as a policy error, and the energy security strategy identifies new generation from nuclear, hydrogen, offshore wind, solar and further oil and gas licensing as ways to achieve a more independent system. However, the need for greater detail and long-term public support to drive change in the present remains somewhat lacking, and even though renewables accounted for around 40% of the UK total generation in 2022, prices remain set by fossil fuels.

Running parallel to the security challenges has been a cost-of-living crisis largely driven by the cost of energy. This period has been dominated by ever increasing energy bills and record profits by energy companies. The Energy Price Guarantee was introduced by the UK Government which set an average household bill at £2,500 in September 2022, rising to £3,000 in April. This unprecedented action has been criticised as a sticking plaster solution, however the scale of impact from the energy price rise has seen fuel poverty numbers rise over the same period from 4.5 million households to 6.7 million (NEA 2023). The impact of this economic burden is arguably immeasurable once the full work, health and well-being effects are considered. Over this period a strong consensus on climate action was present amongst both the public and the political class. However, in light of the pressures described above, there is a suggestion that the consensus is faltering (UK GOV 2024). Major political parties are shifting positions on net zero and public support is showing signs of decreasing amongst a growing critique of the costs and burdens of the energy system and increasing inequality in society.

1.2.1 Scotland's energy transition

Scotland's energy transition, as being part of the UK both constitutionally and through shared infrastructure, faces many of the same challenges as the UK wide transition, but with distinct characteristics and governance that has made it stand out. The Climate Change Act Scotland (2008) places legally binding targets for net-zero emissions by 2045, ahead of the

UK Government. As with the rest of the UK, Scotland has been heavily reliant on fossil fuels through its own coal industry, wider UK power systems and the oil & gas reserves found in the North Sea. The unique geographic features of Scotland have tended to put it on a slightly different energy pathway from the rest of the UK, typified by the hydro power schemes of the 20th century and experimentation with micro-grids (SSE 2025). Further, the scale of renewable energy resources in Scotland is significant and has to some degree been tapped into at rate ahead of the UK, with renewable power generation equalling 95.9% of electricity demand in 2021 (Scottish Government 2022).

In the context of Scotland's energy transition and taking the proposition of MWT into account, there are two streams worth exploring here in further detail. First, the challenge of decarbonising heating, both residential and commercial, which has significant difficulties relating to technological lock-in and behavioural change. Running adjacent to heat and of key importance to power is the need for the energy system to integrate storage and flexibility. Viewing these three system challenges together has prompted discussion of whole system approaches, decentralisation and integrated smart systems. The final element worth exploring is that of local and community energy, which as a practice and movement has grown significantly in recent years though now finds itself at difficult cross-roads as policy changes and the socio-technical challenges described above rise to the fore. These aspects are addressed in the context chapter later in the thesis; however, a broad overview will be provided here to introduce and frame the challenges relevant for MWT development.

1.3 The heat transition in Scotland

In this section Scotland's heat transition is examined, as part of the wider energy transition, encompassing environmental, social, political and economic goals. This is important as the development of MWT technologies is a niche innovation which provides an alternative source of thermal energy with the potential to contribute to this heat transition. It is one of the main policy areas in which the insights from this thesis can contribute, although as discussed, the wider energy economy, as well as the political economy of Scotland are interlinked, and insights can translate across from a governance perspective. As per the governance arrangements of Scotland, much of the context discussed is from a UK perspective first, further, heat specific data is often only available for the UK.

Following surface transport, space heating is the second-largest source of greenhouse gas emissions in the UK. Accounting for 17% of total emissions, and estimations of 13-14% of those are specifically from residential housing (Energy Systems Catapult, n.d.). Space heating and hot water comprise the total residential demand, which is overwhelmingly reliant

on natural gas (74%) and petroleum (10%) as of 2019 (UK Department for Business Energy & Industrial Strategy 2023) . Heating and cooling accounted for 51% of the global energy demand in 2018, with 10.2% of that met with renewables. Although in some countries such as Norway and Sweden less than 10% of their heating demand is met by fossil fuels, in Scotland, 81% of homes rely on mains gas for heating and the Scottish Government estimate that £33 billion will be needed to reach net zero heat (The Scottish National Investment Bank 2022). Of Scotland's 39.6MtCO_2e total net emissions in 2023, buildings account for the second highest proportion at 7.7MtCO_2e (Scottish Government 2025).

Additionally, the UK has the oldest housing stock in Europe, meaning energy use in typical homes is higher than for elsewhere on the continent, due to poorer energy efficiency in older housing (Humphreys et al. 2011). Figure 4**Error! Reference source not found.** illustrates the comparative effect of housing quality on temperature loss, from a survey of over 80,000 homes. Furthermore, houses are predominantly owner-occupied, though the private rented market is responsible for the greatest concentration of homes facing fuel poverty (Climate Change Committee 2022).

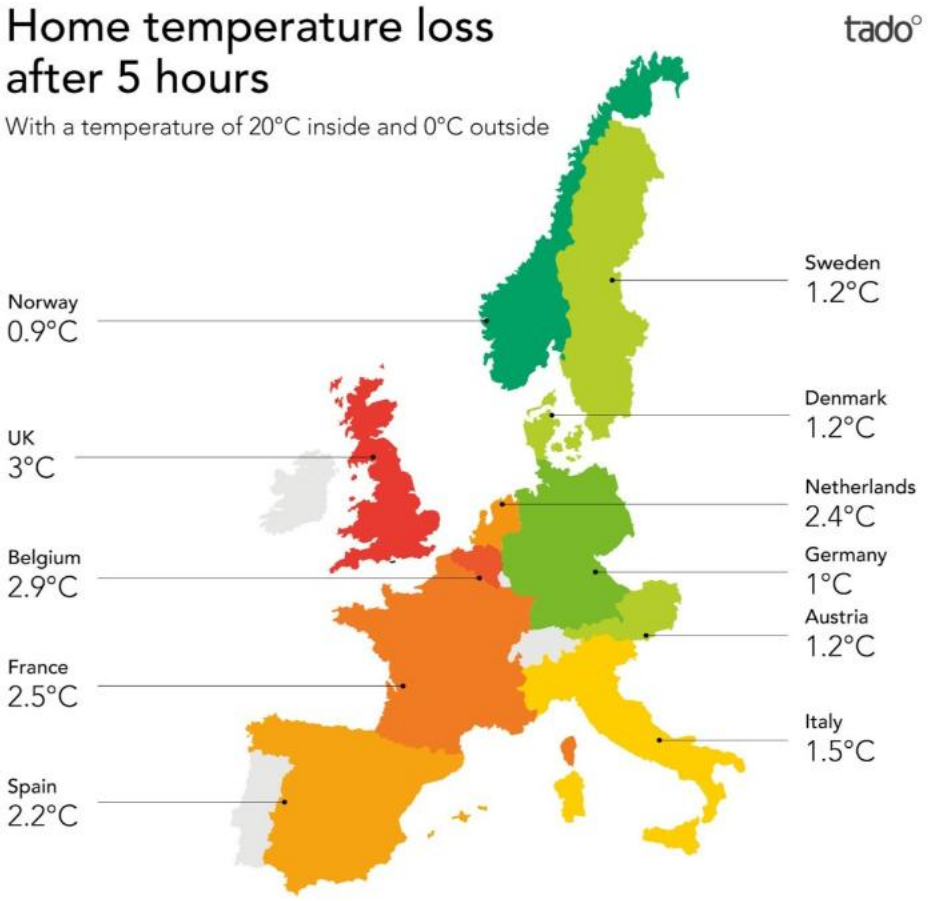

Figure 4 Impact of inefficient housing stock on inside temperature (Tado 2020)

The UK heat sector has historically been from both policymakers and scholars within the wider energy transition (Lowes et al. 2019). The scale and multiplicity of the challenges to decarbonise and improve heating in the UK is significant and greater than for many neighbouring countries. However, this also means that the scale of benefits that can be accrued are immense if opportunities are harnessed. Impacts may include job creation, lowered energy bills, improved living conditions and less volatility of supply, all of which have cascading benefits across society. However, in the time since the Climate Change Act and the shift in energy policy strategy to include decarbonisation, progress has been sluggish (CCC 2024). Thus, there is much progress to be made in the decarbonisation of heat in Scotland. In next two section, two critical aspects of Scotland's energy transition are explored, MWT and community energy.

1.4 Minewater thermal energy overview

Having explored the wider contextual detail of sustainability transitions and narrowed down to Scotland's heating sector, this section discussed the technological focus of this thesis, MWT. Whilst the engineering and technical aspect of MWT are not the focus of this thesis, its developmental history, fundamental principles and configurations are presented in order to set an appropriate level of understanding for the research.

MTW technologies utilise the water found in former mine workings as a source of thermal energy, either through its geothermal potential or as a vector of thermal energy from other sources (Peralta Ramos et al. 2015). Utilising the potential of flooded mine workings as a heat source has been understood and demonstrated since the 1980s in places such as the USA, Germany and Canada (Walls et al. 2021). Active mines require inflowing water to be removed for normal function, this can be achieved through gravity drainage systems for shallow mines and active pumping in deep mines (David Banks et al. 2022). Once mines are abandoned, the pumping system may be switched off whereby the mine will fill with groundwater until it overflows at the surface level. In the UK, the Coal Authority estimates that over 3000 litres of minewater is pumped every second from abandoned mines to avoid damaging overflows (Farr et al. 2016).

The primary configuration of MWT systems involves removing the heat found within the water and dispersing it through a heat network to different users. This is usually achieved through a district heating system. The design typically involves the use of a heat exchanger to capture the minewater heat, before a heat pump upgrades the heat to a suitable temperature for delivery to the user (Walls et al. 2021; Farr et al. 2016). Another element is the ability of minewater to be used as an energy storage vessel. In addition to heating,

commercial or industrial cooling is an alternative and complimentary use which is likely to become more important as climate change impacts are felt. Here, the waste heat from the cooling process is transferred back to the minewater to allow for thermal buffering and replenishment.

As the coal industry contracted in the latter half of the 20th century and following period, mine closures created a new set of socioeconomic and environmental issues. Underground mines required continual draining to allow normal operation in dry conditions and upon closure, the problem of managing water levels is one of the key challenges in managing sites. To avoid contamination and ground stability risks, in many sites water is continuously pumped out of the mines at considerable cost. The journey from active coal production to MWT operations is outlined in Figure 5.

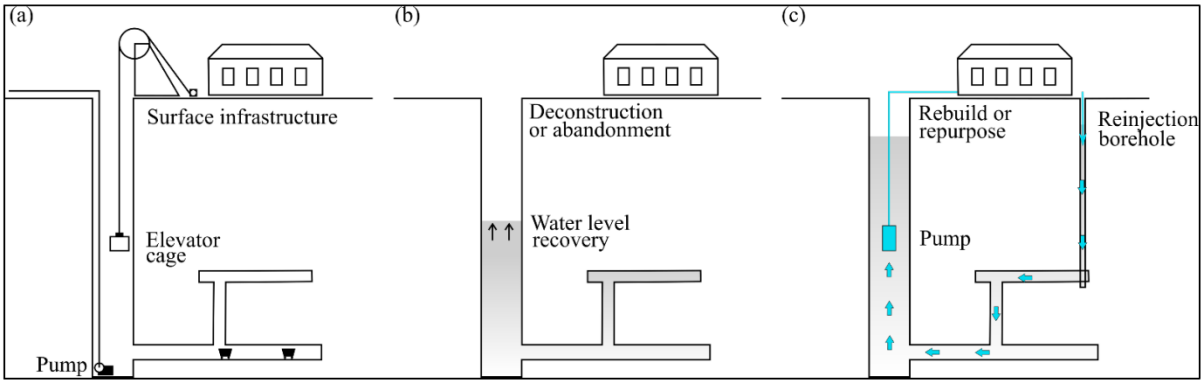

Figure 5 History of a mine from active mining (a) to closure and flooding (b) and use as a MWT system (c) (Walls et al. 2021)

Minewater heat resources can provide a stable year-round temperature compared to other variable heat pump sources which leverage sources such as air, river or shallow soil (David Banks 2012). The depth of the mine has an impact on the temperature profile as shallow mines are influenced by the ground and atmosphere to a larger degree, while deeper mines are warmed by the geothermal profile of the surrounding rocks (Walls et al. 2021).

Depending on the particulars of a proposed MWT development, both technical and economic factors will shape the type of system that is viable. The different arrangements and suitability are directly related to parameters such as the thermal conductivity of the rocks and the size of the resource and demand. Locational factors play the largest role in the technical arrangements of a system. In their review of minewater heat projects Peralta et al. (2015) found the temperature to vary from 6 to 28 °C and the extraction depth from 50m to 700m.

MWT technology is revisited in Section 7.3 in the Context Chapter, where major social challenges are discussed alongside an overview of existing projects today, presenting a

state of play for the technology. The other relevant aspect of Scotland's energy transition necessary to discuss in this introduction chapter is local and community energy.

1.5 Local & community energy

Local energy is a somewhat broad term that captures a range of activities, practices and organisations in which there are varying degrees of local involvement present in an energy venture. The term community in this context, is one that is nebulous and even contentious (Delanty 2002; Bradshaw 2008). The idea of communities of place and communities of interest is one prominent attempt to begin to define the meaning. This thesis acknowledges that attempts to quantify and define community to any fine degree are by nature of the concept, not entirely possible or desirable and that communities emerge in more organic and diffuse ways both spatially and temporally. Here, community energy is conceived as being grassroots led, inclusive of participatory decision-making and a degree of, if not complete community ownership (Haggett and Aitken 2015; Seyfang et al. 2013). Taken from Hannon et al (2024), the following definition is used in this thesis:

> "A community is a collective of people who are connected through a shared sense of identity, which is distinctive either in terms of place, such as a defined geographical boundary and/or practice, such as shared interests, motivations and values."

This concept of community energy can take form in looser ways, though commonly it is captured through legal structures and business models. For example, the development trust model is more firmly rooted in place than the co-operative model in which communities of interest come together despite geography. The technological accessibility of some forms of renewable energy mean that community energy as a phenomenon, is almost entirely geared towards a sustainable energy transition, through small-scale decentralised renewable sources (Brummer 2018). As such, national governments have created policy frameworks that leverage the potential of local energy to contribute to national energy transitions. In the UK, a marketized approach was taken with a feed-in-tariff scheme introduced for a period aimed at projects of a limited size, and planning support for onshore wind and solar energy was suspended (Slee 2020).

Whilst community energy initiatives have arisen across the whole of the UK, state support has been more forthcoming in Scotland than elsewhere, with legislated targets of 2GW of community and local ownership by 2030. According to the State of the Sector Report of 2024, Community Energy England estimate 398MW of community energy capacity is installed across the UK, contributing £12.9 million towards local economies (Community Energy England 2024). In Scotland, targeted support is available through grant funding,

capacity building, and dedicated bodies such as Local Energy Scotland. The majority of projects are located in the Highland and Aberdeenshire local authority areas, which as rural areas contain a large number of estates and farms where a majority of capacity is found. The spatial trend is in part a result of the earlier development of community energy in Scotland, which was primarily based in rural areas and driven by community development trusts (Slee 2020). The movement for land access and community empowerment, occurring in parallel and legislated for through different parliamentary acts has brought relevancy and urgency to the community energy movement in a way that is unique to Scotland.

The community energy sector can be understood as having a diverse range of actors, business models, technologies and institutional involvement. Challenges for community energy are equally diverse, with access to financial capital being the most common barrier (Haggett and Aitken 2015). In part due to the perceived risks of community energy, attracting investment or a community taking it on themselves is a serious undertaking. Issues of capacity are also key, with a lack of time, knowledge, skills and experience found in many communities that have the potential to engage or develop a local energy initiative.

Two other important aspects include social cohesion and capital, and access to land and infrastructure. Social cohesion is important because of the stresses associated with developing an energy project, which can lead to conflict and division. Organising is a serious task, and there is evidence that communities that have organised before engaging with energy initiatives, and have a degree of shared identity are more likely to be successful (Haggett et al. 2013; Bell et al. 2013). Access to land is also a significant barrier for communities, where private and various forms of public land ownership make it difficult for communities to proceed. Scotland has particularly concentrated private land ownership, and many of the most prominent community energy projects have come concurrently with community land buyouts (Skerratt 2013).

Whilst community power accounts for nearly all of the UK’s community energy capacity, community heat is an area of potential as momentum builds in the wider heat transition. Despite the potential for community heat to directly address local fuel poverty and retain economic value, community involvement in heat remains limited. The last update provided by Community Energy England (2024)on community heat in 2024 showed 4.8MW installed with a further 5.7MW planned and only 28 organisations across the whole of the UK involved with heat, all of which used the previous RHI scheme. Significantly lower figures than that of electricity installation and planned schemes. Close to 2/3rds of community heat capacity is from biomass, with the rest made up from heat pumps and solar thermal. In the report, high

capital costs, lack of technical expertise, and problems securing investment against long-term heat demands were all cited as challenges to community heat networks.

The growth of community energy initiatives in the UK has stalled, directly related to the changes to the policy support, upon which the successful business models relied (Braunholtz-Speight et al. 2021). As such, alternative arrangements, partnerships and a diversification of activities is essential for the renewed growth of community energy projects. As community energy has developed, appreciation of the range of impacts and possibilities offered has evolved. Not only as a way to get communities on side and to enable emission reduction targets, but as a distinct practice that achieves social and economic benefit through empowerment and regeneration, tackling fuel poverty and increased skills and community cohesion (van Veelen 2017). In the context of MWT development, the kind of social and economic challenges facing communities in former mining areas requires transformative sustainable solutions which promote regeneration and empowerment for local areas. Therefore, the potential for community energy as a social innovation for sustainable futures is an important area of focus for this thesis.

1.6 The political economy of our times: deindustrialisation and neoliberal governance

Being located in areas of former mine workings, MWT is by design, centred around particular social, cultural and economic legacies from the former mining industry. Indeed, sustainability transitions in former coalfields have been the subject of discussion as coal is phased out entirely, where questions of just process are prominent (Johnstone and Hielscher 2017). In a State of the Former Coalfields report, Beatty et al. (2019) analysed a range of socioeconomic indicators that set out the distinct nature of the UK coalfields. In terms of employment, 55 employee jobs per 100 residents of working age, compared to a national average of 73. Further, an estimated net number of workers have to commute out of the coalfields, around 370,000 against a total population of 5.7 million. Median earnings are around 8-10% below the national average and around 42% of all coalfield neighbourhoods sit within the most deprived 30% in the UK. In summary, the coalfields lag behind on several national averages, on local economic performance as well as socio economic disadvantages and prevalence of ill health.

In the face of stark disadvantages compared to other areas of the UK, it is worth exploring how and why the former coalfields are found in their current situation, centred around the processes of deindustrialisation and neoliberalism, processes which significantly shaped the world lasting until present day. Industrial manufacturing and coal mining played a significant

role in the UK economy over centuries, intensifying around the turn of the 20th century through until relative decline from the 1960s. This decline, it has been argued, reflects structural imbalances and weaknesses in the UK economy that persist today, resulting in a range of inequalities experienced by people living in different areas of the country (Kitson and Michie 2014). A focus on short-term returns and the financialisation, coupled with a lack of investment and disruptive policy for industrial areas led to extremely uneven growth between regions.

The closure of the coal mines in the UK is acknowledged as one the most intense and rapid deindustrialisation processes in the developed world as the period of contraction and transition from the 60s through the 70s accelerated and employment and operational pit numbers collapsed in the following decades (Glyn and Machin 1997; Beatty and Fothergill 1996). In the 1980s, coal accounted for as much as 80% of the UK's electricity generation, whereas by 2022 UK coal demand was at its lowest since 1757. This period has been considered an example of an 'unjust transition' which has left coalfield communities and areas as some of the most economically depressed parts of the UK (Bang et al. 2022; Beatty et al. 2019). As local economies and social life were left to decline, mining communities have expressed a sense of abandonment, with this sense of struggle continuing today. Figure 7 below demonstrates the falling employment in the coal industry in the UK across the 20th century.

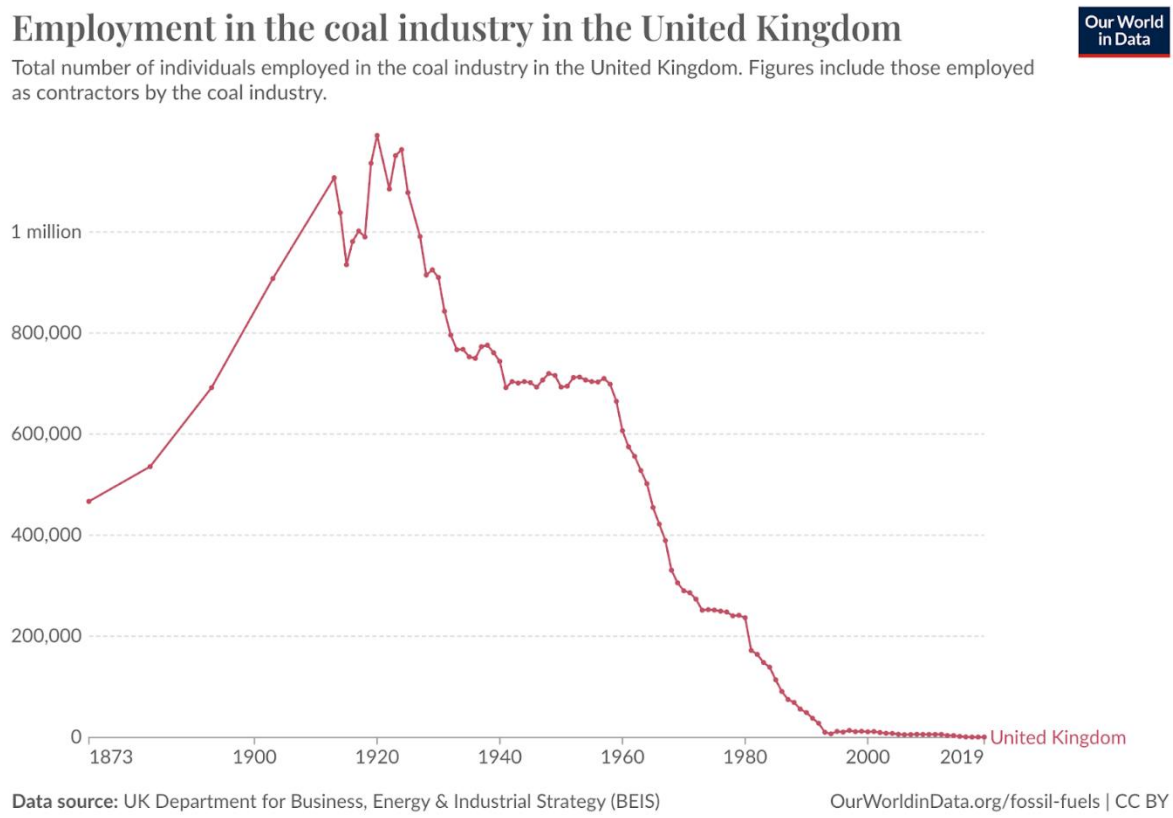

Figure 6 Decrease in employment in the coal industry in the UK. A result of both falling coal production and workforce consolidation (‘Historical Coal Data: Coal Production, Availability and Consumption’ 2024)

Deindustrialisation developed in distinct spatial patterns and signified a shifting base of political and economic power within regions of the UK, in a process seen across parts of the western world. Spatial and geographical dimensions of inequality are prominent areas of focus for academics, policy makers and practitioners as causal understanding for disparities between different areas globally, nationally and locally, is sought. In a globalised world, this question becomes more complex as regional economies face market-led pressures from not just neighbouring areas, but vastly different socioeconomic regions across the world.

One defining practice is the role of centralisation or decentralisation within economies and politics, with respect to redistribution and efficiency. The UK has been described as “almost the most centralised developed country in the world” by a former HM Treasury secretary (Global Government Forum 2015), despite broad claims from the UK and devolved governments in support of local governance and devolution. Lessmann's (2012) study of 54 countries found that in developed nations decentralisation decreased inequality. One-size fits all and top-down approaches to funding, taxation, infrastructure and other areas sees regions in sharp competition with each other and fitting local needs to pre-defined central

directives. This centralisation is reflected in the regional inequality found within the UK, being one of the most geographically unequal countries in the industrialised world (McCann 2020).

With a lack of institutions and industries, the low-income regions of the UK, such as the former coalfields suffer from underinvestment and its effects. This includes limited skills and educational opportunity, lack of infrastructure and connectivity, loss of youth to higher income areas, appropriate skill matching, environmental degradation and the range of household social, economic and health disadvantages previously discussed. Many place-based approaches have failed to tackle the structural causes, and do not mobilise or centre around under-used human and local resources within such regions (Iammarino et al. 2018). As such, the severe regional inequality in the UK is a source of discontent politically and can be directly traced to processes of the neoliberal era, including the significant wave of deindustrialisation in the 1980s (Rice and Venables 2021).

The geographical and temporal contexts are important for decarbonisation and sustainability transitions, where more questions relating to justice, equity and fairness contend that multiple social inequalities must be addressed to provide resilience, which includes local and regional focussed development (Abram et al. 2022). There are important driving forces and illuminating lessons in the political economy, and use of power in the regional inequality conditions found in the coalfields. This will be explored, along with the distinct features of the Scottish coalfields and deindustrialisation later in the context chapter of this thesis.

1.7 The just transition and place-based policy agendas

The issues outlined are long-standing structural challenges that remain unaddressed and as such, require alternative, transformative and regenerative practices and policies which can deliver on the sustainability, energy and empowerment transitions required. These ideas acknowledge inequalities arise specifically from energy industries, but also social systems more broadly, they are inclusive and aim to widen democratic participation and are also rooted in place-based and place-sensitive approaches, meaning that spatial and temporal injustices and difficulties are tackled. Building on such foundations will allow for alternative approaches to emerge, which differ significantly from dominant development approaches and in which long-term, regenerative sustainability is possible. The just transition is the most common alternative policy discourse observed in the context of Scotland's heat transition.

In a broad sense, the 'just transition' paradigm is one that aims to bring together environmental, social justice and labour issues as sustainability transitions unfold, beyond technocratic tendencies (Harrahill and Douglas 2019). It emerged from the labour movement in the US during the latter half of the 20th Century and in more recent years has risen to the

fore in different national and international policy contexts, though the term remains contested (Pinker 2020). Originally focussed on worker welfare and job protection as well community and environmental health, trade unions have been at the heart of just transition practice since its inception and continue to play a central role. An evolution in the meaning, use and intention behind just transition activity first broke into wider prominence with the “Just Transition Declaration” in 2018, which was further developed and supported at COP 26 (COP 26 2021). Signed by over 30 countries, The International Labour Organisations guidelines were at the heart of the plans, which singles out social inclusion and the eradication of poverty as primary aims of a holistic transition to environmentally sustainable economies and societies.

At the national level, Scotland has become among the first countries in the world to formally engage with the just transition, with the creation of a “Just Transition Commission” and subsequently an appointed minister for “Just Transition, Employment and Fair Work”. The commission has produced several reports in which it examined various sectors of the Scottish economy, suggesting what a just transition might look like as well as advice on particular challenges and areas of concern. The Scottish Government produced a response and have published an Energy and Just Transition Plan, which intends to set out Scotland’s energy transition to net-zero over the coming decades. Some of the commitments include, encouraging all new developers to offer community benefit and shared ownership as standard, and working with local authorities to produce area heat and energy efficiency strategies. However, the majority of the actions offered centre around developing skill development plans, continual support of existing advisory agencies, and funding to support the green job market. Clear, detailed plans for citizen, community and democratic empowerment is lacking, and whilst there is ambitious language and understanding of the transformative potential of a just transition for Scotland’s communities, it remains somewhat unmatched in action as of yet, and fails to deal with critical issues of equity, justice and participation. Interestingly regarding former coal mining communities, the Scottish Government’s response to the Just Transition Commission report stated:

> “Scotland continues to bear the scars of poorly managed, abrupt and unplanned transitions of the past. Despite decades having passed, many of our coalfield communities remain disadvantaged in relation to education, employment and income levels compared with the rest of the country. The experience of deindustrialisation has been shown to have long-lasting social impacts, such as poorer health outcomes for people in areas affected by these events. We won’t let history repeat itself.” (The Scottish Government 2021)

Beyond the manifestation of the just transition concept in labour movements, policy and practitioner circles as outlined, there are theoretical and alternative applications which encompass varied and wider-ranging ideas about what a just transition might represent. As discussed earlier with regards to sustainability transitions, there are different conceptions of a sustainable society and how it can be achieved. Harrahill and Douglas examine what a just transition would look like under “weak” and “strong” sustainable development, as policies and industries can be sustainable but unjust when sustainability is weakly defined.

In direct polarity to a “weak” transition, “strong” sustainable development extends democracy, decouples environmental action from the sole interests of capital and profit, moves ownership and power away from incumbents towards niche groups. This would require transformative approaches to economic and social policy towards more regenerative practices at all levels of society. It is also worth considering the converging movements for environmental justice, climate justice and energy justice, through which the meaning and intent of a just transition is dependent. Built upon justice principles and social effects of different anthropogenic activities, whether it be local or international, there is an acknowledged gap within the justice literatures between theoretical and rhetorical claims and practice relating to a just transition (Jasanoff 2018; Heffron and McCauley 2018).

This thesis will address the just transition concept in particular the ties to various cross-cutting approaches to place-based and inclusive economic development. Further alternative approaches are dissected in the literature review, in Chapter 3 which explores the political economy of energy transitions, embedded in the contestation of hegemonic and counter hegemonic ideas.

1.8 Developing a research focus

In this introduction chapter, background and rationale has been presented for the study of a potential MWT industry in Scotland. The following initial problem statement guided the development of a research focus:

> Minewater resources exist in a challenging social, economic and cultural context, across scales. National energy economy challenges relating to environmental sustainability and social equity transmit down to the local level, where energy infrastructures hugely impact lives in a historical context of deindustrialisation.

The justification and reasoning for this research focus is in some ways, very clear; minewater geothermal energy is an emerging and yet to scale renewable energy technology at a time where market, policy and societal conditions appear to be at a juncture, requiring

novel socioeconomic development approaches. Further, geothermal energy is critically understudied from a social science perspective. Whilst such enquiries have been taken as the backbone of this research, it is the wider societal, political and economic challenges and knowledge gaps, of which MWT sits at the cross-section, that give urgency and significance to this work. There are several pressing practical agendas in which this research is situated, which are covered broadly here and explored in detail later in subsequent chapters.

Energy transition

First of which being the energy transition, where providing heat and flexibility is of particular difficulty. Changes in the energy sector can be considered as part of wider 'sustainability transitions', which according to different perspectives can include solely environmental and climate related practices, through to holistic global resource management, and all human political, societal and economic behaviours which do not provide certainty of their long-term impacts and sustainability.

In Scotland and other global political arenas, the just transition concept has gained significant traction, where any sustainability transition is geared towards socially just outcomes. The seriousness and use of this framing requires further exploration and critique, which is an important cornerstone of this thesis. Further, through the prism of MWT development, this thesis aims to contribute to energy and sustainability transition knowledge, with a particular focus on grassroot innovations in emerging technologies and markets. Perceptions of the energy sector have moved with pace towards that of one that is socio-technical in its fabric. The move away from techno-centric perspectives bring further emphasis to the social and justice implications of energy systems.

Economic inequality

Following this, the second contextual challenge is that of regional economic inequality, sustained levels of multiple deprivation in such regions and an entrenched democratic deficit. Put differently, the disempowerment and decline of particular areas and communities. The kinds of severe place-based inequality in focus should not be considered a neutral or natural evolution of development but can be directly attributed to power structures, social relations and ideologies. Whether it is the inequalities experienced between the global north and south, or the disempowerment relating to deindustrialisation, job loss and changes to the international division of labour, a political economy approach is central to understanding the conditions of the present. The insufficiency of current and past approaches is clear and by acknowledging the unjust policies and agendas that have driven inequality, space opens

up for alternatives. Therefore, for post-industrial regions of the global north in particular, new transformative thinking is required and essential in assuring long-term sustainable development.

Reimagining former coalfield communities in the energy transition

Following from the two dimensions of energy transition and widening inequality, there is a third dimension, namely, the future of former coalfield communities which has largely been absent in policy and research discussions. As has been discussed in this introduction chapter, the context and challenges that converge on this topic area mean that the study of former coalfield communities is a critical perspective in which to advance knowledge on heat policy, just transition and community wealth building. Further, because of the challenges of imagining just energy futures and the legacies of injustices related to coal mining towns in Scotland, a focus on imaginaries, justice and political economy is an important intersection for addressing issues that while signposted in wider literatures and policy, have not been sufficiently researched especially in relation to MWT. With this focus emerging, research questions began to emerge, which guided the literature review. These are now discussed in the following section.

1.9 Research questions

The following overarching research question which guides this research was developed:

> What drives and shapes the formation and implementation of minewater thermal energy industry imaginaries for a just transition in Scotland?

Three subordinated research questions emerged in order to help answer the overarching research question. These are as follows:

1. What are the perceived opportunities and challenges facing Scotland's minewater thermal energy industry?
2. What are the collective alternative energy imaginaries as both a process and outcome for minewater thermal energy futures?
3. What forces are enabling and/or disabling the imagining and implementation of alternative economic development minewater thermal energy futures?

In order to answer these research questions, this thesis uses a theoretical framework that draws on several scholarly areas which are explored in depth in the literature review chapters. The first is sociotechnical imaginaries, which builds on a sociotechnical systems approach. It builds on the imaginaries literature in several ways, perhaps most importantly

adding in dimensions of power and politics to articulate the ways in which changing social landscapes and interactions with technological development are experienced by different actors, with a particular focus on future making, deeply connected to past and present meanings, and knowledge conditions. The second is understandings of political economy and development that critique the drivers and delivery models of the energy economy. It interjects the concepts of hegemonic and counter-hegemonic ideas, and the forces within the political economy which co-opt and contest energy transitions. The third can be articulated as social justice theory and its manifestations in energy through theories of energy justice and just transitions. This theoretical perspective enhances analysis with an understanding of conflict, how to identify and modify patterns of domination and systemic societal conflict. It allows evaluation of historical evidence and conditions, and thus, this structural analysis can lead to “liberation” from such conditions by demonstrating what kinds of change are necessary within development pathways.

The methodology at its core is rooted in participatory approaches to qualitative data collection, whereby knowledge is co-developed with the participants and the researcher, utilising ethnographic and case study methods. The data collection is split into two stages. The first phase aims to uncover the characteristics, challenges and opportunities relevant to a future MWT industry situated within the existing regime and landscape of Scotland’s energy economy, collecting data primarily from semi-structured interviews with sectoral professionals. The second phase consists of an in-depth case study of a former mining community, in which grassroot perspectives on the potential development of MWT emerge from focus group workshops. Utilising the analytical framework, contributions are then highlighted from theoretical, empirical and methodological aspects of the findings. Finally, practical and policy recommendations are discussed at economic and socio-cultural levels. As the research focus described here emerged, research questions were developed to direct the study.

1.10 Thesis Outline

This thesis consists of eleven chapters. In this introduction chapter, the background, rationale and main themes have been outlined, the research questions and structure are also presented.

In Chapter 2, the literature on sociotechnical imaginaries is reviewed. Touching upon sociotechnical transitions literature, the Multi-level perspective and grassroot innovations before exploring the imaginaries scholarship. After a thorough dissection of the concept,

including its strengths, weaknesses and research gaps, its usefulness for the study of a potential MWT industry is highlighted.

Chapter 3 examines the political economy of energy transitions literature. A neo-Gramscian lens is applied to the political economy of energy transitions, with an emphasis on hegemonic and counter-hegemonic ideas and the forces in which hegemony is maintained in the face of transition. The forces of neoliberal, growth orientated development are examined, along with counter-hegemonic ideas including the eco welfare state, place-based, community wealth building and energy commons.

Chapter 4 reviews energy justice literature, with a particular focus on the restorative justice lens and how energy justice may interact with business models and governance structures in the delivery of energy systems.

Chapter 5 presents the analytical framework which integrates aspects of sociotechnical imaginaries, political economy and energy justice theories outlined in the previous chapters. This develops an approach suitable for contributing knowledge on the imaginaries of a MWT industry, the interplay between hegemonic political economy, counter-hegemonic ideas and energy justice valuations.

Chapter 6 dissects the methodological choices taken to effectively apply the analytical framework. It discusses the ontological and epistemological foundations of the thesis, drawing primarily from critical realism and interpretivism. Researcher positionality is also provided, reflecting on the personal relationship with the research topic. Qualitative methods are explored as is the choice of an ethnographic and case study informed approach. An account of how the data collection unfolded is also provided.

Chapter 7 introduces the empirical context in which the research methodology is applied, it provides essential knowledge on the end of coal mining and its legacies, the heat policy context in Scotland, and the state of play with respect to MWT technologies.

Chapter 8 presents the findings from the first phase of the data collection. Taken from the analysis of 29 semi-structured interviews with sectoral professionals and aligned to the research questions and the themes that emerged around them. It explains how critical political economy forces are in the imagining of MWT development, as well as the regimes and landscapes in which MWT could develop.

Chapter 9 explores the findings from the second phase of the data collection, which consisted of two workshops in the case study, in the former mining town of Cardenden in

Fife. 19 Participants were present in total across the two workshops which consisted of residents and local community development practitioners including the community council. It demonstrates the disruptive relationship between the energy sector and communities, with trust low and apathy high. It points towards energy futures for MWT that the community are opposed to and others they support, built around democratic inclusion and local benefit.

Chapter 10 situates the findings within the literature to illustrate the key contributions to academic knowledge, directly answering the 3 subordinated and the overarching research questions.

Chapter 11 concludes the thesis, providing a concise summary and the practical and policy implications of the work. It highlights strengths and weaknesses of the study and suggests areas of future research.

Chapter 2 - Sociotechnical Imaginaries

This chapter marks the beginning of the literature review, which continues until Chapter 5. It explores the sociotechnical imaginaries (STI) literature, in order to understand how envisioned desirable social futures are to be attained through technological developments. This literature can aid in the study of materialisation through technological development, as is the case for MWT, with its focus on visions and conceptions of the future, and how they are shaped by a range of understandings and embedded structures within the social world. Interconnected with sociotechnical systems and transition literatures, STI places an explicit focus on the ways in which development is being conceptualised by different actors across scales, economic class, institutional influences and relationality..

The chapter begins with an overview of socio-technical systems and transitions theory, which explores the landscape and actors which govern and affect technological shifts in society across space and time. It then explores the usefulness of imaginaries as a tool in the analysis of sociotechnical processes before examining the forces at play in MWT contexts.

2.1 Understanding sociotechnical systems and transitions

As the study of complex systems and technological development accelerated over the last 60 years, sociotechnical systems (STS) theory emerged and established itself as one of the most widely applied theoretical approaches to understanding the interactions between technological and social systems (Davis et al. 2014). STSs can range from entire sectors down to individual businesses, where effectiveness in attaining particular goals and outputs is resultant on the optimisation of both technological and social arrangements (Bauer and Herder 2009). Fittingly for the context of this research, the term originated from research projects in the British coal mining industry and subsequent studies of industrial activities associated with the Tavistock School (Trist 1981). Hughes' (1987) work on 'the evolution of large technical systems' also informed the development of STS, introducing notions such as system builders, and emphasising the interconnected nature of the social and technical dimensions of large-scale infrastructure.

The initial conceptualisation of STS arose from analyses that explored the deployment of new advanced machinery without consideration of the worker and organisational structures around it. The resulting emphasis on the interdependence of social and technical variables permeates understandings of systems today. To reject the socio-technical interplay results in fairly narrow perceptions of technological determinism, and a technocratic approach to

development, or alternatively, one in which social attitudes alone shape all technological output (MacKenzie and Wajcman 1999; Winner 1978).

An STS approach can be utilised as an analytical tool in order to make sense and appraise different socio-technical objects, how they function and their interactions. These would include elements such as “technology, regulations, user practices and markets, cultural meanings, infrastructure, maintenance networks and production systems” (Geels 2005). Geels uses the example of road transport to illustrate this application in Figure 8 below. As the examples illustrates, STS approaches aim to provide a representative insight into the organisational functions of a system by threading the various elements of its structure, use, goal, meaning and context.

For the focus of this research, the societal function of energy and the socio-technical industry of MWT is the level of system which is under study. Whilst MWT presents a way of fulfilling the societal function of energy, the technology alone by itself is only part of the

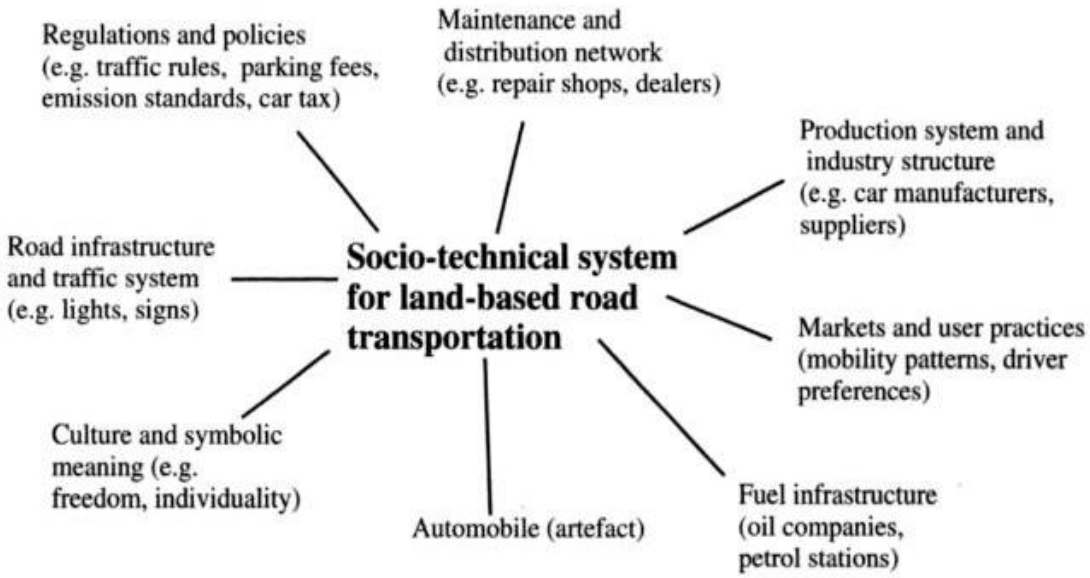

Figure 7 Sociotechnical systems example for road transportation (Geels 2005, 2)

solution. Indeed, as explored later in the context chapters, MWT technology has been studied by scientists and engineers extensively over recent decades. Minimal deployment globally including in Scotland suggests that under optimisation of the social arrangements and structures are a significant reason for its lack of usage and function.

Following an STS understanding, the dynamics of change for STSs can be explored through sociotechnical transitions (STT) theory in the context of energy transitions. STT draws primarily from the field of Science and Technology studies for the purposes of sense making in complex social contexts. It also integrates elements from economics and institutional theory to understand the nature of change as it pertains to STS's (Geels 2011). The stability of existing STS's, and the set of conditions which inform and enable their development, existence and evolution is affected by deeper structures, articulated as regimes. These socio-technical regimes are understood as an embedded set of rules and bring together the routines, shared beliefs, user practices and institutional arrangements which affect systems and their trajectories. Sub regimes affecting socio-technical systems include policy, science, technological and socio-cultural regimes, which interplay in periods of alignment and tension.

Sociotechnical transitions have become one of the critical areas of study for socio-technical theorists, as a range environmental, resource and information related challenges are recognised as critical in efforts to enable a sustainable future (A. Smith et al. 2005). At a fundamental level, transitions are understood as the changing of sociotechnical regime or system (Späth and Rohracher 2016). Therefore, whilst MWT as a yet to exist socio-technical system cannot transition, it is in a co-evolutionary relationship with the conditions of the existing regime.

Across the wide ranging literature examining energy transitions through a sociotechnical transitions perspective, including the prominent Multi-Level Perspective (MLP), limitations have been observed and articulated by scholars. These range from a lack of emphasis on the natural world and social-ecological systems, an overly technological and elite, technocratic perspective, and not accounting adequately for the role of politics and power (Lawhon and Murphy 2012) (Geels 2019). Having established an understanding of the development of sociotechnical thinking, this chapter shifts towards the process of imaginaries. Exploring how they are formed and implemented for sociotechnical systems such as MWT.

Following the grounding in the STS and MLP literature, sociotechnical imaginaries literature is explored in the next section, which emphasise the role of imaginaries as both a process and outcome in how they are formed and implemented for sociotechnical systems such as MWT.

2.2 Sociotechnical imaginaries

Sociotechnical imaginaries (STI) is a framework developed in the tradition of Science and Technology Studies (STS) to understand how visions and ideas of the past, present and future are shaped through science and technological dimensions. The discussion of STI literature is important for this thesis because MWT is a sociotechnical system, yet to exist, and thus it is visions and ideas associated with its potential development that are understudy, MWT imaginaries. STI highlights the duality of technological visions by centering the social and political orders that are co-produced by technological processes (Longhurst and Chilvers 2019a). STI offers reflective examination on how “collective perceptions of the public good and promises of a desirable future shape contemporary politics” (Hendriks et al. 2025). Therefore, the future becomes an object of analytical inquiry and can be understood as performative, partial and political (Muiderman et al. 2020). In their conceptual review of STI, Hendriks et al (2025) specifically focus on the “interconnectedness between perceptions of the future and interactions with the future”. Understanding of what the future may look like and what is considered desirable, is inherently reflective of the political positionality of actors and collectives, as power dynamics affect the abundance of alternatives (Stirling et al. 2023).

In the context of sociotechnical systems and transitions, STIs draw sharp focus on the imagining of alternative futures states and the transition from one system to another. Digging deeper to a more fundamental level, imaginaries are critical to the human experience, shaping our interactions with reality across time and space. Gabora (2015) discusses, the ‘uniquely human capacity to imagine beyond the present’. Before exploring the intricacies of socio-technical forms of imaginaries, this section first proposes the importance of imaginaries as a foundational aspect of human experience. As Hughes (2024) says, imaginaries have emotional and utopian effects, they mobilise fear, desire, shared commitment and bind individuals to understandings of the ‘good life’. Whether as individuals or collectives, the fundamental human drive towards wellbeing can be understood as a result of either instinct or cognition, or both. Wellbeing in this case being a blanket term for survival, improving quality of life, and prosperity. Projecting beyond the present moment and reality, to a possible future, can be thought of as the construction of a purpose and meaning beyond purely surviving in the present moment mechanically and is triggered by a dynamic array of forces from within oneself and from the environmental factors influencing individual and collective realities. To envision an improved or desirable future is to engage with imaginaries.

2.2.1 Imaginaries as a process and an outcome: from formation to implementation

Following the creation of an imagined future, ideas and pathways are constructed which strategise towards reaching particular goals or outcomes in what is essentially a problem-solving process. This problem-solving process provides an imaginary pathway to reach the imaginary wellbeing outcome. In this calculated, cognitive approach, action towards achieving improved wellbeing only occurs after the imaginary, with the desired aim of affecting reality by shifting or maintaining the current set of conditions in a process of trial and error and learning. The character of the individual affects both the construction and implementation of imaginaries, and reality beyond oneself, i.e. the world, is dynamically shaping and interacting with the individual, and thus the whole process. Researchers have conceptualised imagination in similar ways, primarily as a functional practice that provides opportunities for individuals to visual aspirational futures (Jasanoff and Kim 2009; Appadurai 1996; Fujimura 2003).

Conceptualising the ways in which collective wellbeing is envisioned, and the ideas to achieve it, follows a similar line of thought, albeit with more complex considerations and interactions. Just as individuals envision positive futures for themselves, they also construct positive collective futures for communities including and beyond themselves. Collectives and communities can emerge in an immeasurable number of ways. As community identification is sought for various processes of sense making and record, understanding what defines a community becomes a complex question. One approach to this question is that communities can emerge from individuals that share similar collective imaginaries, providing a form of shared identity. This could be a sub population within a village, or collection of people across different geographies. A dynamic and fluctuating community imaginary of a collective future is refined by the interactions and characteristics of the communities' individuals, as is the problem-solving process of constructing ideas and pathways to achieve the imaginary. Attempts and actions in reality then bring about such collective imaginaries unfold in a dynamic process shaped by the characteristics of the community, the imaginary pathways and the wider world, including all its material components and its social systems and structures.

Exploring the link between human cognition and our aspirations at a general, fundamental level through imaginaries, demonstrates its usefulness as a conceptual tool in understanding specific dimensions of socio-technical development. This is because individuals can project their visions of aspiration onto material, technical objects as well as social arrangements, which act as a conduit for imagined possible futures (Magnani and Cittati 2022).

Fundamentally, socio-technical imaginaries (STIs) theory conceptualises interactions between energy and sustainability futures with social change and power relations. It has been used by scholars of energy social science as an analytical and interpretive tool to study systems and transitions, ranging from wind power, smart grids, and coal (Kuchler and Stigson 2024a). The first and most prominent development of STI often cited is by Jasanoff and Kim (2009). They conceptualise imaginaries in the context of a socio-technical world as being not only descriptions of the future, but as effecting and prescribing what futures are feasible. Thus, imaginaries alter, shift and materialise different forces in the present, locking in certain pathways whilst diminishing others.

2.2.2 Sociotechnical imaginaries as a theoretical lens

Whilst originating in studies focussed at the national level, STI's scholarship has expanded as an inclusive and interpretive lens which explores the process of collective imagination by varied organised groups that can be as large as a nation state down to a confined community tied to place (Kuchler and Stigson 2024a). Jasanoff and Kim (2009) understood that the nation state was a particularly important vehicle for STI's, firstly due to the state power to set socio-technical agendas which is encoded in national institutions. Further, cultural ideas of the 'national collective' are amongst the most prominent identities found in contemporary societies, and political communities also tend to form around nation-specific projects. Jasanoff and Kim (2009) explore nuclear energy development in different national contexts of the USA, South Korea and Germany to demonstrate the dimensions at play driving the development pathway, highlighting policy motivations around imaginaries of development and containment relating to national collectives' consciousness. STIs

A prominent thread emerging in the STI literature centres around questions of who's imaginaries matter and in what ways the range of STI's beyond the ones envisioned by powerful actors are understood, particularly ones which challenge and construct alternatives to dominant paradigms (Kuchler and Stigson 2024a). This thread links the STI to emerging developments to frame a political economy of energy transitions, which centres the conflictive nature of dominant structures resisting alternative energy futures (Newell 2019).

Researchers are exploring questions around the ownership of collective imaginaries and the dynamic interplay these imaginaries have with the material and social world (Longhurst and Chilvers 2019b) (Delina 2018), for example dominant global and national energy transition imaginaries act in ways which undermine and exclude localised and community imaginaries.

In the book, Dreamscapes of Modernity, Jasanoff and Kim (2015) orientate the STIs framework as transcending the structure and agency dichotomy, or dualism, as it "combines

some of the subjective and psychological dimensions of agency with the structured hardness of technological systems, policy styles, organisational behaviours and political cultures" (Jasanoff 2015 p.24). Jasanoff suggests the most appropriate methodological approach for STI's is interpretive research that explores the structure-agency relationship through inquiries into meaning-making" (Jasanoff 2015 pg.24) and that integrating and element of comparison into research allows for deeper understandings of collectively held imaginaries. Applied to a MWT perspective, an STI perspective allows for examination of the origins of different imaginaries both competing with and complementing one another.

STIs have been utilised by scholars in many examples outside of the dominant national policy level framing. By exploring non-western and non-technocratic perspectives, scholars have demonstrated the expansive nature of the STI's theoretical potential. In *Dreamscapes of Modernity*, resistances to technological development and expansion are examined alongside broader public perspectives which are often excluded from mainstream discourses. Felt (2015) articulates these less visible visions as an "imaginary of the absent". Further, "appropriate technology" discussions are framed through pluriversal imaginaries, encompassing anti-colonial and economic autonomy histories in the context of grassroot movements against technocratic state and market policies (Moon 2015). Visualisation is explored through the use of corporate graphics by multinational corporations in the construction of imaginaries around corporate social responsibility initiatives and technology development (E. Smith 2015). Kulcher and Bridge (2018) analyse how the coal industry interplays with national identities in Poland and how it relates to contrasting materialities such as resource abundance and health effects, creating contestation between political agents. (Levenda et al. 2019) demonstrate how energy innovation governance is determined by not only national imaginaries but also regional and local ones through their overview of socio-cultural and political-economic contexts in different US states. (Chateau et al. 2021) integrate spatial imaginaries into energy transition imaginaries, deriving a dynamic co-produced relationship in which spatiality is constituted and constitutive of STIs. Boudreau (2007) defines spatial imaginaries as mental maps, filled with diverse, situated and contested collective understandings of a spatialised social world (Watkins 2015). Place imaginaries, spatial transformation imaginaries and idealised spaces are highlighted as ways in which politics of place and space and materialities shape STIs, alongside interconnected issues such as socio-spatial inequality (Longhurst and Chilvers 2019b).

As demonstrated in this section STIs has been utilised as a theoretical lens in various contexts and possesses a range of strengths and weaknesses. Fundamentally, it addresses the shared visions shaping technology, policy, institutions and social order as both drivers and justifications of sociotechnical change. Despite encouraging much critical reflection and

drawing together the interplay of structure and agency, the ambiguous nature of the lens means that boundaries within study are often imprecise. This thesis develops a fully formed conception of the STIs process as demonstrated in the Analytical Framework Chapter 5.

2.3 Chapter conclusions and critical perspectives on sociotechnical imaginaries

Using the STI theoretical lens comes with distinct challenges. Responses to STI critiques have emerged in the literature, and this thesis aims to contend and explore them. The critical perspectives are summarised below:

1. As Sovacool and Hess (2017) state, the study of imaginaries can lean heavily into cultural analysis and bypass important interactions between institutions, social structures and private actors when articulating forces of change, underplaying contestation and elite capture.
    a. One way to overcome this is to integrate and bridge with other frameworks such as the political economy of energy transitions, which this thesis will go on to explore.
2. Further, disaggregating national, local and global imaginaries will aid in clarifying interactions at play across time and space. Sovacool and Hess (2017) also highlight the difficulty in capturing the 'dialectic between past and future', where imaginaries research may erase the past or be burdened by it in ways that ignore the future depending on how one is looking.
    a. Embedding a critical reflexivity and grounding is important to overcoming this critique, by interrogating whose imaginaries are in focus and why they may dominate (Waller 2020).
3. Finally understanding the composition of imaginaries can be a difficult task, how individual and collective visions relate to one another and where imaginaries end or differ spatially. Often marginalised voices and grassroots perspectives are missing in STI studies, and nation state collectives are vaguely defined (Kuchler and Stigson 2024a).
    a. Integrating participatory and ethnographic methods can help overcome this and provide richer understandings of collective imaginaries at local scales.

To summarise this chapter and contextualise the relevance of this literature to this research, there are several fundamental understandings to reiterate with respect to the study of MWT development in Scotland. First, that a yet to exist MWT industry is predicated on a socio-technical systems understanding of development in a rational, mechanical sense. That is to

say that the development of the industry, and transition within the wider socio-technical energy system is guided by the interplay between various social systems and structures. This aids in the understanding of where various actors lie within the MWT ecosystem and how as an emergent system, the co-evolutionary relationship with the incumbent system is critical in its development.

Second, the ways in which different actors and collectives envisage the development of a socio-technical system like MWT, is critical to how power, politics and agency is understood. These imaginaries, in which visions of individual and collective good are projected onto socio-technical objects, such as MWT, are an important way of connecting the past, present and future of development, as visions of the future are not only descriptive, but prescribe and lock in pathways correlated to the influence of different actors in the present. Understanding how different visions are co-produced enlightens us with the reality of sociopolitical dimensions, partialities, exclusions, and lived experiences (Longhurst and Chilvers 2019b).

In acknowledging the effect of the world as it exists and is experienced to create imaginaries and thus futures, it is important to explore the deeper ideological drivers which temper and exacerbate different imaginaries. Ideologies and philosophies of economy and society have an untold impact on how development is imagined, rooted and actualised in a socio-technical system. The next chapter will explore these ideological and systemic drivers which influence imaginaries, by discussing the political economy of transitions literature.

Chapter 3 - The Political Economy of Energy Transitions

As explored in the previous chapter on STI, visions of energy futures, such as for MWT, are shaped by relationality in various ways, be it nationality, to community or class. The economy is one of the primary ways in which social and power relations play out, underpinned by the politics of contesting ideas. This chapter is fundamentally about the role of ideologies in a political economy of energy transitions. Together the interplay between political economy and ideological forces shape the possibilities of transition, through markets, institutions at global and state scales and legal systems. As alluded to in the previous chapter, the transitions literature could benefit from engaging with political economy, and illicit understanding of how ideologies permeate and shape energy system transitions (Burke and Stephens 2018; Gatto 2022; Sovacool et al. 2020; Binz et al. 2020a).

This chapter aims to interrogate the ideologies and structures which drive and dictate economic development as it pertains to MWT and governance of energy systems more broadly. It breaks down how ideologies of sustainable development and transition are driven by growth-orientated and market-led approaches. Taking insight from a range of fields including political ecology, development studies and business studies, this chapter explores how systemic political economy forces, articulated largely through neoliberalism, dominate mainstream green approaches such as sustainable development, and affect the ability for alternative imaginaries to emerge. The first half of this chapter questions capitalism's incompatibility with sustainability, and thus examines the political economy, structures and ideologies which currently dominate. The second half then begins to explore alternative approaches from academia, policy and practice, which are not to be taken as 'perfect' solutions but as possible guides that point the way to other sustainable energy futures.

The chapter begins by articulating the need for a political economy approach which centres the power structures that seek to co-opt and defeat any alternative ideology as it pertains to sustainability and energy transitions governance. It then provides an overview of contemporary sustainability policy making and some of the issues found within it, namely a focus on growth, GDP measurements and the bottom line. It then explores why efforts to integrate social and environmental wellbeing into development policy face difficulty and may be incompatible with growth orientated approaches. It overviews the characteristics of neoliberalism and the dominance of market-led approaches, including its role in deindustrialisation in former coalfield areas, and as a force working to dismantle social democracy and co-opt state power. Finally, it explores alternative ideologies and praxis from post-growth scholarship at a systems scale down to place-based development, including

why these alternative imaginaries struggle to take hold in the face of neoliberal structures that shape energy development.

3.1 Exploring the character and value of a political economy lens

First, an understanding of political economy is necessary in order to utilise it in the study of MWT in this thesis. Political economy is the study of how economic systems, policies and practices are shaped by, and in turn shape, political institutions, power relations, and social structures. As Frey (Whynes 1984, 2) states, ‘there are innumerable relationships between the political and economic sectors of society”.

As a science of economic organisation, the 18th century physiocrats of France are one of the early adopters of the term political economy, as it pertained to discussions of wealth, its reproduction and distribution alongside ‘a dissertation on agriculture and public administration’ (Cannan 2016, 40). Classical economists such as Adam Smith and Riccardo echoed the physiocrats usage of the term, seeing political economy as ‘the science of the nature, reproduction and distribution and disposal of wealth’, or as Smith famously put it, the nature of the wealth of nations (Groenewegen 1987). Marx’s critique developed upon the earlier classical economists to emphasise class dynamics and the emergence of industrial bourgeois society (Engels 1859).

In the time since, and across various debates of the 20th century, the terms political economy and economics have diverged into two distinct schools of thought. Whilst the dominant neoclassical economics of today is more generally concerned with the choices made in conditions of scarcity and contemporary methods of mathematical analysis, political economy draws insight from various disciplines to understand the relations between political institutions, markets and economic systems (Mause 2019).

In this thesis, critical political economy perspectives are drawn from Gramscian informed approaches, where economic structures, ideas and material conditions and their interactions are the central focus. A political economy perspective places the emphasis on historical materialism and ideology, to understand national and global world orders in economic, political and socio-cultural terms (Newell 2019). This is critical for an understanding of the current energy transition and the emergence of new alternative energy industries as it provides an important layer of knowledge which determines the transition paths and system changes that are observed, or thwarted. There are clear and important ways in which these

kinds of political economy analysis can influence transitions literature, which are explored in the following sections.

3.1.1 Applying political economy to the energy transition

As explored in the previous chapter, the socio-technical transitions literature provides a comprehensive breakdown of the mechanised elements of system change, accounting for the interplay between various socio-technical elements. However, within the transitions literature itself, there is acknowledgement of the insufficient role attributed to political forces and how forms of power influence and shape transitions and energy futures (Geels 2019). The analytical framework developed in Chapter 5 explores this gap in transitions literature by integrating these concepts.

Often within the socio-technical transitions literature, management strategies and governance practices are presented in rational, depoliticised terms, where the role of hegemonic institutionalised geopolitical, cultural and ideological forces are underplayed. This absence is acknowledged by scholars working within political economy spheres, and contributions to the study of transitioning energy economies take the form of global, historical and contemporary based critiques, which aim to sharpen focus on the relations of power which shape socio-technical imaginaries and possibilities (Newell 2019) (Van de Graaf et al. 2016). As an example of this thinking, Timothy Mitchell's widely read text, Carbon Democracy (2011) is centred upon the historical political economy of fossil fuel-based development.

Theoretical traditions descending from Gramsci contends that ideas and material conditions are co-dependent of one another, tying the socio-technical imaginaries perspective to one grounded in a materialist, historical political economy development (Gramsci 2020). The linkage of Gramscian political economy ideas to that of energy transitions is currently limited. Ford and Newell (2021) begin to integrate the Gramscian concepts and the MLP in particular, offering potentially fruitful insights relating to structural forces in the framework such as how landscape pressures and niche developments can create opportunities for regime change.

While MLP elucidates the dynamics between niches, regimes, and landscapes, it often overlooks the complex political and economic forces at play. A neo-Gramscian approach, emphasizing concepts like historical bloc and passive revolution, offers a fuller and rounded view by highlighting how incumbent actors may accommodate change through strategic policy adjustments that maintain their dominance. As Ford and Newell discuss, an MLP perspective on niche support policy is attributed to landscape pressure and lobbying from

within regimes. A political economy perspective explains that the introduction of niche support policies stabilises regimes and stimulates new investment in the quest for economic growth under a capitalist economy. Such policies may satisfy calls for change without seriously challenging incumbent firms, such is the case in the fossil fuel to green energy transition observed today. In this way pressure is absorbed and the status quo remains. The neo-Gramscian perspective underscores the role of power relations, institutional arrangements, and ideological forces in shaping transition pathways, advocating for analyses that consider global and multi-scalar contexts rather than focusing solely on national regimes. By incorporating these insights, this thesis can better capture the contested and uneven nature of energy transitions, moving beyond deterministic models to recognize the agency of diverse actors and the influence of transnational dynamics.

Newell (2019) deploys the Gramscian concept of ‘trasformismo’ in their political economy analysis of global energy transitions, alongside theories of hegemonic forces, which together centre an understanding where established political and social powers co-opt and combat ‘potentially dangerous ideas’ that risk dislodging incumbent structures. As Mitchell (2011) and others have discussed, the growth of state designed capitalism goes hand in hand with fossil fuel development and hegemonic energy regimes. The question worth exploring then becomes, whether the direction of energy economies is shaped by advances in human knowledge which increasingly evidences transformative requirements to meet ecological sustainability and wellbeing, or to further protect and advance the interests of hegemonic capitalist energy regimes.

Speaking from a socio-technical perspective, Stirling et al (2023) suggest that common simplifications in sustainability transformations research entrenches ‘patterns of privilege and power’ by ignoring the complex ways in which political dynamics play out. They go on to say that transformative imaginaries and realities may be diminished when focus remains on systems and regimes, rather than political structures such as capitalism, modernity, coloniality or patriarchy. Indeed, Feola (2020) contends that sustainability transitions research has largely failed to engage with critique of capitalism, which has disabled deeper, and forward-thinking research into the actual sustainability of transitions.

A critical insight on transitions emphasises their contested and disruptive nature, which is useful for the approach taken in this thesis. Alternative energy futures will face great difficulty in resisting dominant practices in energy governance. Practices which counter market-led approaches such as energy commons and place-based will require a degree of contestation and disruption if they are to shift energy systems governance. The work of Mouffe (1999), and others in this tradition of democracy scholarship suggest that political conflict is not

something to be overcome or avoided, rather it is an essential aspect of democracy to be embraced. However, the conflict of Agonism is not intended to simply vanquish enemies or achieve a consensus-driven utopia. Instead, it transforms conflict into a democratic productive force; fostering pluralism, deliberation, and resistance against domination (Scudder and White 2023). Such approaches are acknowledged by a range of scholars in the wake of growing resistance to climate policy at national and international levels (Rodríguez-Pose and Bartalucci 2024; Torfing et al. 2024; Mouffe 2022; Machin 2021) (Kakenmaster 2019). The discussion in this section is important for this thesis because it points towards the ways in which a MWT industry in Scotland will be imagined and created from the conditions of the political economy. That contestation and conflict are inherint as the MWT industry is shaped to fit within the acceptable confines of the existing energy economy. A stronger critique of a capitalist political economy will allow for greater analysis of data, and for reccomendations of how to align MWT development with environmental and social sustainability goals.

3.1.2 A political economy understanding of deindustrialisation and energy transitions

As MWT will emerge from a context of deindustrialisation, it is important to understand the political economy forces which have shaped this process and continue to shape the present. One of the major economic developments of the last 50 years is the deindustrialisation experienced in many parts of the west, including Scotland. Deindustrialisation is particularly relevant for this thesis in relation to closure of the coal mining industry which is not only tied up in the technology of MWT itself, but also the socioeconomic landscape that exists today in former mining areas. A contextual, historical account is given later in the contextual chapters, however here deindustrialisation literature from a political economy lens provides many important insights into the nature of energy transitions, emphasising the importance of this political economy theory. In order to understand the ongoing process of deindustrialisation and its fallout, engagement with political economy theory provides insight on the forces and mechanisms at play on a wider scale, and the inter-connected nature of economic development choices from the local, to national and global scales (Pike 2022).

Over the 2010s, renewed concern with social and spatial inequalities have been central to dissections of various political movements including the Brexit referendum, the election of Donald Trump in the USA and different populist agendas in Europe (McCann 2020) (Dijkstra, Poelman, and Rodríguez-Pose 2020). Deindustrialisation has featured prominently in this discourse as the idea of ‘left behind places’ and a ‘geography of discontent’ between regions and populations has been cited as a prominent driving force for this political upheaval

(Hendrickson, Muro, and Galston 2018). However, in the deindustrialised areas of Scotland, voter trends rejected this premise with higher support for the UK remaining in the European Union, as opposed to other post-industrial areas throughout England and Wales. Therefore, there is a need to explore the complex forces at play in structural economic changes, how this process of change affects populations, drawing on economic geography understandings and applying it to the context of this thesis. Further, a novel framing of the processes of deindustrialisation in the coalfields and what it means for the current energy transition is necessary to properly understand the role and function of minewater energy schemes. This shifts the focus to theorising deindustrialisation and its legacy rather than simply documenting or observing it.

Though it is tempting to begin with the Scottish Coalfields, recent scholarly work theorising deindustrialisation has sought to counter previous Anglo-American bias and Global North perspectives, shifting attention to global and geopolitical elements (Barnes 2019) (Pike 2020) (Sonn and Hsu 2022). The intended aim is to emphasise the role of global and geopolitical actions in shaping regional economies as international developments affect both the national and local level, such is the nature of the economy of recent centuries. Pike (2020) proposes geographical political economy as a theory framework for explaining and understanding deindustrialisation and regional development. This builds upon the work of several other scholars in the field of economic geography (Hudson 2016) (Brunn 2019) (MacKinnon et al. 2019), which places economic evolution and path creation in relation to broader dynamics and uneven geographical development.

As a unifying framework geographical political economy (GPE) attempts to counter the fragmentation of urban and regional studies as a way of addressing the commonalities of deindustrialisation across the world. At its core, GPE is a framework that emphasises the causal relations, processes, mechanisms and actors through time and across space (Pike 2020). Space and place are key to relations and processes rather than simply outcomes, and the role of history, it’s legacies and path dependencies shape current evolutionary pathways (Perrons 2004). This is especially useful for understanding long-term queries of geographically uneven development and the role of institutions. A particular focus on the state, capital and labour and the inherent tendency within capitalism to produce uneven development differentiates the GPE approach to others emanating from economic geography (Hassink 2022). Ultimately this perspective enables the exploration of the power and agency of different actors operating within structures at varying scales.

3.1.3 Spatial dynamics of deindustrialisation

As MWT is located in deindustrialised regions, it is important to understand the spatialised dynamics of the political economy that shapes energy transitions today. The UK is one of the most regionally unbalanced countries in the Global North (NIESR 2023) , and consists of a highly centralised, top down and service sector dominated governance system (McCann 2020). This opens up questions of justness with regard to the process that unfolded in the Scottish coalfields considering political agency, treatment of labour, use of innovation and decisions of investment.

Making sense of the complex picture of global economic restructuring, the offshoring of industries and the closing of century old village pits in Scotland requires a high, mid and low-level analysis. This means understanding that at a high level, plant or pit closures follow well established practices to expand profit making in the financialised logic, producing forms of injustices for workers at both ends of the transfer of labour, through unemployment on one end and exploitation on the other (Lynch 2017). For this present thesis, this provides a macro framing and understanding of the international impacts of deindustrialisation in developed countries. At the national and local level this process can be understood as non-linear, in that it was led by changing public policy priorities within the UK as a whole. The distribution of employment by the industrial sector was deliberately altered by policymakers seeking more rapid rates of economic growth. Labour and capital resources were invested in assembly goods manufacturing especially in consumer goods, electrical-mechanical and then electronic engineering that would yield higher rates of return than in coal and other ‘heavy’ industries (Phillips 2019; Gibbs 2021).

Deindustrialisation can be understood as a significant period of economic restructuring and is classically framed as reduction in manufacturing employment caused by a combination of internal and external factors. Internal forces are usually identified as increased labour productivity and domestic expenditure and externally the international division of labour and exportation of services. However, the UK experienced the largest decline in manufacturing employment of any advanced economy (Coutts and Rowthorn 2013). Conventional accounts which deemphasise the political dimensions, draw upon ideas of natural economic evolution, from the Clark-Fisher maturity model to broader modernisation theories which view development through distinct phases from agriculture economies to manufacturing, to services and to knowledge-based (Pike 2020).

A second theory of explanation is the idea of trade specialisation which understands cities and regions as being specialist in particular economic activities which gives them a strong

advantage over other places. Regions of the global north defined their economic activity through manufacturing specialisation, though by the 1970s under the globalisation of production and political rejection of previous labour settlements industrial jobs were moved to the global south (Dicken 2007). Outsourcing manufacturing to emergent industrialising countries, particularly in Asia relied on relatively lower wages which allowed for expanded profit making, and this shift in specialisation generated deindustrialisation in the Global North regions which we can begin to observe now in Asia. A third conventional explanation is that of competitive failure and disinvestment of firms and states. The internationalisation of production and strategies based upon global value chains together with the financialisation of economies placed manufacturing in the middle of an investment competition where its high capital costs and lower profitability render it relatively uncompetitive (Tregenna 2015). This lead to existing industrial areas being unevenly abandoned, with under-investment further fuelling unemployment and output losses and as a political strategy the exiting of states from the sector and host regions through privatisation or reduction of support (Pike 2020).

Using the GPE approach, we can acknowledge deindustrialisation as an international and inter-connected phenomena though with a variation of pathways and differences in how the process is constituted. By focussing on actors and process the globalised economic restructuring element can be reconciled with the particularities found in temporal and geographical contexts (Peck 2017).

Now that the political economy lens is firmly established, it can be turned to better understand the dominant ideologies, power structures, and social relations which drive transitions and dictate the future that is and can be imagined.

3.2 Hegemonic ideas of transition: capitalism and neoliberal energy governance

The previous section positioned political economy insights as critical to understanding how energy transitions occur, and that they should be considered fundamentally as ideological. This approach is a more accurate and effective way of understanding the ways in which transitions unfold, as well as how the future itself is imagined. Now we explore the primary ideological fault lines shaping debates on energy transitions. This discussion is important for this thesis to better understand ideas as they emerge within MWT energy futures. First, in this section the dominant ideologies of capitalism and neoliberalism are discussed, before exploring green growth and sustainable development in the following section.

The UK has been at the forefront of economic transition observed more widely in western economies in the last 40 years, where market dominance has emerged as the primary strategy for governance, as has been observed in the energy system. This phenomenon has been articulated through the ideological and structural articulation of neoliberalism, which has gained traction in a powerful analytical discourse in recent decades (Springer et al. 2016).

Neoliberalism has many strands and has shifted over the decades in various contextual forms relating to its origins in academic schools of the 20th century. From a small group of intellectuals, the doctrine has shaped the global economy since the 1970s with the development of what is known as the Washington consensus. The consensus rolled out economic policies through institutions such as the World Bank, the IMF and the US treasury that revolved around tax reform, privatisation of state assets, deregulation, the supremacy of individual property rights, fiscal policy restrictions and the reduction of the welfare state (J. Williamson 2009; Jessop 2002). During the Thatcher and Reagan era neoliberal policies were observed which saw a direct break with the post-war consensus of social democracy, including mass deindustrialisation, offshoring of production to chase cheap labour and an assault on workers unions (Tomlinson 2016). There were massive ramifications for the energy systems, as ownership, pricing and workforce changes were undertaken, establishing the primacy of energy as a private commodity.

Neoliberalism is however more than simply opposition to Keynesian economic policy and social democratic welfarism. Indeed it related more fundamentally to the philosophy and economics of liberalism as they relate to the state and the social world, where market logic and competition are expanded into all aspects of social and cultural life (Peters 2023). The expansion of this logic is critical to understand the process of imaginaries and future making, creating a strong link to the socio-technical imaginaries literature in Chapter 2. In his seminal work Capitalist Realism, Mark Fisher (Fisher 2022) explored the ways in which capitalism as a monolithic system, which commodifies all aspects of life, has become so pervasive that imagining an alternative seems nearly impossible. In the context of a capitalist, neoliberal energy regime, the question then becomes, how can we imagine alternative energy futures, or pathways to alternative futures in this context?

As McCarthy (2006, 6) states, neoliberalism is complex and “especially difficult” to recognise in “real-world circumstances”. This in part due to misunderstandings and misuses of the term relating to its anti-state, free market associations, which when relied narrowly relied upon can eschew its manifestations. As academics such as Hudson (2021, 2013), Graeber (2010, 2001), and Slobodian (2018, 2023) have observed, the primary goal of neoliberalism is the

empowerment of financial capital over industrial capital by controlling the states levers of power to insulate markets from democratic mandate.

Debt and the monetary system play a significant role in enforcing the neoliberal structure of governance as well as growth ideologies according to various unorthodox economic perspectives (De La Barra 2006; Streeck 2014; Stockhammer 2016). Thus, enabling the insulation of large areas of the economy from democratic mandate. In the UK, there is majority support across the political spectrum for common ownership approaches in the energy sector as well as other utilities and services, and yet, this is never seriously imagined or considered within political structures. It is the facilitation of more private sector involvement that is the common sense of the day, and any plans for public investment are attacked from a monetary responsibility and inflationary perspective. As the currency issuer, the state has the ability to invest into the economy up until real resource constraints and the inflationary limit. However, since the empowering of financial capital since the 1970s, state spending which would crowd out private investment is subject to intense challenge by the currency exchange and bond markets which speculate to destabilise the currency and the government fiscal situation. Capital flight is the other major tool deployed by the financial investors to ward off redistributive policies and investments which alter political economy away from market logic towards public good. A network of tax havens exists to facilitate this (Ogle 2017; Lesage and Vermeiren 2011).

The literature on neoliberalism is of particular relevance to the UK energy system more broadly, and especially for the development of new energy sources such as MWT for several reasons. First, as discussed in the introduction and context chapters, viewing the UK energy system through mainstream objectives, several challenges are present in meeting the demands of the trilemma: affordability, security and environmental sustainability. The UK faces insecurity from global fossil fuel volatility as it is a net importer, which is particularly relevant for heating. Secondly, it has some of the highest energy prices in the world. Thirdly, it is behind on its own carbon budgets and needs to move quickly and at scale to meet renewable power deployment targets. Running through the heart of these challenges lies a critique of the project of liberalisation and privatisation within the sector.

The UK and Scottish Governments have invested and subsidised the industry which has enabled the growth of renewable electricity in particular. However, there is growing discontent with ‘net zero’ and renewable energy developments, and a developing consciousness that energy developments do not deliver public good. Although community benefit models continue to exist, community owned energy itself has stalled, and the development of a local supply chain is relatively minimal. Sustained mass employment over

generations is not forthcoming due to the nature of renewable energy projects. The income from community benefit along with lease agreements for offshore wind is a tiny fraction of the income generated by energy companies, where nearly all projects receive a form of subsidy or financial support from the state in the first place. Further, energy companies' profits were again subsidised by the state with the introduction of the price cap during the energy crisis.

A common understanding of neoliberal policy and ideology is the defeat of the state by the market. As demonstrated in this section through an examination of the UK energy system, this may not be quite correct. As Slobodian (2018) suggests, neoliberalism's primary concern is in fact the control and co-option of the state in order to insulate markets from democratic governance and sovereignty.

The first half of this chapter has explored the political economy as it exists at various scales and across a spectrum from ideological domination to experienced phenomenon. At the highest level, growth orientated approaches are completely entrenched across all economic and development activity. Meaning that energy systems are primarily understood and developed under conditions in which they increase production and consumption, growing GDP, missing a whole range of factors that more directly relate to ecological wellbeing and may not require growth in such traditional metrics at all. Neoliberal approaches are ubiquitous in the UK and across large swaths of the global economic system which applies market logic to all aspects of life in totality and prioritises the private ownership, leasing and profit-making ability of investment decisions. Present political economy is entrenched by a range of hegemonic structures across institutional, market, ideological, and legal structures which make the possibility of imagining alternatives near impossible and co-opt and disarm any serious alternative.

3.2.1 The growth paradigm

The political economy literature discussed in the previous section enables an understanding of the dominance of current ideologies of sustainable development and energy systems governance. In the context of a planet with finite resources and the ecological challenges present today, the ideologies of growth which drive energy development are worth unpacking for this thesis, as they shape any new industry in Scotland today.

In many ways, the story of energy usage is the story of modern industrialised societies, with its mobilisation being described as "shaping the possibilities for life on earth" (Daggett 2019, 12). In the post-war era, energy development exploded alongside an insatiable demand for economic growth and geopolitical strength (Mitchell 2009). It is within a framework of

structures and institutions defined by growth led policies in which energy resources are developed.

As discussed in this thesis, the heat transition in Scotland relates to a complex array of experiences and outcomes which encompass social, environmental, health and cultural dimensions far wider than the narrow lens of economic growth. Whilst there may be contexts in which economic growth as it is traditionally measured can result from action which improves people's lives, it is by no means a certainty. Critiques of bottom-line, growth led economic development which highlight its distant and undefined relationship with wellbeing and nuanced value are well established and ongoing (Daly 2013; Spash 2021; Büchs and Koch 2017; Schmelzer 2023). Thus, it is worth exploring the ways in which growth is understood and measured at a higher level of analysis, before exploring its specific manifestations through energy, climate and wellbeing focussed adaptations.

Haapanen and Tapio (2016) provide a 'qualitative content analysis of growth critique' in which they identify three different yet complimentary themes emerging from critical growth literature. First, growth as a phenomenon which explores the forms and impacts of growth. Second, its institutionalisation of growth where it is supported or depended upon. Third, growth as an ideology, 'perceiving economic growth as an overwhelming and hegemonic political goal above other goals'. Together the framework articulates the ways in which growth is experienced as a practice, how it is structurally enshrined, and how it permeates as an ideology. It goes beyond merely critiquing the idea of GDP growth and encompasses a wider critique of 'growth societies'. Haapanen and Tapio (2016) illustrate the different themes through a mapping exercise, with the ideological dimensions of growth shown in Figure 10

Modern economic policy, as well as national and international goals, all require indicators and measurements to better understand progress and impact, such as in the sustainable development 'sustainable growth' metric. However, overall performance relating to social, environmental and economic wellbeing has been mistakenly enveloped by the limited confines of one indicator, gross domestic product (GDP). GDP was not intended to be used in such a way, and contains within it a range of issues making it entirely unsuitable for understanding human progress (Costanza et al. 2009). This is simply demonstrated by the fact that GDP and growth do not account for any forms of redistribution amongst individuals

and collectives, which has huge well-being implications (Wilkinson and Pickett 2011).

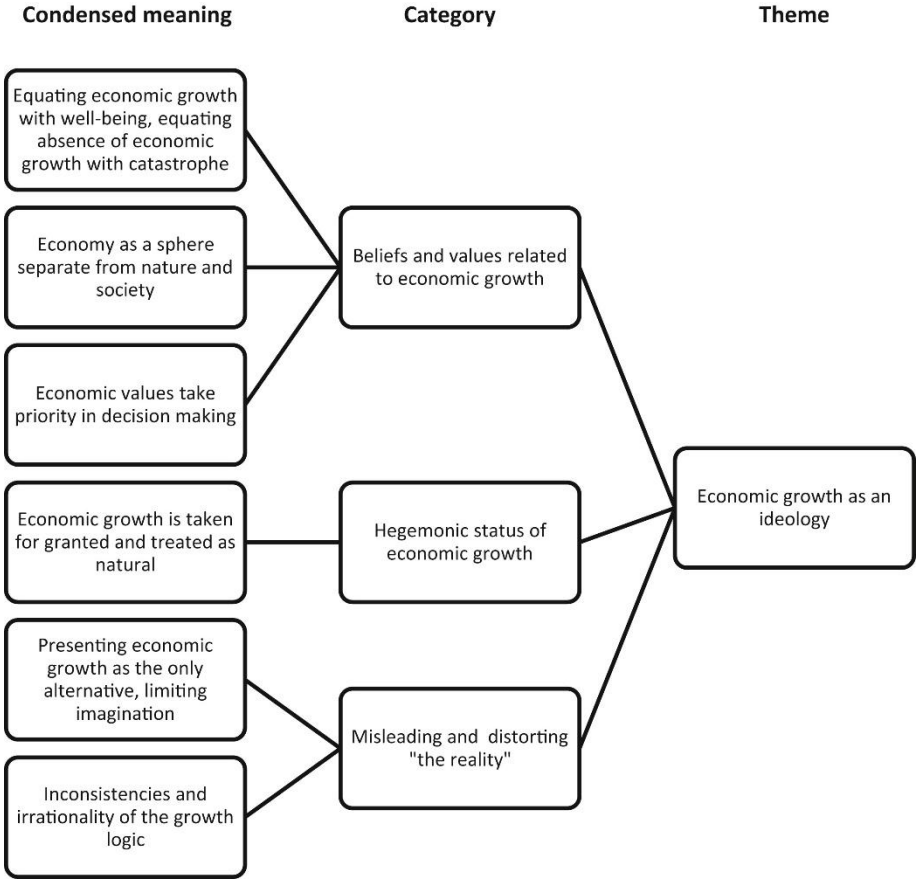

Figure 8 Analysis of critiques of growth as an ideology *(Haapanen and Tapio 2016)*

Feminist critiques of growth and sustainable development have long articulated how these ideologies consolidate domination and subordination(Pietrzak 2024). Further examples which GDP does not account for would include the act of growing vegetables and cooking a meal for friends or family, childcare or consuming off-grid electricity directly. Such is GDP's unsuitability for the modern age, and oil spill would increase GDP due to the expenses of cleaning up and remediation (Kubiszewski et al. 2013). The 'bottom line' is another often-used expression to designate the growth orientated, profit making mechanism at the heart of economic development in modern economies. Calls to transform towards 'triple bottom line' economic development has been widespread in business studies since at least the early 90s (Alhaddi 2015) (Elkington 1994), where social and environmental considerations are levelled alongside that of profit. However, the failure of triple-bottom line approaches to meaningfully impact climate, environmental and social justice approaches may be rooted in its fairly conservative and conflict adverse approach (Sridhar and Jones 2013). Indeed, in the UK and globally, corporations and governments continue to prioritise GDP growth and the bottom line today as the key driver for policymaking (The Labour Party 2024; Beyer et al., n.d.). As

discussed in the previous section, a political economy analysis that centres contestation of various power structures can aid in understanding to this picture.

In summary, this his section evidenced the incompatibility of a growth orientated society with its sustainability, and that the political economy of capitalism distorts any attempt to break from this system despite well-established critical analysis. In their expansive systemic overview of growth critiques, Schmelzer (2023) demonstrates the long and diverse history of critiques of growth going back to the advent of industrialisation in the 18th century. The critiques take many forms, which they designate as ranging from socio-economic, feminist, south-north, cultural, anti-capitalist, reactionary and critiques of industrialisation. These forms consider the alternative critiques, out with the dominant ecological framing prevalent since the latter half of the 20th century. As calls for a reckoning with growth ideologies continue to proliferate, social and environmental concerns have increasingly been co-opted or positioned as complimentary to techno-orientated growth approaches. These movements of 'green growth' and 'sustainable development' are explored in the next section.

3.2.2 Green growth & Sustainable Development

The dominant forms of energy imaginary found in Scotland and the west more generally can be described as forms of the green growth & sustainable development paradigm. These terms emerged following the growing prevalence of environmentalism and social justice within mainstream cultural and economic spheres. The ideologies of green growth promote an idea of development where continued economic expansion is compatible within planetary ecological boundaries as well as the alleviation of poverty. It emphasises technological substitution, allowing for the decoupling of economic growth with greenhouse gas emissions and resource use (Hickel and Kallis 2020) (Dale et al. 2016). Three major international, agenda setting organisations promote sustainable development, green growth ideologies: the World Bank, the OECD and United Nations Environment Program (UNEP). As (Hickel and Kallis 2020) state, none of the organisations present precise definitions, but are united in their call for governments to accelerate the process of ecologically orientated technological change through regulation and incentive that prioritises market led solutions and a compliant public sector.

Green growth is also enshrined into the UN' Sustainable Development Goals, which were created in 2015 following the end of the Millenium Development Goals programme. They embraced ecological considerations alongside human ones, though with the focus of goals 1 and 2 being an aggressive ambition to eradicate extreme poverty and hunger by 2030. Global North led developmental ideology has made similar targets dating back to the 80s, and though no doubt some progress has been made, when critique is placed upon the dollar

per day figure selection and its relative purchasing power, a picture of progress becomes much less clear. Further, to raise the standard for the world's poorest to a minimum of $5 per day, global GDP would have to increase 175 times. That would mean producing and consuming 175 times more commodities than at current rate (Hickel 2017). The question of whether green growth is achievable within planetary limits is therefore suspect or indeed a fallacy. Research from King, Savin, and Drews (2023) surveyed 789 climate policy researchers from across the globe and found huge scepticism that continued economic growth in developed countries was compatible with sustainability goals. The study revealed that up to 73% of the researchers supported post-growth positions and in the EU that number rose to 86%.

Despite these concerns, the growth and GDP narrative has rooted itself firmly into international and national level sustainability policies. In their study, (Gómez-Baggethun and Naredo 2015) reviewed the evolution of policy going back to the early 70s and found 3 trends emerging to the present. First, a shift away from growth versus the environment to growth for the environment. Second, a shift from states and regulation to liberalised, market-based approaches. Third, a change from political to technocratic discourse. By denying conflict between growth, equity and environmental wellbeing, alongside the commodification of policy towards marketisation approaches, a dominating paradigm is now firmly rooted within institutions which aligns itself with the power of capital and markets.

In the context of this research, this section laid out the issues inherent within dominant ideologies of sustainable development. This approach is one that dominates the global economic system and dictates the ways in which energy development occurs in Scotland in the present. Even those of more growth-sympathetic persuasions have levelled criticism at the current paradigm, where environmental policy is failing a climate and biodiversity crisis and inequality is rising, sowing social discord and democratic disillusionment. The following sections explore alternative approaches to economic development which focus on distribution, ecological wellbeing, the importance of place-based governance and collective ownership.

3.3 Counter hegemonic ideas: post-growth & well-being approaches

As this thesis aims to explore the conditions around the emergence of an alternative MWT industry in Scotland, it is important to understand the different kinds of ideas and praxis existing which is counter to capitalist hegemony. The previous sections within this chapter outlined the dominance of capitalist growth paradigms within imaginaries of human

development and how it permeates throughout mainstream approaches to environmental and climate transitions. The role of GDP and the bottom line were also emphasised to demonstrate the unsuitable and singular nature of growth as a phenomenon, institutional structure, and ideology to pursue ecological wellbeing (Haapanen and Tapio 2016; Daly 2013).

However, growth led governance can occur in many different arrangements, both more broadly and within particular sectors of economies such as energy. In rather simplistic terms, one can think about the ways in which the former USSR grew its economy, or the Chinese state in more recent times, as opposed to the approach in many western and global south countries. All are growth orientated and to varying degrees exhibit forms of internal or external colonialism (Hickel 2017), but do so under various ideological, institutional and market approaches and thus have a range of goals, outcomes and impacts across social, cultural, economic and environmental fields. In essence, the governance structures here articulate the level of public and common models of ownership in the economy as opposed to a market, private and financialised model. Despite the widely acknowledged hegemony of growth and neoliberal approaches discussed in the previous sections of this chapter, and the power of capitalism to constrain the imagining of alternatives; there are countless configurations and ways of organising societies beyond incumbent regimes.

First, in relation to a growth orientated global economy, there are various strands of scholarship which aim to reframe the function and operationality of economies and energy systems away from growth and towards human and environmental need. In such approaches, energy functions to provide particular energy services such as heating, mobility and illumination, which map to beneficiary activities such as participation in social and cultural life, as well as wider wellbeing outcomes (Lamb and Steinberger 2017) (Millward-Hopkins et al. 2020). The thrust of much of the post-growth literature is that planetary and social boundaries relating to resource consumption must be enacted with both upper and lower limits; as seen in the Doughnut Economic model (Raworth 2018), which is based on empirical estimations that suggest the current use of resources is not sustainable. Further, it involves shifting focus from over reliance on technological and efficiency improvements towards essential needs and redistribution through democratic deliberation (Fuchs et al. 2021).

There are various criticisms levelled at post-growth approaches, and at degrowth literature in particular from across disciplines and the political spectrum (Schwartzman 2012; Liodakis 2018). One of the major critiques, particularly from those sympathetic to the argument made by degrowth approaches, is the language and terminology itself. The term can inject

confusion as it does not mean simply the reduction of GDP, but the redistribution of material and energy throughput and reducing patterns of commodification (Hickel 2021). Secondly, and related is that degrowth translates to austerity, loss of livelihood and quality of life, proponents counter this by reasserting that austerity happens in a growth focused economy, and degrowth is an entirely different economy altogether. Whilst often positioned as bottom-up led, degrowth and post-growth proposals focus on the role of nation states and the government as the major driver of change, emphasising that in transforming the system of the present, government plays a critical role from a democratic, legal, monetary and regulatory perspective (Cosme et al. 2017).

As stated, post-growth approaches are driven by the provisioning of human needs and well-being and require structural shifts in the economy. Some popular policies associated include reducing inequality, full employment under reduced working hours, universal access to energy, water, health, education, transportation and housing (Hickel et al. 2021; Kallis et al. 2018). To synthesise the main critique of growth hegemony, high income countries have detached growth from any concept of need, vastly beyond the requirements for a flourishing society. It is these needs and flourishing societies that matter, not GDP or ever-growing consumption, which is impossible in an ecologically limited world. Post-growth approaches can influence energy policy in several ways, however, most centrally is that energy development would be structured around universal affordable access, and a green jobs guarantee, fuelled primarily by public funds.

As discussed in the previous section, financial markets have a strong grip on public spending which make this difficult, beyond the very real resource constraints and inflationary risk. Post-growth approaches would require tax reform at national and international scales to burden fossil fuels and ecologically damaging activities as well as wealth inequality more generally. Alongside coordination to stop capital flight and the pervasive offshoring of wealth in havens or tax-free zones, together these measures would help to keep the monetary supply below inflationary limits as well as reducing demands on unnecessary and damaging material consumption. Together with tax reform, the utilisation of the state's role as the currency issuer would allow for mass investment in public infrastructure to meet social and ecological objectives. The capability for such spending has been observed during the financial crisis of 2007 to bail out banks, again during the COVID-19 pandemic and more recently relating to military spending in the Ukraine War (Jackson, Jackson, and van Lerven 2022; Nersisyan and Wray 2021).

Research from Post-Keynesian and Modern Monetary Theory (MMT) scholars suggest that a fine balance of fiscal and monetary policy that accounts for ecological limits and the

productive capacity of economies is capable of funding and supporting a post-growth just and sustainable transition (Olk et al. 2023; Arnsperger et al. 2021; Jackson et al. 2022; Berkeley et al. 2022). However, critical to its implementation is the democratisation of governance structures, which as we have explored earlier have been co-opted by hegemonic neoliberal markets and institutions. As described in the previous sections of this chapter, the current energy governance regime is comfortably insulated from meaningful democratic mandate, and is market-focussed, in its approach. However, movements for a more sustainable, just and democratic energy system have gained traction as ecological, social and wellbeing challenges grow in scale and urgency. The very essence of many alternative wellbeing centred economic development approaches is that a pluralism and specificity of place, people and context must be empowered, pointing to not one great solution, such as the market, but a variety of ways in which local places and national polities determine their energy futures democratically. Such futures will face huge pushback and contestation, as was explored in the political economy subsection.

The following sections of this chapter provide overviews of some of the major alternative economic development approaches that point the way to futures aligned with ecological wellbeing and place. The rest of this chapter explores ideas and praxis such as an **eco-welfare state, place-based approaches, energy commons and community wealth building,** which can provide insight into ways in which MWT technologies and heat transitions within Scotland can unfold under alternative economic development paradigms.

Alternative implementation strategies for economic system change that could enable a degrowth agenda are present and emerging within the context of energy transitions and are explored in the following sections: demonstrating some strategies that can overcome capitalist hegemony and the inability to imagine an alternative.

3.3.1 The state and the common good: an eco-welfare state

In this literature review thus far, the state has been discussed in terms of its role in a capitalist, neoliberal and growth orientated political economy. Having emphasised its central role in this current political economy regime, the state can be understood as equally important in any transition to post-growth, democratic and wellbeing orientated economies. This is critical for understanding how a MWT may emerge that aligns with these counter hegemonic perspectives.

The role of the state within sustainability transitions, and the energy economy has been the focus of scholarship from various disciplines (Johnstone and Newell 2018a; Eckersley 2004; Grin et al. 2010). As Bauwens et al (2024) acknowledge, ‘there is a strong case to be made

that only the state can wield sufficient power to rapidly undertake a mission requiring the scale and coordination that climate change mitigation demands' and many other have called for a recentring of the state in green transition discourses (Christophers 2024; Gerbaudo 2021).

The literature review in this thesis emphasises the role of the state, having demonstrated that climate change mitigation as well as efforts to develop human wellbeing also require the dismantling of neoliberal capitalism and that the state is the primary vehicle in which this action can be taken. However, as the political economy and Gramscian analysis finds, the state and institutions will be controlled, co-opted and in direct opposition to any use that does not advance incumbent fossil capital regimes of power. Thus, states are just as capable of facilitating unjust and undemocratic extractive practices as any capitalist private actor (Velasco-Herrejón et al. 2022). Whilst the thrust of post-growth and democratic movements look to transform or move beyond the capitalist state, scholars have pointed to the notable achievements of previous capitalist regimes in which the common good was a more significant driver, such as the New Deal in the USA or the UK's postwar settlement, pointing the way to possibilities of transition (Huber 2024; Aronoff 2020; Newell and Simms 2021a).

State coordinated legal authority, fiscal tools, infrastructure and regulation are the underpinning of any energy governance regime, delivered through democratic mandate to address challenges associated with transition (Scoones et al. 2015a). Whilst community and local energy initiatives can have deep impact on the energy transition, without state frameworks, their inclusivity across society and longevity are in doubt (Stephens 2024). Further, political spending by incumbent fossil industries overwhelms grassroots coalitions within the energy transition, necessitating a more involved state if green ambitions are to be met (Hess 2014). Thus, the state is critical in ensuring transitions enshrine democratic participation, inclusive decision-making and the countering of technocratic and corporate domination.

Evidence has suggested that energy transitions are likely to create new and deepen existing inequalities (Bouzarovski and Tirado Herrero 2017), and it is only the state that has the authority to redistribute resources and wealth along more equitable lines, thus social policies of the state and ecological developments must align for sustainable and equitable energy transitions to occur (Koch 2022; Hasanaj 2023). Hasanaj (2023) describes the emergent and growing literature on the eco-welfare state, where scholars have synergised concepts from environmental and welfare states as a practical way of addressing challenges of climate change, poverty and inequality. Despite the various synergies, many challenges and

tensions are also identified in present between environmental and social welfare, such as consumption patterns, cost of living, and the debate over prioritising public expenditures.

In order to address the fiscal challenges facing a potential eco-welfare state, there are two critical strands of scholarship to address. First, are heterodox economic insights from various post-Keynesian schools of thought which demonstrate alternative accounts of the monetary system and ways to manage demand, consumption, resource use and activity in the economy. Government fiscal tools, especially spending, are deemed essential in order to maintain full employment and stabilise aggregate demand within the economy in a post-Keynesian vision (Lavoie 2014). Any post-growth, wellbeing orientated economy that offers meaningful and sustainable work for all people would require the state to manage programmes, such as green job guarantee. Further, public investment is essential to tackle the instability of capitalism, linked to cycles of investment, speculation. Thus, the state plays the central role in guiding investment towards socially and environmentally desirable outcomes and is critical in providing a strategic role for long-term planning. Insights from Modern Monetary Theory also emphasise the role of the state as the currency issuer in fiat economies, and thus deficits are essential as the state provides the buffer to allow for greater private savings and investments (Wray 2019; Kelton 2020). As Mazzucato & Ryan-Collins (2024) state ‘how debt is being used is more important than the level of debt’. This fundamentally rebuts the tax and spend model, as governments must bring money into existence before it can then be taxed back in order to manage inflation. Inflation is controlled through demand management, taxation, job guarantee and by matching these elements to real resource constraints in the economy. Berkeley et al (2022) detail the UK’s monetary system in their analysis ‘The self-financing state’, concluding that fiscal constraints are self-imposed and that household budget frameworks are politically motivated. MMT or post-Chartalist analysis is equally critical of the borrowing fiscal arrangements, in which government bonds, and bond yields in a fiat economy primarily function as an investment vehicle for excess private wealth.

In summary, the post-Keynesian and MMT scholarship positions the state in opposition to neoliberal austerity economics, not as a market-corrector of last resort, but as the proactive defining actor in the economy providing direction and momentum towards equitable, environmental and sustainable goals. Olk et al (2023) provide an outline of why ‘MMT and degrowth form a strategic symbiosis for addressing social and ecological crises’ by developing a theory of how public investment can achieve socially and ecologically sound economic activity whilst maintaining macroeconomic stability. The bedrock of such a vision

would rest upon stronger regulation of private finance, tax reforms, price controls, public welfare programmes and job guarantees directed by democratic deliberation.

Complementing the heterodox economic literature and post-growth approaches is scholarship on the state as market shaper and participant, an entrepreneurial state working in the interest of common good. Mazzucato has developed the idea of the 'entrepreneurial state' over the past decade to position the state as critical in shaping collective goals and delivering action towards them (Mazzucato 2024a). Further links emerge between the economic positions of MMT and post-Keynesian scholarship, as wealth creation and distribution alongside inclusiveness are central to the entrepreneurial state concept (Mazzucato 2024b). Dosi et al (2023) research the importance of 'mission-orientated' innovation policies, such as policies which enable economically and socially productive forms of R&D and investment, with public research bodies deemed as the most effective way of coordinating innovation. This allows private, community and forms of grassroots innovation to gain a footing against incumbent regimes, as well as skills diffusion across multiple competing 'missions'. Whilst much of the knowledge here is relevant to macro, national level economic strategies, it is equally important at regional and local levels. Thompson et al (2020) introduce 'entrepreneurial municipalism' as a democratic and socially progressive local level strategy which combines municipal state power with local community development practitioners. Led by a critique of neoliberal entrepreneurialism which asset strips public land and infrastructure, and hinges upon speculative growth, their municipalism repositions local institutions as critical in promoting democracy and a focus on local needs through the utilisation of state funds away from private actors and towards forms of public and community activity.

As green investments have been routinely rolled back in the period since the global financial crisis (Tienhaara 2018), an alternative theory of the state is essential in order to meet the pressing needs that scientific knowledge is raising with regards to environmental breakdown as well as societal issues relating to material inequality and poverty. The state can also play a significant role in advancing community and democratic forms of economy activity rooted in place. The following sections explores place-based approaches and community wealth building, as two most prominent and insightful discourses observed in the literature and in practice, in Scotland and further afield today.

3.3.2 Place-based energy governance

Place-based energy has emerged as a powerful tool of analysis which emphasises a plural and proactive approach to energy governance (Dunlap and Tornel 2023). By centering the

role of place in the energy system, as many ways of knowing and being are acknowledged as there are sites of energy production, inherently encouraging further considerations of the value and purpose of energy. This is because they prioritise addressing local energy needs across urban/rural, indigenous, and other classes within society. When thinking about the former coalfields in Scotland in which MWT is to be developed, an approach which emphasises place is important, as these unique characteristics of place are essential to the emergence of a successful system.

The need for place-based approaches has been highlighted by energy and social science research (Schlosberg 2004; K. Jenkins et al. 2016). It can take forms that vary from ownership of energy, proactive engagement in the siting, governance and benefit processes of energy production along with a broader shift to decentralised and localised investment policies. As energy governance approaches have become increasingly centralised, place-based approaches offer ways to rescale in ways which encourage outcomes of energy democracy and energy citizenship (van Veelen and van der Horst 2018; Wahlund and Palm 2022). Despite its focus on the local, place-based approaches have the potential to create networks of connections and solidarity across boundaries, recognising the pan-geographical elements of energy production and consumption (Kothari 2022; Healy et al. 2019).

Place-based approaches acknowledge that energy resources are anchored in specific places, giving identity, legitimacy and connection to the local environment, as often observed with community energy initiatives (Aiken et al. 2022; Brouwer et al. 2025). Place is understood as more than a backdrop and as critical in shaping community interaction with energy production, and that the relational power of place is emphasised. Place-based approaches benefit from faster permit processes, fewer appeals and shorted project durations than commercially owned projects as conflict is reduced, and trust is rooted in the acknowledgment of local context. In dialogue with grassroot innovation literature, techno-social innovations can be grounded in local needs, values and capacities and thus, pushing back against capitalist imaginaries (Sareen et al. 2024). However, it is worth acknowledging the tensions present between a neoliberal energy governance and a place-based approach which focuses on a communitarian spirit of democracy and collectively.

Laes & Bombaerts (2022) analyse these tensions through ontological, economic and power politics dimensions, stating first that flexibility within neoliberalism encourages community energy initiatives to be integrated into market structures. The professionalisation and elitism found within energy systems can be challenging for non-profit and volunteer led communitarian energy initiatives, however hybrid models are more commonly found to more successfully navigate this issue. Finally, as place-based energy initiatives prioritise

democratic control over the energy system, positioned as alternatives to neoliberal incumbents, they require innovative approaches to remain grounded in local need and empowerment.

Challenges emerge from place-based approaches to energy, particularly from a scaling perspective. Often dismissed as low impact, or overwhelmed by what Aiken et al (2022) identify as 'Instrumental imaginaries', where internal and external pressures drive desires for place-based initiatives to grow. A possible result is that local place-based approaches are never deemed sufficient, becoming a means to an end, serving a wider system and risk losing local embeddedness. Some critical reflections highlight romanticization and instrumentalization attached to such approaches, which can de-emphasize the issues of identity, local and indigenous knowledge and various other non-scalable elements in a situated setting (Taylor Aiken et al 2022). Further, within the literature, calls are made for greater emphasis of the spatial dynamics of energy transitions, highlighting the role of scale, place, and space in determining socio-technical change (Binz et al. 2020b).

Place-based approaches offer a way of exploring shared visions and values (Parkhill et al. 2015), providing fruitful ways of analysing the role of political economy in shaping sociotechnical imaginaries. As an alternative approach which is in opposition to the neoliberal political economy, it shows a potential way in which post-growth, non-capitalist energy futures can emerge. However greater understanding on how place-based approaches develop in the imaginary and in practice in relation to incumbent structures is necessary, precisely where this thesis aims to contribute.

3.3.3 Community Wealth Building

A further approach worth exploring in the context of Scotland's former mining communities is that of Community Wealth Building (CWB). These communities are facing some of the highest levels of inequality and social challenges, as discussed in the introduction chapter.

The idea of community development is far-reaching and somewhat nebulous, as is the term itself, and has grown in prominence as a formalised approach taken across the world as communities and supporters engage in community development efforts (Matarrita-Cascante and Brennan 2012). Indeed, (Abbott 1995) situate community development paradigms as a search for an alternative from the kinds of modernisation and economic development experienced in the second half of the 20th century, where strategies failed to deliver appropriate benefit to communities and an attempt to break dependence was made. The key principle being that of participation of the community in processes to advance social and economic progress. Whilst contestation over what is meant by community development and

community itself, (Gilchrist and Taylor 2016) note that common themes are ever present around social justice, collective action, enabling participation, and altering power imbalances. In this trajectory, the emergence of asset-based community development approaches represented a shift from a focus on needs to strengths or assets. It's strength lies in its emphasis on the central role of communities in driving local development centred around existing and unrecognised assets (Mathie and Cunningham 2003). There are a range of sources driving alternative approaches relating social, economic and political conditions, but also the opportunities afforded by technological advances. Greater technological accessibility means that decentralised development opportunities remain unachievable and cycles of unsustainable practice continue without the meaningful participation of local populations. At its core, asset-based community development is done by communities - for communities - and is not so much a complete stepping back of government participation, but a cultural change in the rebalancing of power in partnerships and programmes for development.

Building on the legacy of different forms of community-orientated development and gaining traction is the concept and process of CWB, coined by the Democracy Collaborative in the U.S around 2005 (Guinan and O'Neill 2019). Community Wealth Building takes a systematic approach to economic development that goes beyond individual or connected community development programmes and attempts to provide a framework that brings together a local economic system in its entirety. CWB emerged in response to increasing levels of unemployment, poverty and the lack of political will to reorientate and invest public funding and services in local areas, both urban and rural. At its core, CWB is about democratic, collective and locally-rooted approaches to create a sustainable economy (Kelly, McKinley, and Duncan 2016). Fundamentally, it is about the recirculation of wealth and the embeddedness of regenerative activity and has been described as a 'de-globalisation of capital', where reliance on extractive and competitive inward-investment strategies are overcome. A central focus is on place, on assets and organisations that are anchored and unlikely to leave, from use and support for local supply chains to land, building and community organisations.

There are several higher profile examples of CWB, notably in Preston and North Ayrshire in the UK, and Ohio in the US (The Democracy Collaborative, n.d.). However, of critical interest to this thesis, is the adoption of CWB by the Scottish Government as an approach to economic development, as a means to achieving a 'wellbeing economy'. The approach is seeking to tackle 'long standing systematic challenges and structural inequalities' within communities, where more people own, have a stake in and benefit from the wealth

generated by the economy, aligned to net zero ambitions. The Scottish Government framework is structured by five pillars (The Scottish Government 2023):

- Spending
- Workforce,
- Land and property,
- Inclusive ownership,
- Finance

Interestingly, some criticism of CWB warns of the risk of 'siloing' local areas from one another, however, meaningful national legislation and supportive coordination as developing in Scotland could play a crucial role in countering this effect.

Clearly, developing MWT systems can align with many CWB principles, as it brings under-used land and assets into productive use, contributes to net- zero, and has the potential to tackle long-standing economic structural imbalances whilst delivering community benefit. Further both rely on local anchor institutions such as councils, health, university, housing and private sector employers. It is not necessarily about additionality, redeployment and cultural change of how local areas are owned, governed and planned all contribute to democratising local wealth. Whilst this section has spoken to the policy landscape and wider regimes across local economic and just transition thinking, the frameworks for inclusive development of minewater resources on a project or community level will require a more detailed and rigorous approach.

3.3.4 Energy commons

The commons movement has its roots in European societies in which shared resources such as forests, pastures, fisheries and water were collectively managed by local communities, sometimes granted by the authority of the state, through common rights, although oftentimes without any formal structure (Neeson 1993; Ostrom 1990). The enclosure movement of the16th to 19th centuries saw the privatisation of much common land, leading to the rise of modern capitalism. The commons has revived as a theoretical movement through the 20th and 21st centuries, as an approach it has been utilised in areas as diverse as internet platforms, environmental protections and economic systems as an alternative to neoliberal extractivist forms of production (Bollier and Helfrich 2014; Angelis 2007; Standing 2022).

Commons are understood not just as resource sharing arrangements, but as alternative modes of political, social and economic organisation which show glimpses into a world

beyond markets and states. As such, an energy commons approach is worth exploring for this thesis in the context of economic alternatives for MWT development in Scotland. However, as the commons approach is a direct challenge to capitalist hegemony, a political economy perspective emphasising the tensions and challenges commoning approaches face in their implementation is useful. Post-growth perspectives interact with the commons through a focus of collective agency and democracy, and a priority of care, relationality and sustainability towards both the human and the natural worlds (Bollier 2024).

As an energy system led by market informed approaches it is increasingly criticised for its failure to transition at pace or scale to meet social and environmental needs. With scepticism over whether the state is capable of changing its structural approach, energy commons is situated as a third way of governance. Ostrom's (1990) original Socio-Ecological Systems framework was originally applied to various resources, but not energy or electricity (Laerhoven et al. 2020). Energy commons research is a gap within the wider commons movement, however in recent years scholars have begun to conceptualise across disciplines a cohesive framework (Bauwens et al. 2024). Various definitions exist for energy commons, many informed by post-growth philosophy, that include a focus on community, common welfare, local use and democratic organisation. Bauwens et al (2024) use the following insightful and detailed definition:

> "The sets of social relations and governance rules developed by communities of energy producers, users, and prosumers to collectively and democratically co-create and co-manage (bio)physical resources related to material extraction (e.g., minerals for energy technologies or biomass), energy production, distribution, use, and storage, as well as the handling of waste or decommissioning of infrastructure, with the aim of enhancing energy access, efficiency, and sustainability."

Energy commons approaches are present in diverse degrees in practices such as community energy and municipalisation. An example of this in practice is the municipal government of Delhi offering 200 free KWh of electricity each month to residents, where energy is treated as a basic right and common resource. In their systematic review Bauwens et al (2024) emphasise three intersecting dimensions of energy commons literature, the material, institutional and cultural. Energy commons overlap with some of the key energy social science discourses of the moment, including energy justice, energy democracy and citizenship, however its distinctive approach offers a comprehensive and actionable possibility in which to govern energy resources. Despite its focus on locality and community, the authors identify critical dimensions of the energy commons literature including a western

bias, the need for coordinated governance across scales, the decentralisation of power and the need to avoid co-optation and more firmly reject capitalism.

In their paper, Acosta et al (2018) apply the energy commons approach to the energy transition. They identify unique socio-technical challenges presented by the energy commons approach, including effective governance, coordination amongst participants of various commons, and fair distribution of costs and benefits. Amongst common members, aligned incentives, low entry barriers, shared decision-making and a clear role for institutional actors were revealed as paramount. The authors discuss the importance of addressing regulatory, techno-economic and social-organisation dimensions equally, whilst energy commons emerge in a capitalist environment. Other challenges identified within commons scholarship include issues related to scalability and the hierarchical relationalities between different commons (Harvey 2012).

As a potentially radical alternative approach energy commons is an informative theoretical tool in the context of this thesis. However, it is less advanced both in scholarship and policy than some of the other alternative energy futures discussed, and thus requires greater supportive infrastructure and embeddedness within legal and economic systems (Bollier 2024). Energy commons offers a meaningful and potentially fruitful response to the ecological, social and democratic challenges of the present day. Some forms of community energy represent the closest existing energy commons systems and thus present a tangible way of envisioning an energy commons future for MWT.

3.4 Chapter Conclusions

As this chapter has explored, there are several research gaps and fruitful avenues emerging from a political economy perspective on energy transitions. Firstly, the chapter highlighted an ideological political economy lens, which elicits understanding on how transitions are shaped, entrenched or suppressed by incumbent, hegemonic forces operating at institutional, market and legal levels, as well as the realm of alternative ideas. Secondly it has broken down the dominant growth focussed neoliberal ideologies which shape sustainable development, and alternative approaches which are oppositional, being both democratic and needs based. The chapter has revealed how a better understanding of the institutional arrangements which facilitate and suppress different kinds of transition within the energy economy is necessary, how the policy and market spheres interact with respect to the power of incumbent regimes. It highlights a geographical political economy of energy transition, which is shaped at different contexts and scales, where global and place-based forces interplay at local levels. Interconnected to the last points, is a need to better understand how institutional support for markets and financial systems interacts with place-

based developments, how governance systems enable or disable the place of local, non-neoliberal forms of development, such as community wealth building or energy commons. The following chapter continues the literature review with a dissection of the energy justice literature, in which many of the concepts discussed in both this chapter on alternative economic development approaches, as well as energy imaginaries in the previous chapter have many overlapping features.

Chapter 4 - Energy Justice

In previous chapters, we discussed the socio-technical nature of the energy system and a potential MWT industry, as well as the tendency for individuals and collectives to project visions of the future onto such socio-technical systems. Following this, the ideologies and political economy which shape dominant power structures and imaginaries was explored. In this final literature review chapter, energy justice scholarship is explored to understand how the interlinked processes of imaginaries and political economy are related to notions of justice within energy systems. Whilst the previous chapters explored how transitions occur, what forces drive them and distort alternative pathways, this chapter examines the role of ideas of justice and fairness in energy imaginaries. Energy justice is explored as to understand the normative ambitions and practical application of justice concepts, with particular reflection on the plurality and tensions present in visions of just energy futures.

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4.1 Energy justice origins

Energy systems have varied impacts across national and global societies, which can disproportionally effect different groups, thus raising implications for justice and fairness (Jones et al. 2015). Whether it be climate change, ongoing environmental pollution, singular events such as oil spills or nuclear disasters, harsh transition of industrial employment or unequal distribution of costs and impacts from what would be deemed a functional energy system; the connection between justice and the energy sector is clear. Though energy and well-being are widely accepted as inter-connected (Day et al. 2016), policymakers and practitioners continue to centre energy system decision-making almost solely on economic terms as if there decisions are void of moral considerations (Jones et al. 2015; Sovacool et al. 2017). For the focus of this research, and as has been discussed previously, there are distinct elements of fairness and justice which are important to the MWT landscape. Past energy and industrial transitions in the coalfields have led to a range of just and unjust outcomes, notably shifting in their focus from purely economic agendas to periods of wider social and moral rationale. The legacies of the previous transitions and transformations are still felt today in disadvantaged social, economic and health outcome. To build future energy systems, including MWT, investigations of the justice dimensions are crucial to develop understanding of different processes.

The concept of energy justice has become an important pillar of energy social science research. Environmental justice emerged in the 1970s and climate justice scholarship

followed in the 1990s, both of which have arguably focused on preventative action or mitigation. Energy justice builds upon this whilst aiming to facilitate wider social, economic and more transformative approaches to impact energy systems (Heffron and McCauley 2017) and is now a major research issue; with major journal dedications to the topic and limited adoption in policy-making and energy commerce (Heffron 2022). More recently, the global 'just energy transition' agenda has been prominent in UN and COP contexts and the US appointed a Deputy Director of Energy Justice in the Department of energy during the Biden administration. Distinct definitions of energy justice vary but tend to share central themes. The Initiative for Energy Justice (Sheehan 2019) define the concept in the following way:

> "Energy justice refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system"

The Initiative has developed a number of diagrams and frameworks for understanding energy justice and approaches to enacting it which will be used here to visualise some of this context in Figure 11 and Figure 12.

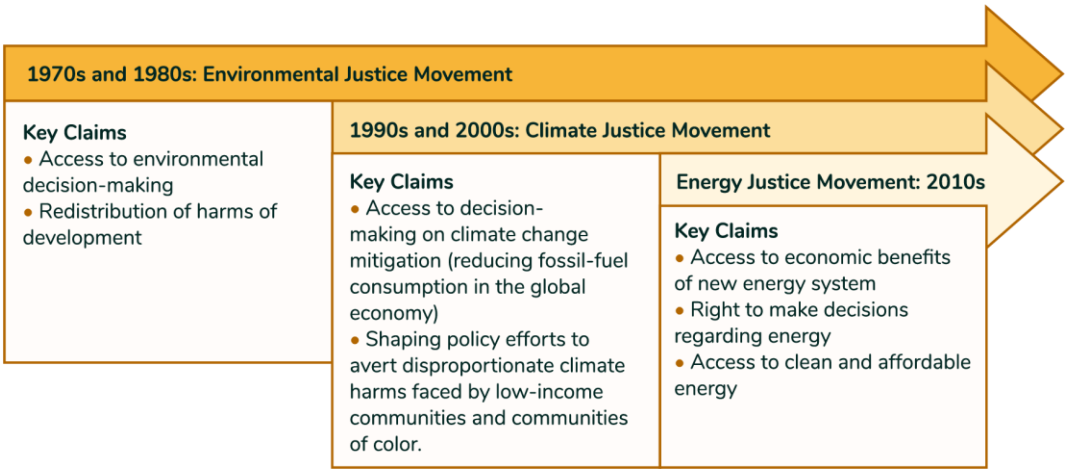


Figure 9 Origins of different related justice movements (Source: IEJUSA)

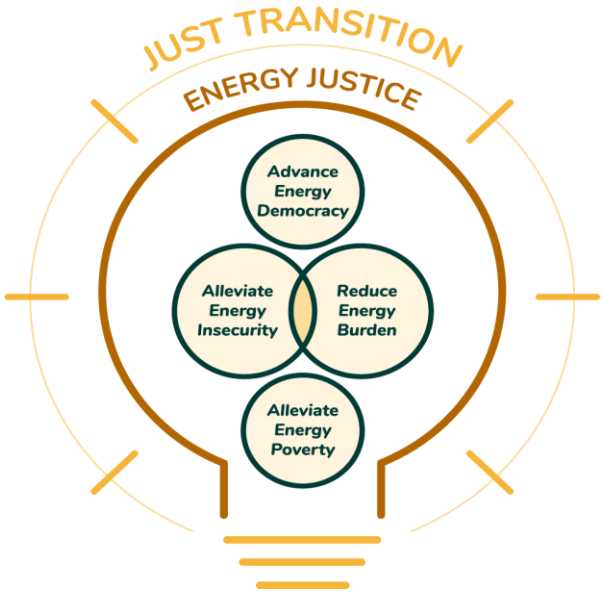


Figure 10 The goals of energy justice as part of a just transition (Source: IEJUSA)

Exploring the emergence of energy justice as a concept, term and field of research, Heffron and McCauley (2017) note its origins in practice, primarily in the context of fuel poverty charities. In academia it was initially used as a relational term to other climate change topics with articles focussing on topics such as energy poverty and ethics. McCauley et al. (2013) acknowledge the debate and contestation at the heart of justice claims, from Aristotle through Adam Smith and Karl Marx, and the differences between distributive and corrective justice, which exist today in social and legal justice approaches. The tenet approach has become the most established lens in within energy justice scholarship, beginning with McCauley et al. (2013).This “triumvirate of tenets” approach conceptualises justice through distributional, procedural and recognition principles. Distributional justice can be understood as the distribution of benefits and burdens, acknowledging that these tend to fall unfairly across different groups (Heffron 2022). Procedural justice concerns the use of equitable procedures, engagement and participation in a non-discriminatory way (Heffron et al. 2015).Recognition justice claims that different identities, knowledge systems and lived experiences should be recognised and respected within energy governance. Some scholars have added additional principles such as cosmopolitan justice and restorative justice. Cosmopolitan justice is a conceptualisation of the global nature and effect of energy developments, that as citizens impacted by cross-border energy activities there must collective consideration (Heffron 2022). Restorative justice recognises part harms, and stipulates that injustice caused by the energy sector should be recognised and rectified going forward (Hazrati and Heffron 2021). All forms of justice in this framework are intimately connected in various ways.

In their re-conception of the energy justice topic, (McCauley and Heffron 2018) acknowledge the dominant frames of distributional and procedural justice and present the “new triumvirate of tenets’ as including restorative justice, replacing recognition justice, this has been replicated in further work (Wallsgrove 2022). Cosmopolitan is also of less relevance to this case as its central focus is on whole systems and energy policy serving international obligations regarding emissions, waste and environmental impacts. An energy justice framework that visualises the three tenets is outlined in Figure 13.

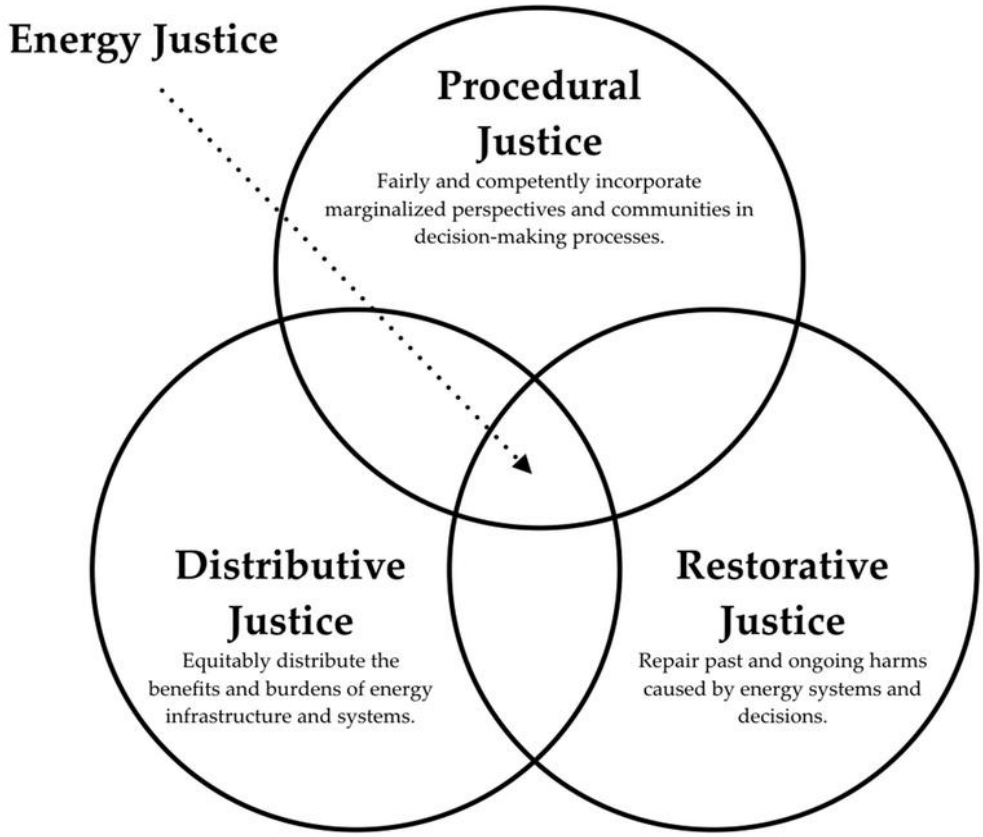


Figure 11 Three core energy justice principles taken from (Wallsgrove et al. 2021)

The justice framework approach of the three tenet has arguably become the most prominent academic approach to justice informed energy transitions. This framework has increasingly highlighted the importance of a holistic transition, heuristically this of often denoted by the just transition terminology, where intersecting environmental justice, climate justice and energy justice constitute systemic social and economic transformations (Abram et al. 2022). By using insights from energy justice approaches an opportunity emerges to explore where injustices occur, highlighting the maldistribution of burdens and benefits and allowing for the development of new processes of avoidance and remediation as well as the recognition of new actors. Applications of energy justice in academic research have extended to a range of areas in law, public health, and business studies beyond its original geography and sociological core (Sovacool et al. 2017). There are calls for more direct integration of the

different approaches, in order for more holistic interpretations of changes within the energy sector and their relation to wider society (McCauley and Heffron 2018). By appreciating various vulnerabilities and the impact the energy system has on particular disadvantaged groups, the justice literature can define the limitations and possibilities of system transformation.

Having explored the origins of energy justice as a scholarly field, the following section focusses on the concept of restorative justice, as the past harms associated with deindustrialisation within Scottish coalfields are important to understanding how MWT energy futures develop.

4.2 Restorative justice

With the context of this research inextricably connected to the history and outcomes of previous energy and economic transitions, namely deindustrialisation and the closing of the coal mining sector in Scotland; there is an important and novel line of inquiry from a restorative justice perspective; how to approach past and ongoing harms from previous fossil fuel transitions, in the face of a new sustainable energy transition. Indeed the origins of the just transition concept included a restorative focus, with trade union usage in the 1980s as a direct response to fossil fuel industry shutdown and the addressing of environmental and social harms(Abraham 2017). McCauley and Heffron (2018) suggest that restorative justice has been neglected and understudied within energy justice scholarship, which threatens the transformative possibilities offered by energy justice approaches. With its practical relevance for this research, it is a worthwhile theoretical focus to bring to the thesis.

Restorative justice finds its origins in criminal law, where questions of accountability and consequence are raised after an injustice has occurred (Heffron and McCauley 2017). It focuses on repairing harm rather than punishing the offender, demonstrating where preventative measures need to occur, and can bring to light the true cost of decisions in the energy sector. At its core, restorative justice can be more simply conceived fulfilling an obligation to return a victim to their original position (Hazrati and Heffron 2021) and can occur after the damage has already taken place but also at the beginning of a process. In this conception, restorative justice in application forces decision-makers to consider all potential harms as every injustice must be rectified, which in some cases would make energy actions too costly and unable to proceed. By forcing the final outcome into focus, restorative justice can provide closure and a uniting goal across disciplinary focuses (McCauley and Heffron 2018). (Heffron and McCauley 2017) site examples of restorative justice already occurring in practice, including through Environmental Impact Assessments, Social-Licence-to-Operate and Energy Financial Reserve Obligations, as ultimately these

processes require decision-makers to ensure that nature, society and local populations are not harmed by energy actions before projects go ahead.

Restorative justice can encompass the recognition element present in earlier iterations of the energy justice tenet approach, though it can also go further by bringing a more transformative framing to impacts of systemic injustices across class, cultural and gender differences (Wallsgrove 2022). In their account, Wallsgrove (2022) proposes that linkages between the language of energy justice and criminal law interpretations of restorative justice will aid in its usefulness. Therefore, by considering the pillars of restorative justice in the context of criminal law with a focus on harms, accountability and participation; this places the focus on people and relationship and an obligation to make things right. If this energy justice approach is to be used as a transformative tool, the duality of the restoration must be noted, where restorative justice speaks to remaking what has been lost, and also repairing wider social relationships and rectifying injustices.

Ultimately, restorative justice questions ask, “does the policy aim to remedy prior and present harms faced by communities negatively impacted by the energy system?”(Sheehan 2019). Without a first step of recognition, there can be no remedy, which in turns requires responsibility and reconstruction. If imperatives of justice, as exemplified by growing calls for a just transition, are not built upon repair and recognition, it is unlikely that urgently required low carbon energy will be able to represent a fairer, more equitable form of energy development.

4.3 Utilising energy justice in this thesis

Having discussed the origins of justice approaches to energy transition, and the role of restorative justice in understanding cases of past harm and transition, this final section aims to highlight the pathways in which energy justice approaches can be utilised and contributed to in this thesis. Whilst energy justice, and in particular the tenet approach has grown significantly in prominence within academic scholarship, several strands of critique have emerged, which aim to reform its practical useability, and normative ambitions. Energy justice scholarship has increasingly acknowledged its limited translation into policy, business practice and institutional decision making across the lifecycle of energy projects, from planning through to operation and decommissioning(K. E. H. Jenkins et al. 2020; Hazrati and Heffron 2021; Heffron 2022; K. E. Jenkins 2019). On the other hand, the tenet approach has faced criticism for moving away from the intellectual roots of environmental justice, and isolating the tenets into sequential items to be checked off (Bouzarovski 2022; Wood 2023). According to Wood et al (2024) the concept has become thin, were its vagueness allows it to be used across cases, whilst failing to provide depth of guidance in its use. Thus, a tension

emerges in energy justice between the desire for politically useable heuristics for practical uptake, and the normative goal of overcoming inequalities.

According to Wood et al (2024), paths forward for the use of energy justice concepts lie in embracing the plurality of justice perceptions, their tensions and contestations. Such tensions raise important questions regarding how justice is valued from different contexts, particularly in relation to dimensions that resist quantification or monetisation, such as through care, dignity, recognition or cultural expressions. Attempts to reduce justice to measurable economic outcomes risk the narrowing of its meaning and may obscure the contested and plural nature of justice claims (Frigo and Hillerbrand 2022).

From this perspective energy justice and just transition scholarship may be most useful not as fixed, measurable policy frameworks or metrics, but as a critical and interpretive tool through which competing visions of transition are analysed. Justice is not singular, consensual, or politically neutral. It is negotiated across social, spatial and institutional relations (Pellegrini-Masini et al. 2020) . An emphasis on dialogue and deliberation may shift energy justice debates away from thin, predetermined frameworks and illicit richer, contextual understandings of justice. Recognising justice as plural and contested allows for energy research to move beyond technocratic approaches centred on distribution, and instead engage more directly with questions of power, participation, recognition (Dunlap and Tornel 2023).

Clearly, this perspective has many useful intersections with the political economy and imaginaries literatures. By accepting the contestation present in plural visions of justice, political economy and hegemonic forces are in sharp focus, alongside the subjective, fluid and context dependent nature of justice imaginaries. Space is opened in which interests, values, and futures driving energy transition can be explored. In exploring a future MWT industry emerging in Scotland, language of fairness and justice are critical, as are understandings of how justice visions are created and envisioned.

4.4 Literature review conclusions: summary of research gaps

Across chapters 2-4, this literature review has identified research gaps across the sociotechnical imaginaries, political economy, and energy justice literatures that are relevant to the study of an emergent MWT industry, they are summarised broadly here.

1. Both the sociotechnical imaginaries literature and energy justice literature have not paid enough attention to a political economy understanding of transitions, which

emphasises the power structures, ideologies and social relations enabling and dictating what energy futures are possible and what can be imagined.

2. Energy justice literature can benefit from this perspective, a plural and contested conception of justice is shaped by hegemonic political economy, throughout different dimensions of justice.
3. Consequently, this thesis argues the need to better integrate theoretical and conceptual approaches from political economy, sociotechnical imaginaries and energy justice in order to present a more effective theory of system change and energy transition, through the lens of an emerging low carbon industry.
4. As the conditions and visions of a potential MWT industry Scotland are examined, it is important to understand what kinds of visions are shaped through this sociotechnical object, their interplay between dominant market hegemonic ideologies, and alternative approaches, as well as the normative standards of justice and fairness applied to them.

Taking these factors into account, the analytical framework utilised by this thesis is presented in the following chapter. The methodology is a plan to mobilise this analytical framework against the empirical data, and answer the overarching research question: *What drives and shapes the formation and implementation of minewater thermal energy industry imaginaries for a just transition in Scotland?*

Chapter 5 - Analytical Framework

This chapter introduces the analytical framework developed and utilised in this thesis. It integrates understanding from theoretical conceptions of sociotechnical imaginaries, political economy and energy justice from the scholarly literature, which were all deemed important areas of knowledge for theoretical and contextual reasons relating to the research focus, as explored in the previous chapter.

The analytical framework is mobilised by the methodology to understand and interpret the empirical research. It acts as a bridge between the literature review, the methodology and the findings, as it is crucial in the exploration of the interplay between the research findings and the established literature. An analytical framework provides structure and guidance for the researcher as they undertake data collection and its analysis (Kivunja 2018). The framework is constructed from the most appropriate areas of knowledge from the literature in order to structure the data analysis and to makes sense of the results. Simply put, the analytical framework can be understood as the tool which is used to guide the empirical investigation and utilised by the methodology in order to find answers to the research questions.

5.1 Synthesizing theory from sociotechnical imaginaries, political economy and energy justice

The literature review chapter provided insights across the relevant strands of literature and summarised the key areas of use for this thesis, as well as the gaps where greater attention is necessary. Using theoretical triangulation, the analytical framework thesis draws on a few different scholarly areas. Before the framework is presented, the bridging of the literature gaps is undertaken first in this section in order to lay the ground for its development.

5.1.1 Understanding the sociotechnical imaginaries process in the context of MWT

As a yet to exist niche energy industry, MWT can be understood as an emerging sociotechnical system, embedded in the wider energy system and drifting in the tides of system transition. Its material development is not certain, and tied to the ways in which sociotechnical system change unfolds, thus MWT is an imagined space within energy futures, where different imaginaries are predicated on a range of individual and collective positionalities.

MWT functions as a sociotechnical object whose projected meanings, modes of implementation, and systemic roles diverge based on the positionality of different actors in the empirical landscape; ranging from national and institutional perspectives, through market actors and communitarian orientated organisations, to citizens and communities. In short, a range and interplay of individual and collective imaginaries will manifest themselves, shaped by material, cultural, political and social factors.

When exploring the sociotechnical imaginaries literature and as discussed in the literature review, I observed a lack of scholarship attempting to concretely describe the process of imaginaries. I propose, taken from my summary of understanding in the literature review, that the development of social-technical imaginaries and their actualisation would operate in several steps, from idea to materiality. I have developed the following figure to illustrate the process of sociotechnical imaginaries, which is now explained.

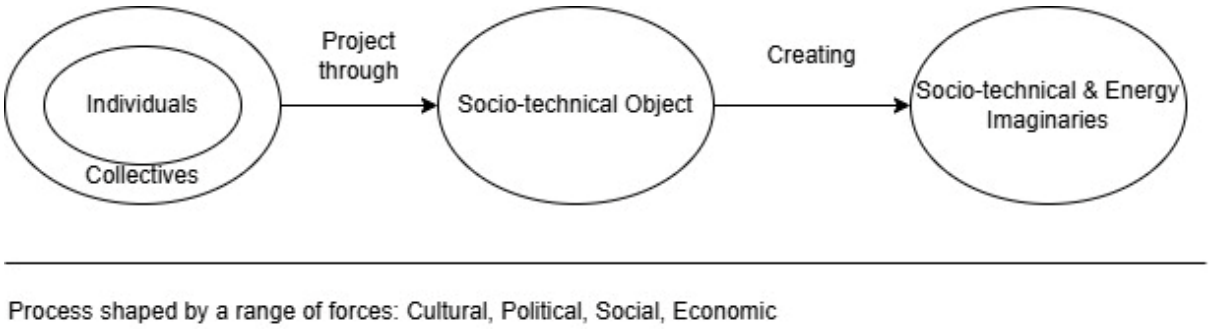


Figure 12 First Principles Understanding of Socio-technical Imaginaries Process

In Figure 15, the creation of socio-technical imaginaries and energy futures begins at the individual level, and with collectives of individuals that share similar imaginaries. These individuals and collectives then project through a socio-technical object or system, to create a new and bespoke imaginary for that object. Moving to what this process may involve in the case of MWT, I have developed Figure 16, which is now discussed.

In this worked example for MWT in Figure 16 below, imaginaries are created by projecting through the object of MWT from a range of social groups, which are made up individuals, some will share imaginaries, other will differ. Alternative imaginaries examples are shown here which highlight prominent theories within the energy transition space as an example. This is a worked example based on literature insights discussed in section 2.2, and it should be noted that these imaginaries are not set visions, groups and individuals may take elements of different imaginaries together, complement and competition between different imaginaries creates unique visions. However, this process excludes the political economy influence, the role of power structures, social relations and ideologies that influence this entire process at a higher level.

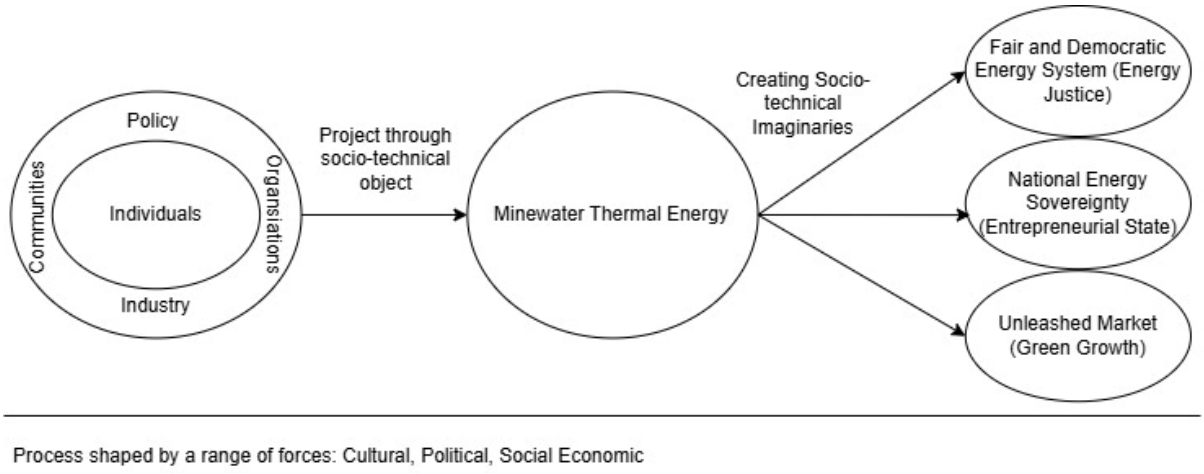


Figure 13 First Principles Understanding of Minewater Thermal Imaginaries Process

As discussed in the literature review, heat technologies - and MWT in particular - have been understudied from a sociotechnical imaginaries perspective. Bioenergy was explored by Eaton et al (2014) with a focus on 'frame keys', and how national imaginaries are interpreted differently by local actors. Magnani and Cittati (2022) explore community renewable energy development in Italy by using the STI perspective, to identify the main drivers behind the promotion of CRE, which result in stronger connections between humans and nature, a sense of community and support for vulnerable populations within regions. More focus on the imaginaries of heat transitions would do much to reveal how material conditions and both individual and collective positionalities interplay with ideas of development. Object based, socio-technical imaginaries do more than simply offer visions of the future, but indeed shape development in the present, as ideas very much influence materiality. However, one important understudied aspect of the sociotechnical imaginaries' literature relates to the role of politics, power dynamics, ideologies and institutionalised development structures. By combining insights from the various imaginaries of MWT, with wider political economy analysis, additional conceptual contributions can be made to both sets of literature in this context.

Beyond the creation of imaginaries, another important level of analysis that needs further attention is the step from imagining to actualisation; how ideas become reality. The post-development concepts demonstrate that other futures are imagined, yet the steps required to reach alternatives are often not present, which as referred to earlier is a key thread emerging from work such as Capitalist Realism (Fisher 2022). The steps taken to successfully bring imaginaries to reality would, I propose, take the following pathway, summarised below and visualised in Figure 17.

1. Individuals, and collectives create socio-technical imaginaries and futures, through the lens of a socio-technical object or system.
2. From this, ideas and strategies are imagined, which would enable and actualise futures developed in stage 1.
3. In a process of trial and error, actions are taken based upon stage 2 at both individual and collective levels to achieve futures developed in stage 1.

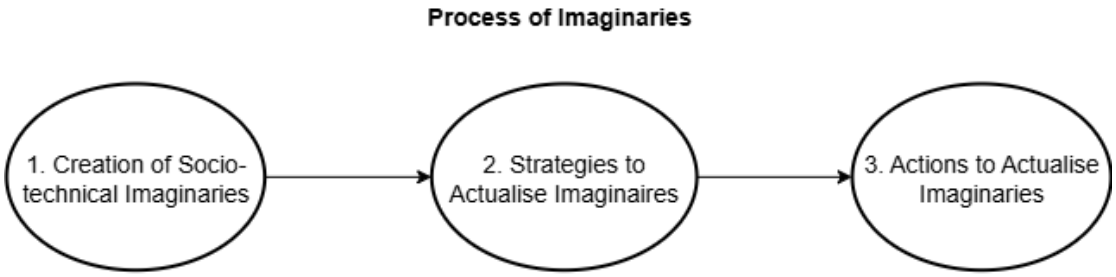


Figure 14 3 step process of Sociotechnical Imaginaries, from creation, to strategy, to deployment

These steps are used as the basis of the integrated analytical framework presented at the end of the chapter. First, the other layers of the framework relating to political economy, hegemonic ideas, and energy justice are discussed.

5.1.2 The dominant political economy forces shaping imaginaries

Now that the sociotechnical imaginaries understanding utilised in this thesis has been explained, it is now appropriate to summarise the political economy dimensions that make up the final framework, as discussed in depth in Chapter 3. As observed in literature, oppositional and alternative imaginaries face huge difficulty in the context of lock-in and incumbency due to hegemonic political forces and power structures. As Gramsci (2020) contends, the possibility for change lies in reaching an understanding of power relations and naturalised assumptions. The realising of alternative imaginaries is suppressed and co-opted in a system which protects the hegemony of neoliberal fossil fuel dominated energy markets (Gandesha 2018).

Building upon neo-Gramscian concepts of hegemony (Cox 1981) in which the design of institutions and their capture by powerful actors and forces co-opt, and disable imaginaries that threaten its hegemonic grip. This is an underexplored area for energy social science research, and of energy justice and socio-technical transitions literature. Equally, political economy studies can gain much from understanding how such hegemonic forces, which ripple through different scales impact and shape the trajectory of energy transition, and more

specifically the emergence of MWT in Scotland. For the purpose of this analytical framework, and taking from various scholarly work (Newell 2019; Hickel and Kallis 2020; Newell and Simms 2021a) ideological, market, institutions, legal structures and economic systems, are taken as the cornerstones of the existing political economy, which is articulated as being growth-led and neoliberal in its making, dominated by hegemonic ideas. Counter-hegemonic ideas, as explored in the literature review are also contesting the existing political economy. A further layer of interaction between energy justice orientated understandings, in the imaginaries of policy and delivery and political economy insights is occurring here.

5.1.3 Energy justice as a normative heuristic to understand energy imaginaries

A final layer of the analytical framework is that of energy justice, which was explored in Chapter 4. Energy justice provides a way in which different imaginaries can be appraised, as well as hinting at the power structures at play, which can be complimented by a political economy lens (Lee and Byrne 2019; Wood and Roelich 2020). Energy justice principles involve distribution of costs and burdens, recognition of appropriate coalition of groups involved, and the procedural elements such as governance and management. As experts discuss, MWT imaginaries from both a delivery model and landscape perspective, an energy justice framework forms a useful way of investigating the desired delivery outcomes. This theoretical perspective enhances analysis with an understanding of conflict, how to identify and modify patterns of domination and systemic societal conflict (Sovacool and Hess 2017). It allows for evaluation of historical evidence and conditions, and structural analysis of such conditions can lead to “liberation” from such conditions by demonstrating where and what kinds of change are necessary within development pathways

Despite the depth of understanding and knowledge relating to socially just and environmentally sustainable imaginaries, what they might look like, what approaches would govern them, there appears a much weaker and understudied focus on what understandings are required to enable more transformative change in the energy system. Such understandings would have strategic and theoretical implications, as well as better understanding what actions are required to enable it. Further, it would also better understand why such imaginaries of change and their implementation are so lacking across individuals and collectives. There are a plethora of conceptions or tools to analyse energy systems with respect to social and environmental justice, how communities should interact with energy systems, though material benefit and democratic participation, yet this knowledge has not become mainstream or common practice and the world remains un-transitioned. Thus, an important next step is to understand, investigate and critique the impeding forces and

structures that inhibit the implementation, adoption and institutionalisation of such energy futures.

By bringing these elements together, a fuller, richer and more grounded understanding of MWT development can be achieved, by addressing the gaps discussed in each of the bodies of literature. It also provides theoretical contributions outlined above to socio-technical understandings with a particular emphasis on imaginaries, energy justice, and political economy knowledge. This is a novel analytical framework, primarily in how it brings together these distinct fields. It provides opportunities for new knowledge generation, but there may also be limitations or challenges. Before exploring these limitations, I will illustrate the development of the framework, and how specific aspects emerged and were highlighted from the literature.

5.2 An integrated framework for analysing an imagined energy industries development

To summarise, the framework builds on a sociotechnical systems approach, adding in dimensions of power and politics to articulate the ways in which changing social landscapes and interactions with technological development are experienced by different actors, with a particular focus on future making, deeply connected to past and present meanings, and knowledge conditions. It integrates a political economy analysis, in which energy governance is shaped by dominant interests and embedded power structures that strongly influence decision-making, resource allocation, narrative and transition pathways in the production of energy. These hegemonic forces, which exist at multiple scales exert influence through neoliberal state and global institutions, growth orientated market ideologies, fossil fuel and financial private actors forces, and a capitalist legal and regulatory framework. Contested understandings of development are utilised, taking perspectives from sustainable development, post-development and business studies to critique the drivers and delivery models of economic activity. Finally, energy justice scholarship is integrated to understand the plural ways in which just energy futures are imagined as a result of political economy and contextual power dynamics.

I believe this short description demonstrates the complimentary elements and similarities between these theoretical pillars, and the importance of utilising all of them for this research. As acknowledged in literature, sociotechnical literature in general has not contended sufficiently with the role of political economy in shaping transitions and transformations. This is the role that the primary phase of the analytical framework will explore, as outlined in Figure 18.

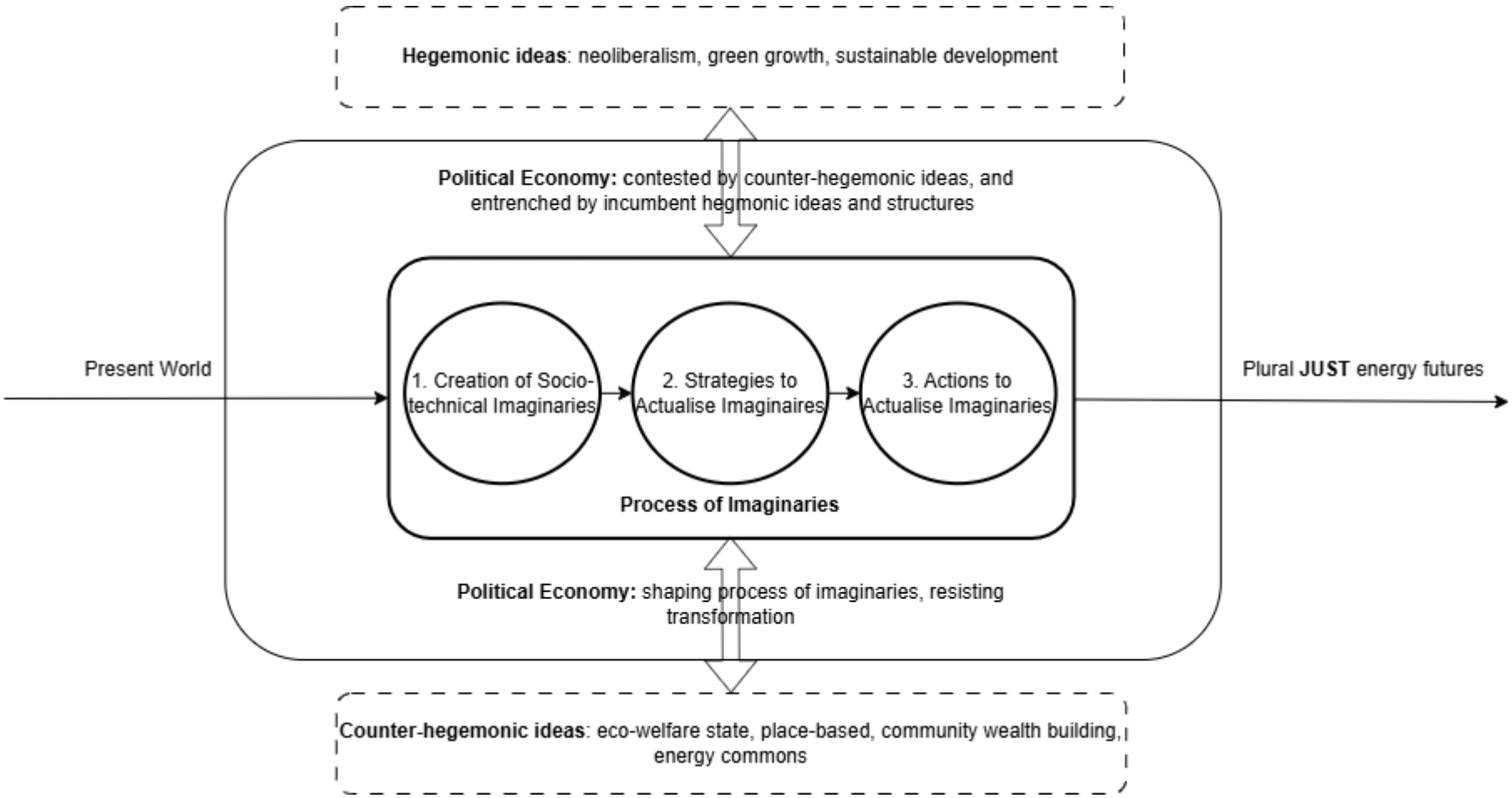


Figure 15 An integrated analytical framework illustrating the dynamics of energy imaginaries interplaying with political economy forces, hegemonic and counter-hegemonic ideas, creating plural JUST energy futures

By moving through the framework from left to right, the process of sociotechnical imaginaries is shown. All three steps of the imaginaries process, the visions, the strategic ideas, and the actions in which to bring visions to reality are in dynamic interplay with the political economy. This political economy layer is thus in fierce contestation with the imaginaries process, as hegemonic forces attempt to co-opt and combat new and transformative ideas, deter and interfere with the strategies and actions necessary to actualise them. Hegemonic and counter-hegemonic ideas as discussed in the literature review influence and are influenced by both the political economy and the imaginaries process. Finally, the whole process of future making can be evaluated from an energy justice perspective.

Applying this analytical framework to the data analysis process, along with the understanding obtained from the complimentary and foundational socio-technical imaginaries creation process and the energy justice delivery approach will allow for answers to the problem questions articulated in this research. The framework formed the basis of the interview questions and informed the overall approach to interviews where the relationship between different ideas, political economy forces and a three-stage imaginary process was brought the fore for MWT. This is reflected in the structure of the findings chapters 8.2-8.4. It was also used in the community case study, however the emphasis of imaginaries differed with less emphasis on strategic and delivery elements. The framework also heavily influenced the contributions found in chapters 10 and 11, where different literatures were brought together in relation to the specific research problem areas arising from the thesis.

There may be challenges involved with this framework related to both the sociotechnical imaginaries process, elements of the political economy layer, and the interactions between them. It may be difficult to discern where sociotechnical imaginaries under analysis relate to MWT and indeed the wider energy industry as well as their relevance to Scotland and local levels. Whilst the political economy layer can be taken as a whole, where one facet ends and another begins is a difficult task due to the degree in which ideology is entangled with institutions, and markets with states and so on. This could make it difficult to discern where to focus attention when understanding the shaping of particular imaginaries from a political economy perspective. In section 11.3 limitations of the framework are reflected upon in detail, acknowledging the challenges of working with imaginaries as a loose concept both theoretically and practically with participants, as well as the difficult to discern boundary of political economy understandings relevant for MWT.

Having presented the integrated analytical framework this thesis uses to approach the research; the following chapter discusses the methodology of choice in which the analytical framework is deployed.

Chapter 6 - Methodology

In this chapter I set out the rationale and motivations behind the methodological approach guiding my data collection. The data collection consisted of an ethnographically informed semi-structured interview phase with sectoral professionals (n=29) and a case study consisting of two workshops (n=19) in a former mining community. This chapter explains these choices. It builds on the discussion of theoretical and analytical frameworks discussed in Chapter 5 by explaining how these analytical tools will be mobilised in a methodology to collect and examine data, in order to answer the research questions.

The research methodology is constructed in order to answer the following overall research question:

> What drives and shapes the formation and implementation of minewater thermal energy industry imaginaries for a just transition in Scotland?

Three subordinated research questions emerged in order to answer this:

1) What are the perceived opportunities and challenges present in Scotland's energy economy that affect minewater thermal energy?
2) What are the alternative energy imaginaries envisioned by those relevant to minewater thermal energy?
3) What forces are enabling and/or disabling alternative economic development imaginaries of minewater thermal energy futures?

The chapter begins with an exploration of the epistemological and ontological positions which underpin the philosophical approach to knowledge in the context of this research, drawing from critical realist and interpretivist paradigms. I then outline my own positionality and explore reflexivity in relation to this research topic and the research conduct. Following this, I delve into the methods selection, where I emphasise the importance of participative approaches, utilising ethnographic qualitative and case study informed methods. I provide an account of how the research advanced, including my approach to theoretical sampling, as well as participant and case study selection. The chapter ends by reflecting on the ethical considerations shaping the study as well as the limitations of the research methodology. Following this chapter, a contextual chapter provides essential information in which the findings generated from the data collection are better understood.

6.1 Philosophical positioning

In order to utilise the analytical framework and uncover new contributions to knowledge, I position the philosophical grounding within the methodology of this thesis. Any knowledge contributions must be clear as to what paradigms of understanding they are situated within, what is the nature of existence and what we can know. It is important to articulate the ontological and epistemological stances taken, and thus the paradigm in which this thesis is closely aligned with, which I do in the following section. First, it is worth exploring the theoretical and philosophical debates in the energy social science literature in which this thesis places itself, so that my own positionality is clear in its relation to the wider literature.

This research stretches across an interdisciplinary problem domain in which economists, geographers, engineers and others examine the role of energy systems, their relation to society, and the way in which responses and transitions occur in reaction to such interactions. First, it is important to understand the recent rise in social science focused energy research that centres on issues of equity, poverty, justice, access and environmental sustainability, from which this thesis has emerged. Environmental justice literature, and subsequently energy justice literature, is predominantly grounded in ideas of modernity, and objective knowledge, though recognisant of the uniquely constructed and subjective ways in which energy can impact lives and therefore be understood as just or unjust. With a lack of legalities or rules that form the basis of deontological and consequentialist reasoning around justice, many forms of thought can flourish or falter through objective, material and subjective perspectives. This is a point of tension as the universality of justice concerns is contested, as particular ways of understanding the world can simultaneously erase others, for example global north and global south perspectives can come into conflict (Tornel 2023).

Taking a step back, the paradigm that underlies much justice orientated work is the “new mobilities paradigm” which takes interdisciplinary perspectives from areas such as geography, sociology, anthropology, history, science and technology studies, urban studies, feminist studies, transition theory and economics (Leese and Wittendorp 2018). Mobilities in this case, can refer to people, things, ideas and foundational structures, though fundamentally the paradigm emphasises the central role of movement within the workings of social institutions and social practices (Sheller and Urry 2016).

Before the emergence of social science in energy research as a significant discipline, social scientists were laying out arguments for what their perspectives could provide to energy research and practice. Previously social science research and policy goals were driven by physical science approaches, with units such as installed capacity and fuel poverty on costs

of energy deemed superior. Scholars advocated a new stance, in which the energy system is both social and physical, and that more integrated research would deepen impact and advance energy research at a crucial time of transition and change (Cooper 2017; Van Veelen et al. 2019). Calls to include diverse actors, a mixture of methods are built upon a foundation of belief in the social processes of the energy systems and that by rebalancing the focus, research can achieve greater analysis and impact (Sovacool 2014). Sustainable development is equally built upon social claims, integrated with nature for an ecological approach that presumes that alternative resource use and consumption patterns will result in lasting, improved societies (Rees 1998).

I am also interested in the social manifestations that reflect physical and material conditions, whether that be resource accumulation or monopolies of violence in which some social structures are rooted. I am sympathetic to the role of geography and history in the shaping of meaning, and that in most cases relating to the social world, we can best understand particularities and contexts rather than universals. I would distance myself from particularly radical forms of post-structuralist and post-modern thought that heavily rely on discourse theory, which gives no basis for validity and truth seeking particularly on questions of morality or suitability as (Cresswell 2013) outlines.

I am interested in notions of systems thinking, acknowledging the inter-connected and complex nature of all things. Reality and the social world is both relational and emergent and requires a shift beyond reductionism in our attempts to understand the world for a multi-perspective analysis (Mingers 2014). Meaning is created through interaction, and the phenomenon of study affects the interpretation beyond the researcher themselves. As a researcher I accept that I am interpreting the nature of things according to my own world view and feel that whilst bracketing and reflexivity are important and useful tools, one can never or even should attempt to achieve true neutrality in research. Here, the process of problem solving is to understand intentions and actions in a process of unstructured or semi-structured sensemaking.

6.1.1 Ontology and epistemology

I now discuss the ontological position taken in this thesis, the understanding of reality upon which the claims in this thesis are based against. It is one firmly focused on meanings, and understandings of such meanings in how they are configured, through a process of interpretation. There are two major paradigms in which I gravitate and orbit, the interpretivist and critical realist ontologies.

Interpretivism emerged as a major paradigm in opposition to the positivist philosophy of objective science and generalisable laws. It emphasises the role of consciousness, context and meaning in shaping reality (Lincoln et al. 2011). Fundamentally, interpretivism states that reality is shaped by human experiences and interpretations. Thus, its ontology defines reality as multiple and subjective, experienced differently by different individuals.

There are both physical and social elements to reality, which are both experienced in the human mind in a process of interpretation and sense making, resulting in an imperfect representation of reality, reflective of our sensory and cognitive limitations. However, I do not forsake claim to the idea of any useful or measurable objectivity or indeed the usefulness of the scientific methods of positivism outright, positioning myself away from extreme postmodern perspectives. Here, a critical realist perspective is most useful in unpacking this stratified picture.

Critical realism emerged in the 1970s in response to positivist and interpretivist debates, by arguing that while a reality exists independently of our knowledge of it, our understanding of it can only ever be socially and historically conditioned (Bhaskar 2014). This picture of a stratified reality acknowledges that we can make empirical judgements about what we can see, however what is actually happening, and our sense of the underlying real structures will be affected by our incomplete perceptions.

Thus, the ontology I use in this thesis is closely aligned with critical realism, though closer to the interpretivist adjacent spectrum of critical realists. This ontology acknowledges the context-sensitive nature of human meaning-making alongside a critical focus on the social structures that shape this experience; any meaning uncovered is thus related to wider structures and mechanisms. I contend that lived realities are not confined to purely subjective interpretations, making this ontology appropriate for research that is focussed on power, political, marginalisation and inequalities such is the case in this thesis.

The epistemological stance also draws closely from critical realism and interpretivism. It is an epistemology that acknowledges both subjective and relativist ways of knowing. I contend all knowledge to be socially and historically conditioned, and that there is value in the meanings people assign to their experience of reality. It positions knowledge as fluid and fast changing and I do not believe objectivity can ever be achieved in any real or true sense. That is to say, a brick wall can be interpreted, experienced, measured in a multitude of ways, and while we can never confirm objective reality beyond our own individual senses, a process of inter-experience can confirm a degree of commonality between subjective experiences. Therefore, rational judgements are useful ways in which to gain knowledge of

the social and material worlds, however, knowledge is always provisional and subject to revision, meaning there is no final absolute truth that we can arrive at. This critical realist epistemology has space for empirical, rational and social meaning in its pursuit of knowledge.

These philosophical stances provide the basis on which a qualitative ethnographic and case study informed approach was deemed suitable, that utilised a grounded theory strategy of analysis. These are explained in sections that follow, though I first explore my own positionality as a researcher to the subject and context under study in this thesis.

6.2 Positionality and reflexivity as a researcher

Beyond stating my philosophical stance taken towards the research, it is also important to highlight my own positionality and reflexivity and to pose self-critical questions which examine my own beliefs, judgments and subjectivity which inform the research process and outcomes. I relate my own personal story to the subject matter and reflect on how it may influence the conducting of the research. Researcher positionality is of growing prominence in social science research as intersubjectivity and reflexivity are acknowledged as important concepts in the pursuit of more holistic and critical knowledge. Adu-Ampong and Adams (2020, 583), also highlight the '(de)colonialisation of knowledge' as another force which opens up the researcher to different types of knowledge, whilst highlighting the cumulative impact of personal experiences across one's life in the analysis and understanding of research data. Importantly, one's positionality is always in flux, both spatially and temporally as one undertakes research in different places, which come with their own identities and connections, and throughout life as experiences impact our understandings.

As outlined in the section on philosophical positioning, my approach to this research is one in which I am attempting to interpret meaning and understanding as it pertains to the social and material world at the same time, through the insights of theory and the lived experience of the participants in the research. Any ability to interpret and to draw out knowledge from this process is a subjective one, tied uniquely to my identity as a researcher and a human being. This process for this particular research project is complicated further by my personal affinity and connection to the environment and context, which is worthy of scrutiny for the betterment of the research findings, and to allow for more fully informed judgments.

A significant part of my motivation to undertake this research lies in various interconnected personal strands which form part of my identity, or sense of self as I understand it. I will attempt to articulate these in two parts. First, my connection to the research context in a geographical, environmental and cultural sense. I applied for a pre-established research

project which was defined as a study of former mining areas, the set of socioeconomic challenges they face, and their possible future in relation to the repurposing of former mines for energy. Until the age of 18, I spent my entire life growing up in one of Scotland's former coal mining towns, with legacies of the mining past resonating throughout my childhood in Fife and to this day as I visit home and maintain connections. Materially, former pithead winding gear, perhaps the most iconic and notable of all surface infrastructure are found on two nearby walks from my family home. Local museums and memorials to those who lost their lives in the industry were also a visible experience in the community. In a cultural sense, tales of the importance and pride associated with the former mining industry were imprinted and communicated, through local organisations such as the Scouts group, football teams and in the place names of areas affected by mining, such as the bings or slag heaps, or entire villages such as "Coaltown of Balgonie". Two generations ago, my relatives worked in mines in the Midlothian area and were all too happy to discuss when given the chance their association with the industry and the difficult conditions they faced.

However, my relationship with 'home' is a complicated one, as I have moved away and experienced physical and emotional distance to the places and cultures I grew up in. Moving from a smaller town to a city in pursuit of academic and intellectual opportunity is a well-trodden path. Yet in certain ways, this personal journey has made me more interested in the contemporary and future situation of the former coalfields across Scotland. I want to better understand what a sustainable future looks like where there is less desire or need to leave in search of opportunity. The result is that whilst I have deep interest and care for the geographical and cultural markers which are the subject of this research, I am also distanced. The result is that I feel multiple identities co-existing within me as a researcher, sometimes at the same time with a sense of friction, other times harmoniously. Thus, my self-presentation and status within the research is altered according to the contexts and situations I move through, such as in professional environments or 'home' community settings. It is worth acknowledging this layered and unclear experience that affects and impacts both the field work and my narrative reporting of the research data.

The second broad personal interest is, as expected, linked strongly to the first I have described, though can be understood in more explicit political terms which stem from lived experience inside and outside academia. As mentioned, I have a direct experience of the regional disparity found within Scotland, as former coalfields continue to experience relatively worse social, economic and health outcomes. Recently, analysis of deindustrialised regions has used terminology such as "left behind places" in attempts to understand the sense of discontent felt towards mainstream political and economic consensus as determined by the type of democracy which currently governs society. This background has

deeply affected my own personal academic interests, which centre around the social and material conditions and practices which enable greater ecological sustainability, reduction of inequality and human suffering and contribute towards greater collective and individual democracy and agency. This research topic offered an opportunity to investigate and address these interests, revolving around a case study with which I personally identified. Thus, my orientation towards the research is one in which I am motivated to affect change in the most effective way by pursuing knowledge and avoiding falsehoods, whilst recognising my personal biases and positionality.

As mentioned, the aim of outlining my positionality is primarily motivated by the pursuit of intellectual honesty and rigour. I am not attempting to fully distance myself or present myself as an objective observer. As I have stated previously, I do not believe truly objective understandings of the social and material world can ever be reached. I have engaged with reflexivity of my own identity and knowledges throughout this research process, to critically question the set of conclusions I arrive at. The aim is that by creating new knowledge, which is fully accounting of its positionality, and subject to self-critique, I will be able to better contribute to the understandings which can address societal problems such as the ones under study in this research.

6.3 Methodological choices

In this section I discuss some of the key important ideological methods underpinning this research. Building from the previous section on researcher positionality, I emphasise the importance of participatory approaches including conceptual overviews of co-production, reflexivity and situated knowledge. How these ideas hang together, and how they are useful concepts to guide this thesis. I then discuss the qualitative approach taken, overviewing the strengths of ethnographic and case study informed methods and outlining the rationale and motivations behind these choices.

6.3.1 Participative underpinnings

In this research, I take a participative approach to the data collection, I will go on to explain what is meant by this in this section. I outlined some of the reasons for this in the previous section on researcher positionality and will explore in this section why a conceptual grounding co-production, reflexivity and situated knowledges are important and useful for this research.

Co-production is the idea that researchers and participants co-produce knowledge on a levelised field together, rather than the researcher knowing and deciding what knowledge is

to be extracted or developed in advance and managing the research process in a deliberative top-down way (Verschuere et al. 2012). By placing more value on other types of knowledge and the process of creating new knowledge, co-production approaches address imbalances in the dominance of elitist and overly rational methodological thinking with other types of cultural, practical, spiritual and collective knowledges that exist in the world, and which are more suitable for certain research areas (S. Banks et al. 2018; Cornwall and Jewkes 1995). Emphasising co-production may allow for greater mutual-respect between researcher and participant, building trust and accountability (Beresford 2002).

A participatory approach of this kind connects the theoretical elements of research to a world in which all knowledge is situated, by reaching out to people and place in a meaningful way. Further, co-production research has tended to focus on the process over the outcomes (Voorberg et al. 2015). Despite practical and real-world limitations, such as the capacity and access I have as a single researcher, this research uses co-production as a conceptual foundation to approach data collection, most impactfully visible in the participatory workshops conducted in phase 2.

There are several connected underlying assumptions and motivations for taking a participatory course of action within this research. First, with the literature review and discourse surrounding MWT highlighting the justice and just transition relevance to the developments, commitment to the enactment of justice tenets particularly around procedure, participation, recognition and restoration are essential to research practice itself in order to form just outcomes and understandings. Further, there is a strong body of literature which acknowledges the role of engagement, whether through research or practice, as fulfilling little more than a box-ticking exercise as opposed to open democratic processes of involvement (Sovacool et al. 2020). This produces tension, distrust and opposition to energy related developments, with processes being perceived as unjust and unfair (Knudsen et al. 2015; Ceglarz et al. 2017; McGookin et al. 2021).

Collaborative approaches offer an alternative and whilst they do not guarantee more acceptable, efficient or practice outcomes, they do provide more open and inclusive participation and align with justice principles. McGookin et al. (2022) emphasise the place-dependent nature of local energy transitions, and that researchers working in communities facing economic stagnation should not be focussed so much on global existential threats such as emissions and instead should lean into community development needs.

Third, is the concept of different and situated knowledges, and more broader considerations of reflexivity within research, drawing from feminist perspectives and in particular the work of Donna Haraway (1988). At the intersection of science & technology studies and feminist

understandings, the concept of ‘situated knowledge’ is essential to understanding the position we fulfil as researchers as well as the context of the expert knowledge we are collecting. As discussed, in the section on positionality, researchers are not and cannot be neutral observers of phenomena, particularly in cases of complex historical, social and cultural knowledges which can be considered non-academic in nature. Approaches taken and questions asked are a result of a legacy of experiences, learnings and worldviews that research obtain over a lifetime. The same can be said of research participants and so by acknowledging and informing research practice with this perspective, the insights and knowledge from research is both obtained and analysed more critically.

To summarise, this research is rooted in participatory approaches to research design, whereby knowledge is co-developed with the participants and the researcher in order to overcome professional dominance, improve strategies, and demonstrate commitment to democratic principles. The decision was then made to utilise qualitative methods of data collection, informed by ethnographic and case study approaches. Data was collected using field notes, semi-structured interviews and participatory workshops, which should allow for detailed co-production of knowledge. The following sections outline the motivations and rationale for this choice of method.

6.3.2 A qualitative and ethnographic approach

In this thesis, qualitative and case study methods are employed for data collection, which enable the exploration of complex social phenomena, such as the emergence of a MWT industry in Scotland’s energy economy. Rather than observing and quantifying a phenomenon, this research aims to enable the emergence of new insights from the data collection. As such, quantitative methods are likely unsuitable as they seek to collect data in order to test it against more predetermined understandings as opposed to allowing knowledge to emerge interpretively from the interactions between researcher and the research, as is the case for qualitative methods (Henwood and Pidgeon 2003; Saunders 2019). On the other hand, qualitative methods are well placed to provide detailed insight on phenomena which are experienced and constructed by a multitude of actors where different subjective meanings are at play (Saunders 2019). Further, the ontological and epistemological positions taken in this thesis require the use of qualitative methods in order to develop the kinds of knowledge obtainable under critical realist informed paradigms, inhabiting a subjectivity and reflexivity (Schwandt 2000). Therefore, qualitative methods were selected to better understand the development of MWT in Scotland, as the research navigates a range of meanings and knowledges as discussed in the analytical framework chapter.

In the original planning of this research, methodological approaches from ethnography were identified as appropriate to this study as these methods allow for the study of people in their environments, as well as elucidating interconnections across aspects of social life found (Atkinson 2007). Further it allows for an adaptable approach across these different environments and contexts, which favour the emergent and inductive approach to theorisation and research in this thesis (Emerson et al. 2011). Ethnography brings into sharp focus the unspoken norms, practices, cultures and assumptions that different communities embed (Spradley 1980), which is relevant to this thesis in its focus on the constraining effects of political economy on imaginaries, how ideas and materialities affect one another.

Ethnography is, in some sense, difficult to define because of the diverse ways in which it is employed across disciplines for different research purposes, rooted in a range of traditions (O'reilly 2012). As Wilkinson (2013) notes, it is more often used to describe a style of research than a formal method. Wilkinson goes on to describe ethnography in the following, nuanced way:

> "The term is used to describe a range of qualitative data generation techniques that are *naturalistic*, meaning that they involve studying people or phenomena in their "natural setting or context", and produce accounts of research that are *experience-near*, meaning that they are based on people's experience of events, actions and phenomena in the setting or context."

A clear theme running through ethnographic approaches is the aim to move away from ascribed understandings from outsiders and towards explanations from the point of view of those involved . Brewer (2000) states:

> "Ethnography is the study of people in naturally occurring settings or 'fields' by methods of data collection which capture their social meanings and ordinary activities, involving the re researcher participating directly in the setting, if not also the activities, in order to collect data in a systematic manner without meaning being imposed on them externally."

Such descriptions of ethnographic style qualitative research align well with the aims of this thesis, to understand social meanings across scales and places in the potential development of MWT technologies in Scotland. The way in which ethnographic data is interpreted varies significantly according to the perspective and paradigm the researcher employs. From traditional studies of the early 20th century to post-modern techniques, the range of frameworks that fall within ethnography vary greatly.

Brewer (2000) notes the growing role of the ‘post post-modern’ approach, which is of particular interest here as it aligns with the case made as I outlined my philosophical position. This ‘post post-modern’ view is one that emerges in response to the challenges of post-modernism, particularly around the focus on what is real, what is truth and the deconstructing of validity and reliability. Instead, it is more interested in relevance, and that partial truth is of value and can be developed through further knowledge, approaching a critical realist perspective.

Over time ethnographic methods have shifted from limited single-site long-term studies to multi-sited, short-term participatory fieldwork, as is the case in this research. (Seligmann and Estes 2020) discuss these innovations, drawing on critiques that traditional ethnographic work creates borders around field sites, ignoring the mutual exchange and influence of ideas, structures, policies, people and things which shape the phenomena and experience under study. The coming and going of researchers to multiple sites in shorter stints of time provides a different level of familiarisation and avoids the often-unnecessary grandiosity of a great welcome and final farewell. In some cases, this approach more closely resembles the transient nature of the populations being studied and is a more realistic and less taxing way of developing trust between the researcher and participants.

Participatory methods informed by ethnography have come into prevalence in response to a set of critiques which investigate the role of agency, what kinds of data is collected, how the topic of research evolves and finally how the research is presented. Through ethnographic fieldwork, researchers are given insight and position to convey conditions of injustice. Participation allows the populations, networks and practices under study to be communicated with in more egalitarian and potentially effective ways, which can influence policy and public consciousness.

A final trend observed by Seligmann and Estes (2020) is the growing presence of interviews as the primary technique employed in ethnographic studies. They introduce a scepticism to this trend, not aimed at the potential effectiveness of interviews, rather that the substitution of diverse ethnographic methods with singular interview led studies is not sufficient for ethnography, citing the often-observed gap between stated intent and actions taken in human beings.

Through this overview, I have aimed to highlight the key features of contemporary ethnographic informed approaches which demonstrate why it is a suitable methodological choice for this study both theoretically and practically. Critically, the context of place and people, whether that is in former coalfield communities, council offices, or industry meetings

in their everyday setting requires a blended use of ethnographic approaches and tools to draw out understanding. Such knowledge is understood from internal perspectives, and not imposed by me, the researcher, in advance. By utilising techniques such as observation, field notes, interviews and workshops, whilst taking multiple and shorter field visits, I am able to gather data in the most suitable way for the different populations and places under study. Further, a participatory approached centred on the co-production of knowledge, aligns with my philosophical, theoretical and personal ethical considerations, which strives for inclusivity and empowerment in research process and outcomes where possible.

6.3.3 Case study methods

Further to my use of ethnographic methods, I will outline why the case-study design is appropriate for this research. First and foremost, case-study research design allows the research to keep the depth, breadth, richness and all significant characteristics of people, place and real-life events and minimises reductionism in analysis (Yin 2017). As my research aims to explore both the context and lived experience and situated meanings, case studies allow for a richer and detailed account of these social worlds. By centering this real-life context in the present, variables in the data, multiple sources of evidence and contemporary phenomenon are given greater space and novelty in the research. Grünbaum (2007) examines and reviews case study literature, outlining key components which led to a valid case study design.

First, that the study object is related to people, more specifically interpretations of social meanings. Second, that the phenomenon is contemporary. Third, a holistic perspective is used to try and understand the context around the unit of analysis. Fourth, that qualitative tools are used primarily in order to generate or contribute to theory, being descriptive, exploratory and explanatory in nature. Fifth, that the researcher has no control over the phenomena of study and sixth, that numerous data sources are applied. Finally, that the case study produces contextual and “rich” accounts that are detailed in description.

Despite connecting various case study threads to produce this overview, Grünbaum (2007) goes on to interrogate the ambiguity often found around the unit of analysis and the limits of cases themselves. The distinction between the two is muddied at best in the case study literature through the two main approaches of an embedded or holistic study with either multiple or a single unit of analysis respectively . In thinking this through for my research I present the following thought exercise. The case in study is the social and economic elements of the deployment of minewater geothermal energy systems in Scotland’s former coalfield communities. I aim to explore this case through different manifestations of the

phenomena, as minewater systems vary based on the energy resource geographically, and the way the resource is deployed and managed will vary according to the different people involved, which changes across Scotland. One could conceptualise this as multiple case studies, holistic in nature with a single unit of analysis. However, I consider the characteristics of people and place as the object of study, these different place specific factors become the different embedded units of analysis within the case study of minewater energy development in Scotland's former coalfields.

6.4 Data collection and analysis strategy

The general strategy used in this thesis towards data collection and analysis follows that of grounded theory. Grounded theory. There is no definitive view of what exactly constitutes Grounded Theory (Eaves 2001) and concern exists amongst scholars about its vagueness and what adhering to its fundamental principles actually involves. However, as a broad approach, Grounded Theory describes a strategy to research in which theory and insights are found inductively from the emergence of data in an iterative systematic process of review (Glaser and Strauss 2017). Grounded theory is moving further from a postpositivist direction into one that fully embraces interpretivism, however a range of approaches and paradigms are utilised in social energy research. In this sense I believe Grounded Theory to be a useful microcosm of the wider range of philosophical stances within my research area, or "flexibilities" (Denzin and Lincoln 2008). Grounded Theory aligns well with the ethnographic and case study informed approach, as well as a critical realist perspective, as underlying mechanisms come to the fore directly from the data (Hoddy 2018). Research conclusions are carefully developed by paying close attention to social processes and forces, between and amongst social groups.

I utilised theoretical sampling throughout this thesis, as is appropriate for grounded theory and ethnographic influenced research. Data collection and analysis was an evolving process, where thematic analysis occurred concurrently throughout the interview schedule, to allow for emerging themes to shape subsequent interviews. That is to say, what was being uncovered, and any new connections being made, shaped who and what was uncovered next. Further, the content and sequence of questions was dependent on what the interviewee was being interviewed for and their associated experiences. Sampling continued until the point it was deemed theoretical saturation was obtained, at which point fewer novel insights were emerging from the data and a set of themes had solidified across the process.

The themes emerging from the first phase can be understood as an evolution of the entire research process. With the starting point being the research questions developed out of

literature, contextual information, and my own analysis of the socioeconomic and political landscape in which MWT developments occur. As discussed in the methodology chapter, my approach meant that each interview was tailored to the different expertise of the interviewee, and that each interview was shaped by the knowledge acquired by the previous.

Beyond the notes and knowledge I obtained from the interviews, I also began coding interviews early on to solidify the initial findings, allowing them to further inform what data I yet required and what approaches in interviews was most suitable. At what was deemed a sufficient point to stop the active data collection for phase one, still allowing for new connections and participants to emerge naturally, I began a formal write up so that upon entering my second phase I was grounded in the direction and knowledge within the research, allowing me to better design and plan for further data collection. The phase 1 participants are summarised by group type in Figure 19 below and found in detail in Table 1. The sampling strategy described above is also visualised below in Figure 20.

Figure 16 Main Interview Stakeholder Groups

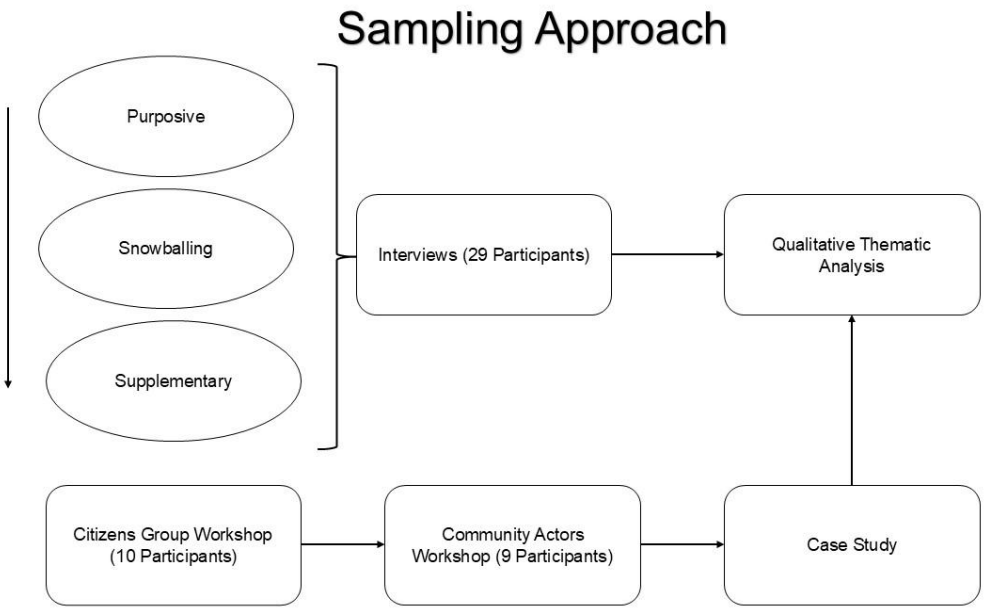


Figure 17 Approach to Analysis

6.5 Practicalities of the research: how it unfolded

This section outlines the practical dimensions of the research plan, and how it actually occurred. In essence, this research was studying a concept, rooted in the social world and yet to be actualised as a phenomenon in the material world, as there were no active or under development MWT schemes in Scotland at the time of the investigation. The material world and social world are inextricably linked, shaping one another in a range of complex spatial and temporal interactions. As the MWT sector in Scotland, the conceptual case study for this research, is in what might be understood as a pre-development stage, it is these preconditions which are the focus of the study. By studying the conditions, ecosystem and landscape for MWT development, the scope of what development may entail is more expansive and accessible for alternative ideas, analysis and contexts. Thus, throughout the early stages of the research I worked to better understand who the relevant stakeholders for this yet to exist sector were. As key themes emerged around renewable heat transitions, political economy, policy and theory around social justice and sustainable development, and the contested space of socio-technical imaginaries within the context of coal mining; I was able to map out a foundational ecosystem from which to begin informing data sampling and case study selection.

6.5.1 Phase one: sectoral interviews

The first phase used semi-structured interviews, field notes and non-scripted conversations with sectoral stakeholders to gain insight on the state of play and key elements of the MWT development landscape. Interviews were semi-structured, with an interview schedule and guide used to shape the overall format for the interviews. Interviews were recorded with a dictaphone and with the consent of the participants, then transcribed using NVivo software. Field notes were used particularly in the early stages of the project as the researcher is first experiencing and interacting with different stakeholders at different events and scenarios, where recorded discussions and formal interviews are not appropriate. The aim here was to capture feelings, reactions and to build a network of stakeholders, in order to improve the selection of interviewees and the quality of the questions in the interviews that follow.

The selection criteria for interview participants were based off an understanding of the MWT landscape as it exists in other countries and the different actors involved, knowledge of the particularities of the UK energy system, and an exploration of organisations and individuals working on themes emerging from the literature review. Participants with experience of minewater were reached out to first and foremost, followed by those with successful heat network experience, as both are directly relevant to any future MWT industry under study. Following this those engaged with the heat and energy transitions in Scotland were contacted in order to provide the wider landscape perspectives. Further those with policy and advocacy expertise as well as community development participants were engaged with in order to provide insight from different scales and ideological perspectives. Organisations represented in the interviews included both private developers, energy consultancies, local authorities, non-departmental public bodies amongst others. I spoke with several third sector groups and independent experts including community energy groups, co-operatives, academics with expertise on particular themes and a sitting MP, former MSP and parliamentary researcher. This is detailed in Table 1. I conducted the majority of these interviews online through either Microsoft Teams or Zoom software, although several were hosted at either Strathclyde Business School or at the interviewee's organisation office. In total this phase included 29 interviews, the first began on the 8th of September 2023 and the last was undertaken on the 20th of February 2025.

Interview Reference	Job Title	Firm Type	Sector	Date
P1	Retrofit Co-Op Co-founder	Home Retrofit Co-Op	Third	19/09/2023
P2	Policy and Engagement Lead	Alternative Economy Network	Third	27/09/2023
P3	Minewater R&D Lead	Regulator	Public	29/11/2023
P4	Energy Consultant Co-Director	Energy Consultancy	Private	05/10/2023
P5	MP	Politician	Public	11/10/2023
P6	Former MSP	Politician	Pubic	11/10/2023
P7	Parliamentary Researcher	Politics	Public	11/10/2023
P8	Community Energy Director	Community Energy Organisation	Third	28/09/2023
P9	Community Urban Hub Manager	Land Policy Organisation	Third	22/09/2023
P10	Land Policy Manager	Land Policy Organisation	Third	28/09/2023
P11	Fuel Poverty Researcher	University	Academia	15/09/2023
P12	Land Policy Lead	Land Policy Organisation	Third	29/09/2023
P13	Urban Regeneration Manager	Urban Regeneration Company	Private/Public	29/09/2023
P14	Global Inequalities Historian	University	Academia	08/09/2023
P15	Community Energy Manager	Community Development & Energy Organisation	Third	15/09/2023
P16	Coalfield Development Manager	Coalfields Community Development Organisation	Third	03/10/2023
P17	City Region Development Manager	City Region Development	Public	13/10/2023
P18	Non-Executive Director Housing and Energy Developer	Housing and Energy Developer	Private	06/03/2024
P19	Geothermal Energy Specialist	Geothermal Energy Company	Private	29/02/2024
P20	Council Energy Lead	Local Authority	Public	04/03/2024
P21	CEO Community Energy Consortium	Community Energy Consortium	Private	26/03/2024
P22	Heat Developer	Multinational Heat & Energy Company	Private	28/03/2024
P23	Council Net Zero Innovation Officer	Local Authority	Public	15/09/2024
P24	Council Minerals Planning Lead	Local Authority	Public	17/04/2024
P25	Council Climate and Energy Lead	Local Authority	Public	17/04/2024
P26	Energy Anthropologist	University	Academia	13/11/2023
P27	Coalfields Development Manager	Coalfield Environmental Restoration Organisation	Third	25/10/2023
P28	Council LHEES Officer	Local Authority	Public	13/02/2025
P29	Council Energy Project Director	Local Authority	Public	20/02/2025

Table 1 List of interview participants in the phase 1 data collection stage

6.5.2 Phase two: community case study

The second phase revolved around participatory workshops within Scotland's former coalfield areas, in which members of the community were invited to share their perspectives. The area of choice was selected on likelihood of MWT development (i.e. resource potential), mining history, presence of community organising, housing stock, local governance and local energy policy, and multiple indices of deprivation. Workshops were deemed appropriate as a way of engaging several members of the community at once to dissect perspectives. In this setting, the researcher serves as the glue within the workshop providing bridges, context and information to support the co-creation elements. Ideally more case studies enables greater comparison and would potentially reveal how differences in place, community, and experience would shift the perspectives and priorities that former coalfield communities express relating to the development of minewater technologies (Creswell et al. 2007). However, after the initial exploration of case study opportunities and a better understanding of what would be required, as a solo researcher the decision was taken to focus on one case study in one community, providing rigour and depth to the insights acquired, I will detail this approach in the rest of this section.

I decided to contact and utilise existing community organisations to help facilitate the workshops. Research has shown that using existing, networked organisations in a particular place or culture is an effective way to gain access to participants, as not only can the existing connections themselves be leveraged, but the trust built up over the lifetime of the organisation is particularly useful. Trust is extremely important, particularly when reaching outside of professional organisations and academia to work with citizens, and due to the material and cultural conditions which invoke the 'left behind' narrative around former coal mining areas, this is a factor that was worth seriously considering.

Secondly, working with organisations potentially gives my research practical and useful purpose. Too often communities have described the process of research being done to them by outsiders with no actual gain to the community or participants themselves. Working with organisations provides opportunities to tie my research to the plans and activities already occurring or desired within communities where possible.

During my studies, I had produced a short video as part of a course I attended, in which I had travelled around Scotland's former coalfields, putting together a short narrative piece with the intended aim of making an accessible film which would raise awareness for the wider public. It occurred to me that the film could be used to provide a short overview of my research topic as well as show my seriousness and commitment to potential participants. I

decided that my strategy would be to post the video onto community Facebook groups, along with an invitation to ‘comment’ their interest if they would like to be involved in the research.

Figure 18 Stills from the video created and shared to community groups "Repurposing Scotland's Coalmines"

Ultimately, Cardenden emerged as the leading case for several reasons. I had visited the former coalfields of central Fife twice as part of community heritage events where I toured a former open cast site and attended a film screening in a village hall. On both occasions I was able to meet local residents including several connected to the Cardenden History Group, who shared contact details with me. Further on in the research, I had interviewed both Fife

Council and the housing association based in Cardenden and central Fife, who had mentioned their vision of a heat network in Cardenden that could incorporate MWT and so this case study seemed well worth pursuing.

I joined the Cardenden History Group's Facebook page, posting the short digital story I had previously created, where I toured around Scotland's former coalfields, speaking to the historical and contemporary tensions associated with energy developments, alongside a call for interest in a session. I was able to arrange this with the group's key organisers to be held in the community hall in Cardenden in place of their usual meet-up. Ten people attended the focus group that I chaired with a light touch, introducing the concepts and letting the participants lead the conversation as much as I could, with signposting at various parts. I recorded the discussion and asked participants to write a postcard to the future, a scenario in which they were to imagine themselves twenty years into the future and to be writing a postcard to a friend who had left Cardenden. They could state the future they wished to see, or what they saw as inevitable or likely.

From this meeting and using the trust gained with the participants I was able to be connected to the Cardenden Community Council and the Cardenden Development Forum, two local groups made up of active community development focussed residents. The logic was that in order to provide depth to the case study, the perspective offered by these groups would complement and enrich the overall findings and insights of community perspectives in this former mining town. Nine people attended the Community Development Group meeting, which occurred under the same format as the History Group event, though the flow, direction and substance discussed was significantly different. Due to the nature of the workshops and recording equipment, it was not possible or necessary to identify individual contributions, given they shared similar background and expertise under study. Further, a conversational flow of debate was prioritised to make the participants as comfortable as possible. The participants are overviewed in the Table 2 below.

Workshop Group	**Present**	**No. of Attendees**	**Date**	**Location**
History Group	Cardenden History Group, unaffiliated citizens	10	05/11/2024	Corrie Centre, Cardenden
Community Development Group	Cardenden Community Development Forum, Cardenden Community Council, Ore Valley Housing Association	9	02/12/2024	Bowhill Centre, Cardenden

Table 2 Overview of Workshop sessions from phase 2 of the data collection

Based off the learnings of recent research discussed in the section on positionality and reflexivity, I had decided that I wanted the sessions to embody co-production and participation as much as was possible in order to avoid extractive practices, incorporating every lived experiences (Devine-Wright and Ryder 2024). I prepared for the relatively low awareness and visibility of MWT technologies but made sure specific social, cultural and political contexts were emphasised throughout the guide I developed to provide a loose structure for the workshops. As in phase one, the recordings for each focus group were coded and analysed, with themes emerging. These are presented in the following sections, where the data from each group is compared, contrasted and explored with respect to themes.

6.6 Ethical considerations

As per University of Strathclyde procedure, a full ethics application and data management plan were submitted and approved by the ethics board at the university. This section will overview the content and ethical considerations that formed part of the ethical process. The consent form and participant information sheet given to participants is found in Appendix A. This research investigation collected data through field notes, interview transcripts and observations, utilising semi-structured interviews and participatory workshops. There were no obvious physical effects or discomforts posed by the research to the participants, as we are investigating the development approaches for potential MWT schemes in the context of local social, economic and cultural realities, and personal stories of difficulty were not directly enquired about. This may have involved accessing and communicating person-based information in the context of poverty and other vulnerabilities. However, I had no way of truly knowing the vulnerabilities of participants unless they were communicated to me, as was encouraged in the participant information sheet. Thus, appropriate sensitivity was enacted and taken at all times.

Ethical considerations arise relating to consent, safety and wellbeing, confidentiality and researcher responsibility. Regarding consent, participants were always given the opportunity to withdraw from the study at any time and can request full anonymity or that any information or data is excluded from the research at any point of collection. Regarding safety and wellbeing, the researcher informed the line manager of their whereabouts and kept a mobile phone charged and to hand. Participants were offered to meet and conduct interviews and informal conversations at locations of their choice where they are comfortable, this would include either in their home, in a public place, online or over a phone call. Further attempts to make participants feels more comfortable were attempted as was practical and safe.

The issue of confidentiality primarily concerns the sensitivity of the data collection contents. A data management plan ensured that once collected data was secure. The nature of the study means that personal information concerning welfare and personal circumstances was discussed in some cases. Through appropriate anonymisation, participants are never referred to directly by name unless they have signed consent, and a general consent form was signed by all that confirms that data will only be used for the purpose of this research project.

The second phase of the research, centred around workshops is engaging in a form of community-based participatory research, where knowledge is co-developed in a partnership between research knowledge, professional knowledge and experiential community knowledge. This means that the specifics of the design, particularly around the workshops changed over time. Challenges relating to this approach include the blurring of boundaries, power distribution between participants, conflict and democratic representation within research processes, and agreements around dissemination of data. This requires a centering of “everyday ethics” (Centre for Social Justice and Community Action & National Coordinating Centre for Public Engagement 2022), of mutual respect, equality and inclusion, democratic participation, active learning, making a difference, collective action, personal integrity. Participants will be selected on a basis of who will form a good research partner, based upon their ability to handle different kinds of information and work in a constructive manner.

6.7 Limitations

This section aims to reflect and offer critique of the methodological process, examining details of both this individual study and wider considerations relating to social science research choices. Foremost, a central limitation to the methodology and wider thesis is capacity and resource, concerning time, financial restrictions and availabilities. This is often the case with both ethnographic and case study qualitative research (Brewer 2000; Merriam 2009). Considering this issue from both my own capabilities and that of the participants, a limited window of availability was possible that worked with respect to both parties where data could be collected. Further, the limits of time and finance available to travel, record and process data meant that the geographical spread of the data collection was limited, particularly with respect to research within communities. As such, in the analysis and findings I acknowledge that the specificity of each community and place is central and that there are limits to how representative or illustrative the findings are for different former mining communities across Scotland. Therefore, it is the depth of the case studies that are the strength of this research, rather than the breadth. In addition, whilst trying to obtain a

balanced and representative sample from different stakeholder groups, community members, policy, industry and NGO's, this was not always possible. In part due to the aforementioned capacity factors but also due to the difficulty in receiving responses from invitations to participate in the research. Access is widely acknowledged as a significant challenge for ethnographic style research (Fine 1994). As I have demonstrated in this chapter, the greatest possible effort was made to contact, arrange and develop as in depth a study as possible within the confines of the capacity and resources available.

In summary with a longer research timespan, availability to collect data across this longer period and greater pre-existing connections to participant groups, this study could have been improved, particularly in terms of breadth but also in terms of depth. However, a counter to this somewhat rigid view is that the mental taxation of working on this PhD research as a single researcher over a longer period with a significantly more complex data collection process could counterintuitively impact productivity and wellbeing, resulting in a poorer study.

Worth addressing is the complexity of using a social media platform in Facebook to make connections and facilitate data collection arrangements. This step was taken out of practical necessity, where it was discovered that a large portion of local debate and dialogue takes place within Facebook groups. Using this group, however, may have resulted in a limited diversity of participants. The local history group that was used was likely to be mostly made up of locals who had the spare time to engage with history activities and meetings. As later transpired at the workshops, the group was lacking in younger participants. These same criticisms can be labelled at the community development forum group, as capacity and interest in community development is usually reserved for older people with time to give. The strategic decision to engage with these groups was critical in attaining the data collection opportunities required for the focus of the thesis; former mining communities. However, it does mean that diversity of participants was limited. This critique is not applicable in the same way to the sectoral interviews, of which the sample was of varied professional, sectoral, gender and age backgrounds.

Following this examination of the practical elements and experiences of the data collection, I will explore criticisms of the methodological choices that apply at a more abstracted level, and how such criticisms may have affected my own data collection. As I have utilised a qualitative approach, drawing from ethnographic, case study and participatory action research methods, I will explore the limitations associated with each before relating to challenges in my implementation in this research. As discussed in this chapter, the reflexive nature of ethnography and my own positionality will impact this research, though the

ideological position I take is that this is inevitable and fundamental to all social science research. Scholars suggest that the objectivity and validity of ethnographic informed methods are open to question and that unchecked subjectivity can lead to selective interpretations (Atkinson 2007; Maxwell 2013). As such, steps have been taken to address and acknowledge this, by confronting these challenges head on in the hope that this thesis can be as useful and appropriately conducted as is possible.

6.8 Methodology chapter summary

This chapter summarised the choice of methodology used in this thesis. From the philosophical positions drawn from critical realism and interpretivism, to the personal reflexivity, the approach to knowledge and positionality was fully explored. The choice of particular methods was also rationalised, where a participative and qualitative approach informed use of ethnographic and case study methods and techniques such as semi-structured interviews and workshop focus groups. The research strategy and an account of how the data collection unfolded was discussed alongside ethical considerations and limitations of the methodology. Before exploring the findings produced by this methodology, further context is necessary so that the findings are better understood. The following contextual chapter provides essential knowledge on the end of coal mining in Scotland, the policy and governance situation for the heat transition in Scotland and, finally, MWT technologies are explored in more depth.

Chapter 7 - Context: The End of Coal Mining, The Heat Transition and Minewater Technologies

This chapter provides context, which is essential in underpinning the chapters that follow, where the findings and knowledge contributions are discussed. The context also aided the data collection process, as having appropriate background knowledge which informed the types of questions asked, sensitivities, and who best to interact with in order to answer the research questions as fully as possible. This context chapter follows three important historical and contemporary accounts surrounding the coal mining industry and its closure in 7.1, the governance arrangements for the heat transition in Scotland in 7.2, and finally the development of minewater technologies themselves in 7.3. By emphasising these three threads, understanding of the former coalfield communities present situation is enhanced, alongside the social, political and economic aspects of the energy economy, with a particular focus on heat technologies, and the role MWT could play, as well as the challenges present in both the wider transition and niche innovation of MWT.

7.1 The end of coal mining and deindustrialisation in Scotland

The aim of this section is to explore historical accounts of the Scottish Coalfield areas and engage with different arguments around the process of deindustrialisation. The section illustrates how these communities have gone through transitions in the past, showing that these transitions occurred in different ways relative to political choices, and therefore, that future transitions, including any that involve MWT, are made under the same kinds of political conditions.

The material and cultural legacies of the period of deindustrialisation are still felt today, shaping the conditions in which minewater geothermal energy developments are situated. Processes of deindustrialisation, and economic restructuring more broadly, can be understood as decisions of power. There are historical and political economy perspectives which can usefully inform understandings of development pathways of the present and future for coalfield areas in any energy transition. this section will draw on works of social and economic history from scholars and historians who have investigated this subject. Two books in particular are highly influential in their documenting, theory, and analysis of the topic: Jim Phillips' 'Scottish Coal Miners in the Twentieth Century' (2019) and Ewan Gibbs' 'Coal Country, The Meaning and Memory of Deindustrialisation in Post-war Scotland' (2021). Ultimately the contextual review in this section will form part of a baseline of understanding for the current social, economic, and cultural environment in which minewater energy projects can exist in Scotland.

7.1.1 The Scottish coal mining industry and its contraction

Towns and villages across the coalfields developed with the coal mining industry, shaping the social and cultural fabrics of such places. Thus, the community response to changes within the coal mining industry and regional change more broadly was uniquely shaped by that history of joint development. Nationalisation of the coal industry was deemed a win by most workers, balancing production with employee welfare; additionally, the National Coal Board played an important role in extending economic security in the coal fields (Phillips 2019). However, it is important to note the lack of any intent to shift towards industrial democracy within nationalisation, with large coal regions such as Scotland having one chairman to head up management despite the diversification found within the area. This top-down management structure also played-out in pit operations, with many managers from the privatised era rehired to NCB roles and a collective memory reinforcing a sense of class division and social hierarchy through generations (Phillips 2019). Workforce tensions between employee and employer reinforced the patriarchal 'breadwinner' mentality within

coalfield communities, appearing to privilege male interests. Though this far from equal relationality did not negatively impact the actions of women who would stand in solidarity with men in recognition of greater material inequalities (Gibbs 2018).

Across deindustrialisation studies and in the historical and popular accounts, the story of the coal industry's decline is weighted heavily towards the closure programmes of the 1980s and early 1990s, the 1984-85 miners' strike and the economic policies of the Thatcher Conservative government. Both Philips and Gibbs contest this narrative and instead emphasise the long-term factors and processes of contraction experienced in the coal industry. From the 1950s onwards some of the central factors include changing UK energy policy, internal industry arrangements and restructuring as well as alternative industrial priorities in regional policy.

Within the coal industry, the period from 1950 through until the mid-1970s has been characterised as a managed transition, where job losses and colliery closures were mostly secured through negotiation with the workers. Economic stability was given to communities as miners were transferred to higher productivity pits and alternative industrial employment was created within the coalfields. Mass production facilities and assembly plants were developed with inward investment, and such transitions were billed as improvements by policymakers, allowing new and improved lifestyle opportunities. This politically constructed diversification of the industrial sector which played out in the 1960s demonstrates the alternative possibilities to the deindustrialisation narrative post 1990s, with financial incentives offered to businesses to encourage their movement to areas of slower economic growth. Along with more job opportunities for women, the result over the medium-term was that overall employment in the coalfields remained more or less stable (Phillips 2019). Drawing from the work of Karl Polanyi Carrier (2018), Phillips (2019) and Gibbs (2021) build on the concept of a 'moral economy' existing within the Scottish coalfields. The moral economy or 'national conscience' emphasises the social obligations of the industry to its workforce and communities, where natural resources and local employment are understood as community resources, as these very communities sustained Britain's economy for much of the industrial era. This perspective can be summarised as 'non-economic norms affecting commercial interactions' (Gibbs 2021), and in this early restructuring period, moral economy obligations were met and legitimate closures were agreed by the workforce.

Philips contests that coal communities can be best understood as "economic localities and ideological communities". As the industries' share of economic activity declined, ideological strength grew, and the communal value of miners retained value in areas undergoing

deindustrialisation. Raymond Williams described this as a ‘resource of hope’ as men and women continued in their struggle for economic and social security (Williams 2016)

Throughout the 80s and 90s, obligations to communities and to the workforce were side-lined, with accelerated and enforced closures. Thatcher’s Conservative government characterised coal as being of too high a cost to consumers and taxpayers as well as being shackled by trade unionism (Phillips 2013). The cultural and material associations of the mining industry and its end are still felt today across much of central Scotland. The pathways between loss of employment and poor health are well established, suggesting post-industrial decline in health standards is underpinned by poverty (Walsh et al. 2009). Disadvantages to socio economic prospects interact with other structural and cultural and behavioural factors to produce the health conditions seen today, where the west coast of Scotland has the worst health record of other deindustrialised areas in Europe. This may in part be accounted for by the scale and severity of deindustrialisation in this area of Scotland (Walsh 2011).

Legacies of employment and memories of closure are still formative to the lived experience of communities in the former Scottish coalfields (Gibbs 2021). This leads to a conceptualisation of deindustrialisation as neither linear nor a politically neutral process where job losses and damages to communities are not inevitable and which can be managed in different ways. By demonstrating the ways in which the coal industry shaped life for communities and showing how transitions occurred in different ways with different impacts in the past, a critical perspective on deindustrialisation and transition emerges, useful for understanding transition in the coalfields today.

7.1.2 Understanding deindustrialisation for transitions today

As the political economy chapter in the literature review revealed, the governance of the energy economy is the result of political choices and the alignment with or against different hegemonic regimes. By demonstrating how this played out in past transitions, the relevance of this perspective is critical for transitions today, particularly in the coalfield communities which in many ways, faced the sharp end of neoliberal market reforms. The moral economy perspective found within the coalfields was more than a claim for financial compensation for labour market instabilities. It was the position that community control over resources, mines and employment were the only legitimate way of managing the industry, adhering to principles of social and economic justice (Gibbs 2018). In the context of a transition to a financialised logic and as the earlier restructuring period demonstrates through industrial agreement and adherence to the moral economy approaches, we can understand mine or plant closures and job losses as not inevitable. They can be managed in different ways, according to the balance of forces in the struggle between labour and capital, as they were

in the coalfields of Scotland from the 1940s to the 1990s, or as alternatively demonstrated in places like Germany. The socioeconomic, health and "cultural scars" (Perchard 2013), associated with the closures and way in which it occurred are a direct result of different choices of political power at the national and global level. Gibbs (2021) contends that the experience of the Scottish coalfields demonstrates that deindustrialisation does not just happen, or is an inevitable natural phenomenon created by resource depletion or market forces. Instead, relationships of power between miners, employers and the state were at the heart of deindustrialisation and its legacy through the choices to marginalise economic security for workforces and communities.

The process of deindustrialisation is of significance when examining the principles of a just transition as it is understood today. There are strong parallels between the concepts and political outlook of the moral economy leveraged from industrial society and the era of coal and other fossil fuels, where meaningful alternative economic opportunity is part of a wider programme for social and environmental justice. In Scotland, the just transition programme developed by the Scottish Government centres itself on economic security, widening employment alternatives and social justice (Scottish Government 2021):

> *"(A just transition) … Supports a net zero and climate resilient economy in a way that delivers fairness and tackles inequality and injustice."*
>
> *"In Scotland we have recent and painful experience of unfair and unplanned transitions in many industries. Our former coal-mining communities still bear the scars of rapid, unplanned change. That cannot happen again."*

This discourse of shared national interest and collective partnership builds upon the moral economy principles observed in the coalfields and in earlier restructuring. The perceived injustices of the accelerated contraction and closures of the later period are directly referenced, and Scotland has become the first home nation to award legal pardons to former miners in the Miners' Strike Pardon Bill. Other historical injustices including the pattern of land ownership in Scotland have been addressed through various Land reform policies including the community right to buy.

Ultimately this section emphasises the social, cultural and economic context in which minewater energy developments are situated, with local communities on the receiving end of varying political agendas and facing different levels of (in)justice across generations and with lasting legacies. This will be important for future energy resource development in the former coalfields; however, it is unknown to what extent this historical journey will manifest in the minewater energy sector. Therefore, there is a need for greater understanding of how the legacies and injustices associated with deindustrialisation are addressed in this development

of minewater schemes. Before providing context on minewater technologies, the heat transition in Scotland is explored in the following section.

7.2 Current policy paradigm: shaping heat policy in Scotland

In this section, the heat transition in Scotland is explored from a policy and governance perspective. In the introduction the picture of Scotland's heat transition within the wider UK transition was described in terms of historical trends and contemporary figures. As this thesis aims to contribute to the knowledge base which policy and governance is informed by, it is important to explore the layers of governance that are relevant in Scotland for the heat transition, alongside the wider energy economy. It is particularly relevant due to the role of devolution and the UK's local governance arrangements, which enable or disable interconnected actions at local and national levels. Additionally political dynamics emerging from the governance arrangements affect the discourse around policies, where governments at different scales can position themselves in opposition to the policies if pushed by party-political opponents. After exploration of the governance picture, MWT technologies are examined as a niche innovation which engages with the heat transition.

First, a high-level perspective on UK policy initiatives is explored in relation to the heat transition in Scotland. In October 2021 the UK government published both the Net Zero Strategy and the Heat and buildings strategy, outlining the direction of travel for the coming decade, and elements of implementation in order to reach net zero by 2050. There are stated aims to phase out the installation of new and replacement gas boilers by 2035, targets and support for heat pump uptake, and an intent to decide upon the role of hydrogen gas in heating systems by 2026. The Boiler Upgrade Scheme provides grant support for household heat pumps alongside Social Housing Decarbonisation policies; however, uptake has been slow, with greater momentum occurring by 2025. The glaring omission is on the detail provided around energy efficiency and home improvements, with the previous policy programme - the green homes grant, scrapped early due to mismanagement. Instead, there is a statement of intent to raise as many homes as possible to an EPC Rating of at least C by 2035 "where reasonably practicable", with fuel poor homes prioritised to achieve this by 2030. In summary, household led electrification of residential heating levels is the current priority, with other pathways such as heat networks receiving limited support or delayed action.

There are three distinct levels of governance in the UK which have varying controls over climate and energy policy: the central UK government, the devolved governments of Scotland, Wales and Northern Ireland, and regional governance through local authorities.

This situation is complicated by the power relations between national, devolved and local governments, in which authorities can be restricted by their limited financial and legislative powers (Cowell et al. 2017; Wade et al. 2022). Whilst the role of central government is crucial in achieving transformational change in the heating sector, coordination and co-operation between central and local government will also be required for effective and efficient strategy and delivery. Central government can set the direction of travel through legally binding targets, the parameters and limits of action through regulation, and provide targeted support packages through various funding schemes. In this arrangement, the government aims to enable market actors to scale-up by providing certainty and risk assurances (Sovacool and Brown 2009).

However, in order to enact and enable effective action, local circumstances are of utmost importance to inform strategies with the most suitable approach. As such, local government is an appropriate agent to design and deliver strategies for heat decarbonisation in which particularities of locality are well reflected, from building stock through to geographical features (Gillich et al. 2018). The UK National Policy Planning Framework and Guidance designates several roles to local authorities relating to energy, including consideration of suitable sites for smaller scale renewable energy, the ability to set their own energy efficiency standards, making sure buildings comply with local building regulations, and retrofitting their own council housing stock. The Home Energy Conservation Act 1995 remains the central tool for national Government to engage and encourage local authorities to take action on energy efficiency in their area. However, reporting remains voluntary and it has not received new resources or oversight since it was established (Mallaburn and Eyre 2014). More generally, public body procurement for services must demonstrate economic, social, and environmental wellbeing for their local area. Further, some public funds including the recent Green Heat Network Fund requires a Market Transformation Commitment where public bodies must demonstrate how a heat network enables growth within the supply chain and lasting benefit. After illustrating the key insights from a UK policy and governance perspective on Scotland's heat transition, a closure looking at devolution and local governance is appropriate.

7.2.1 Devolved and local governance in Scotland

It is important to note the policy context in which Scotland's energy sector is situated, with energy policy being reserved in the most part to the UK Government; though aspects such as planning, housing, local government and economic development are within the remit of the Scottish Government and its Local Authorities (Woods and Overgaard 2015; Cowell et al. 2017). Energy efficiency policy in Scotland has been relatively stable, despite the

difficulties found at UK level, providing a platform for long-term policy planning (Wade, Webb, and Creamer 2022). Local authorities must adhere to several standards with residential housing in their area, producing Local Housing Strategies which detail how fuel poverty is being addressed, and that housing stock meets Scotland's Energy Efficiency for Social Housing. As part of Scotland's own net-zero legislation for 2045, and the 2020 Climate Change Plan Update which sets out how the Scottish Government intends to achieve the target, emissions from heat are required to reduce significantly over the coming decades.

The Heat in Buildings Strategy published in 2021 is the central policy platform which sets the pathway to zero emissions buildings by 2045. Though now incorporated into the Heat in Buildings Strategy, energy efficiency has been regarded as a national infrastructure priority since 2015, resulting in the establishment of a 20-year national programme centred around the delivery of 'Local Heat and Energy Efficiency Strategies (LHEES)'. LHEES will require all local authorities to develop area-based plans for improving energy efficiency and decarbonising the heat supply in all buildings in their area. While focussing on delivery aspects such as zoning, LHEES is also intended to be the basis for local public engagement. Pilot programmes have been funded from 2016 in distinct phases to test local capacity and provide learning opportunities with the final strategies for every authority to be rolled out by the end of 2023. As a statutory duty for local authorities, this places more direct authority in the hands of local government, requiring authorities to produce a strategy to be delivered over 20 years with flexibility over implementation (Kuzemko and Britton 2020). Additionally, new energy standards have been developed in Scotland, active from December 2022 targeting newly built homes and non-domestic buildings, in order to support the overall aim of reducing emissions from Scotland's building stock by two thirds by 2030.

Despite developments such as LHEES and wider discourses of localism in the UK, Wade et al. (2022) suggest devolution has not significantly altered the role of local authorities, with their role remaining largely subordinate and administrative. As in the case of LHEES, local statutory duties being decided centrally and left for local authorities to administer results in tension between the respective structures, within an ongoing context of decreasing budgets from central governments. This model can also be restrictive for local authorities in having their own policy agendas and strategic abilities to implement them, which may in turn impact their ability to fulfil promises; uneven progress in energy and climate change plans may partly be a result of this (Tingey and Webb 2020). Ultimately this picture of mixed governance creates potential challenges and opportunities for technologies such as MWT in Scotland, as Scotland specific measures enable a degree of autonomy in pursuing niche innovations and more ambitious heat transition plans. It can also mean that there is a

disjointed and adversarial relationship between levels of government, and that much work is left to local authorities, without appropriate support from centres of power. The next section explores specific policy areas relevant for MWT, both the heat network and geothermal energy policy context in Scotland.

7.2.2Heat networks & geothermal energy

As mentioned, the challenge to decarbonise heat within the UK remains significant, with slow progress to date. Lack of regulation around access for subsurface heat resources and heat networks, difficulties in retrofitting existing buildings and insufficient policy assurances are some of the key factors (Gross and Hanna 2019; Abesser et al. 2020). However, recent policy developments including the UK Government Green Heat Network Fund, Scottish Government Heat in Buildings Strategy and Scottish Heat Network Fund have begun to provide an initial degree of assurance and support in the sector.

The Heat Networks (Scotland) Act sets statutory targets for heat network development of 2.6 TWh by 2027 and 6 TWh by 2030. It also includes requirements for new non-domestic public sector buildings to assess heat network suitability, the creation of heat network zones across Scotland and the introduction of heat network permits and licenses for long-term development standards and assurances. The Heat networks delivery plan lays the groundwork for how the act will be delivered and also includes details such as prioritising connection of existing buildings in planning and creation of Heat Networks Support Unit as part of a National Energy Agency to provide national oversight.

Currently there is no bespoke regulatory system for geothermal energy in the UK, and it is not recognised by law as a natural resource (Abesser and Walker 2022). Permissions from the Environmental Agency are required for water abstraction and discharge mine energy schemes are facilitated and licenced by the Coal Authority who have responsibility under arrangements with BEIS to manage non-coal mining related contexts in the Energy Act 2011. Thus, a mine water heat recovery access agreement from the Coal Authority is an essential first step in minewater project viability. The Scottish Government produced a regulatory guidance report for geothermal heat in 2017, which outlined some of the central considerations and practices, highlighting the role of SEPA, the Coal Authority, Planning Authority and the Health and Safety Executive depending on the particulars of a project.

7.2.3 Heat Network Delivery Models Report: Summary

In order to develop understanding on Heat Networks in Scotland, it is worth spending time dissecting a report released in the duration of this research project. A report titled “Heat

Networks Delivery Models" was prepared by the Scottish Futures Trust for the Scottish Government and published in 2023. In the extensive report, authors gathered insight from stakeholders, analysed delivery models against selected criteria and made suggestions on how to drive the heat network industry forward. The report outlined the following themes as the key challenges for the pace and scale in the deployment of heat networks in Scotland. First, "Multiple & competing policy objectives", namely the lack of clarity around competing heat solutions, mandatory connections and dates for switching from fossil fuel heating. Second, "Lack of knowledge, skills & capacity", despite local authorities receiving statutory duties, difficulties in attaining capacity that bridges from delivery plans to project identification and development. A lack of vision, and clear project pipeline also deters private sector recruiting for delivery capacity in Scotland. Third, "Demand assurance to encourage investment", when projects are identified, particularly reliant on large anchor loads, there is no policy agenda which provides assurance on the vital connections taking place. Finally, "Public procurement", streamlined procurement through national government and local authority to reduce time, complexity and cost.

In the analysis undertaken in the report, the authors used a definition for heat network delivery model as being "the set of role allocations to different parties, the commercial & financial agreements governing the relationships between the parties, and the applicable regulatory arrangements that collectively underpin the provision of services to customers via a heat network". They used characteristics such as ownership, financing, risk allocation, income stream and procurement to structure each model and evaluated them against core attributes such as ease of deployment, potential for private sector investment, simplifies delivery, reduces demand risk, and supports transition to a self-sustaining market. Whilst the methodology of analysis taken in this report is extremely useful in understanding heat network delivery in Scotland, it is important before going into the findings to note there was a lack of analysis on critically important areas such as public good, community empowerment, community engagement or participation, public sector return on investment, community wealth building or just transition.

The report suggests several overarching recommendations, delivery models that are most favourable and further recommendations relating to enabling mechanisms and alternative delivery models. The first overarching recommendation is that flexibility should be built into any approach taken that utilises specific models, based on specific contextual information relating to Scotland as a whole and in local place-based contexts. The second is that a long term 'vision' for heat networks in Scotland should be developed, defining the role of the public and private sectors, ownership and operation and preferred outcomes. Third is that existing models can be optimised in the short term, regardless of any medium or long-term

intervention. The fourth is around budget implications and government risk appetite, namely that some degree of central government investment was necessary in at least two of the top performing models, and therefore the government should outline its appetite for investment, and the time period over which it will hold such investments, on or off government balance sheets. The final recommendation is that ongoing stakeholder engagement will be required.

Following the overarching recommendations the report proposes four different heat network delivery models which scored highest in the evaluation and warrant further detailed development and consideration. The highest recommendation is a “Regional ESCo model”, where local public sector bodies, such as the local authority, NHS, universities come together to jointly procure a private sector delivery partner, in this ESCo, the private partner maintains majority stake and the public sector takes a minority stake. Benefits of this approach are in the streamlining of the procurement process for potentially multiple regional projects as well as bringing public buildings with large anchor heat demands onboard. Further it creates opportunities for local supply chains based on long-term partnerships within regions. A similar model was used for the community infrastructure hub programme, and learnings from that programme could aid in the development of a ESco model for heat

networks.

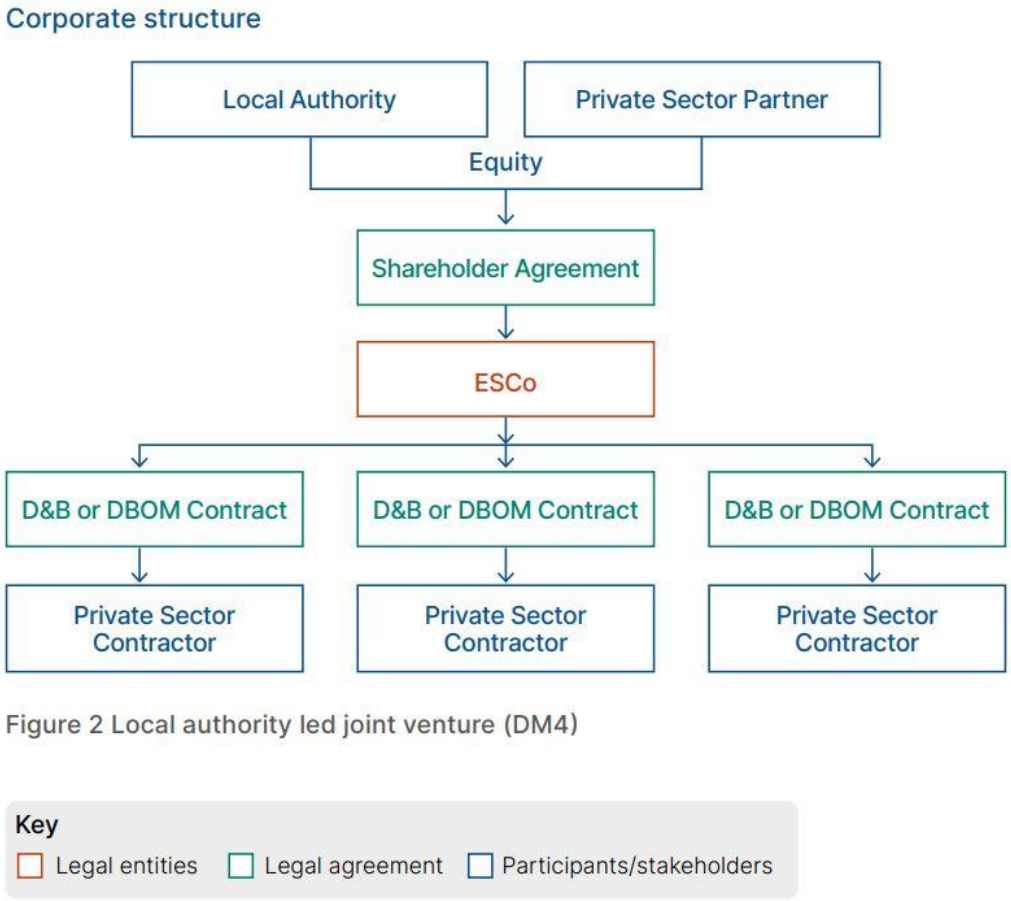


Figure 19 Joint Venture Model (Scottish Futures Trust 2023)

The second highest recommendation was for a “Local authority led joint venture” model. Again, key benefits of this model include the simplification of delivery and procurement and the potential for future projects to come out of the original venture. Further it allows both the public and private sector to ‘play to their strengths’, with the former providing anchor loads, stakeholder relations, planning policy and land access, and the latter offering technical expertise and delivery capacity. As both entities share in the risk and returns, it also promotes collaboration rather than adversity. However, the exclusivity offered to the private sector would have to be highly scrutinised and transparency around in-house delivery and procurement will be essential.

The third model recommended was “Local authority led delivery, with Scottish Government stake”, where beyond supplying grants to local authorities, the government invests and takes a stake in projects, demonstrating a high level of commitment. This will help to derisk projects and allow for a more rapid delivery, whilst keep benefits in the public realm. It also allows for national coordination across regions, whilst still allowing for locally led solutions. This model was highly championed by local authorities, where a central body for skills and

experience would allow for shared knowledge across multiple projects, and for more systems-led planning.

The final model recommended was “Centrally led delivery”, where delivery routes are created at scale in situations lacking paths forward either through local authorities or the private sector. This model allows for control of strategy across all of Scotland and can remove barriers to expansions and interconnection between projects, as well as allowing for installation ahead of demand. This could mean that pipe installation is done strategically ahead of time alongside other infrastructure upgrades in anticipation of future demand. As with the previous model it allows for skills and knowledge sharing across delivery which would build over time within the Government. However, this model is perhaps at odds with the current LHEES approach and under-utilises existing local authority expertise and would require extensive capital funding affecting the Government balance sheet.

Amongst the other range of models analysed that were not recommended by the report, is a “Community led” model. The report states that despite the positive outcomes community projects can deliver, they are challenged by the scale, capacity and resources required for bigger infrastructure such as heat networks. The report does suggest that if community involvement is a priority, that guidance and case studies could be prepared alongside alternative ways for communities to engage and benefit other than ownership, such as community benefit funds and best practice built into procurement.

Finally, the report touches on the enabling conditions, which to a degree work independently of the delivery model choice. Primarily these relate to the procurement process and demand assurances. By taking steps such as policy directing large public buildings to connect to heat networks, or even mandatory connections, the investment profile of developments could be significantly de-risked. Greater efficiencies in the procurement process would reduce timescales, associated costs and information exchange. The report suggests that the established Heat Network Support Unit in the Scottish Government should pilot and analyse this process through work with live projects.

The Heat Network Delivery Models report provides a useful platform of knowledge around heat networks delivery in Scotland which this research contributes to. Whilst providing insight on the delivery models, and mechanisms which can be utilised to deploy projects, it does not explore the conditions which allow or enable the selection of different models, in other words the management of state power to make decisions on investment, and crucially, on what terms and outcomes such decisions are made. In what ways can heat networks or different models benefit and improve the wellbeing of people and livelihoods, and how citizens relate and engage with the development ecosystem for energy infrastructure. This

project builds on the work of the Heat Network Delivery Models report and also aims to answer these additional critical areas of query. The heat transition context in Scotland has been summarised in this section, next, the technology of MWT is explored to highlight the state of play and challenges to its development as an industry.

7.3 Obstacles to minewater thermal energy development

In the introduction section 1.4 the functionality and technical dimensions of MWT was explained. In this section, further context on the technology is provided through an overview of the key obstacles across technical, planning and economic dimensions. After discussing the obstacles, existing MWT projects throughout the world are examined to better understand the enabling factors for deployment, taking the best lessons learned. It is important to emphasise these obstacles and lessons before the findings are presented, as the context provided in this section is necessary in order to understand the kinds of questions asked, and knowledge revealed across different expertise.

With a particular focus on the UK, some of the issues impeding the uptake of MWT include technical limitations such as the risk of cool water entering the warm abstraction stream, a perceived risk of clogging and ware to pumps, heat exchanger and pipelines (Banks et al. 2019). Accessing the heat resource and assessing its sustainability are the first challenges before any hole is drilled. As mineworking's are often interconnected, the challenge to understand reservoir flow and suitability are complex and represent the first barrier (Monaghan, Bateson, et al. 2022).

In addition, licensing issues around longevity of pumping and abstraction operations, managing potential future pollution and the presence of an appropriate demand centre or anchor customer within vicinity of the mine are some of the key barriers (Banks et al. 2019). Minewater quality may be impacted by pollutant migration, chemical and flow path changes and so solutions to manage this risk must be included in any plans (Alison A. Monaghan et al. 2022). Legal requirements for cases where the an old mine shaft is re-opened and repurposed also need to be properly explored (Peralta Ramos et al. 2015). Economic and distribution models are also considerable uncertainties, arising around how the heat will be distributed, where ownership boundaries lie and how co-financing models will operate (Banks et al. 2019).

In their study, Menéndez et al. (2020) explore the feasibility of minewater heat and cooling schemes of varying scales within Spain. The economic analysis strongly demonstrated that the distance between the user and mine is a defining factor, as distances increase the capital investment and electricity consumption increases in order to supply appropriate heat.

Civil works such as pipe installation and excavation, and larger pumps are required, this is also the case when the water level in the mine shaft increases. Highest profitability is achieved when thermal demand is high and distances to potential users are short. Their study suggests within the Spanish context, that plants of 1MW power are not economically feasible, 3.5MW, 5MW and 10MW reach profitability at maximum distances from 1.5km to 2km to the user. Whilst this investigation noted the significant reduction in CO_2 for minewater energy comparative to other fuel sources and the opportunity it provides for economic development in mining areas; lingering drawbacks included higher investment and in some cases operation and management costs, uncertainties around security of supply relating to the complex equipment involved, and suitability for higher levels of heat demand and infrastructure.

(Walls et al. 2021) reviewed the performance of known minewater heating and cooling systems using cases from across the world. A summary of the challenges faced by MWT throughout their lifetime is outlined in Figure 23.

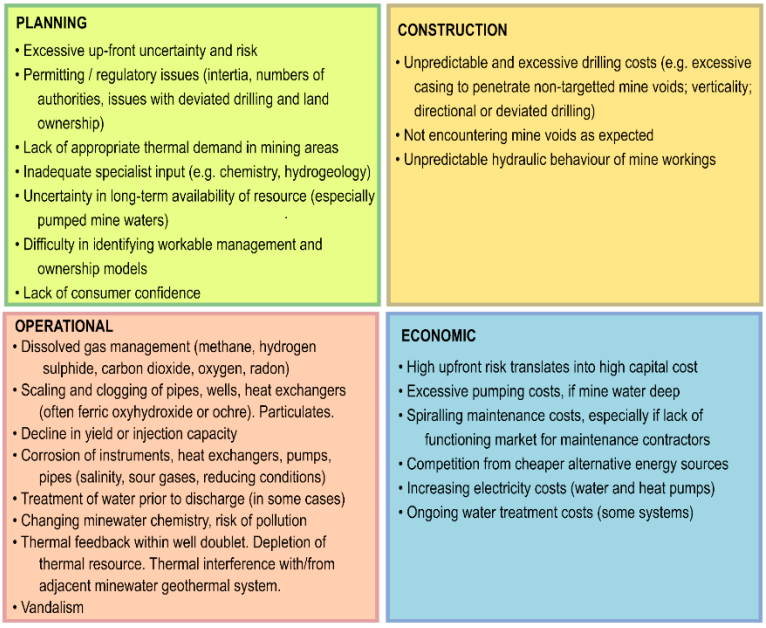


Figure 20 Challenges facing MWT systems (Walls et al. 2021)

The paper provides an overview of prominent issues around evaluation of an available resource, its sustainability and future use, and the distance from a development to a suitable heat and cooling user which provides appropriate balance to the system. Furthermore, navigating the planning and regulatory permits is unique to a national context, however difficulties arise in the timescales and unpredictable nature of MWT schemes, with some permits expiring before others have been provided and extensive testing requirements in order to meet permit requirements. Delays can have significant impact on projects as increase the period of no revenue, which has more significance for MWT schemes which

have inherent high upfront capital costs and risk. Their study also notes the range of expertise required for MWT projects which spans hydrogeologists, mining engineers, economists and planners to name a few. Successful integration of the different disciplines can be challenging task for developers. Finally, they suggest technical good practices to mitigate challenges including thorough mine characterisation and testing in order to understand the optimum operational configuration and ongoing monitoring to overcome operational challenges as soon as they are identified.

In their paper overviewing business models for geothermal heat in Scotland, Townsend et al. (2020) explore several minewater case studies and highlight some of the practical difficulties encountered as well as a set of recommendations. Fundamentally, the paper argues that the commercial case for MWT is currently weak in contrast to natural gas. Whilst the embedded nature of natural gas infrastructure is still present, fossil fuel volatility following 2022 has changed this picture somewhat. Upfront capital costs remain a significant barrier, though the potentially lower running costs are not necessarily valued in conventional evaluations, which can make MWT less attractive. They call for wider assessment criteria for energy projects, that captures sustainability, environmental and social benefits more effectively, ultimately requiring greater value emphasis on non-economic factors. Greater up-front financial support such as that previously seen for hydrocarbon exploration and production should be considered, though a range of support mechanisms such as those seen for offshore wind are suitable. Policies need to be designed specifically for geothermal energy instead of lumping with all other forms of renewable energy. On the other hand, integrated solutions for heat and power should be considered, ‘smart’ balanced systems that include PV, battery storage and EV charging, furthering integration of energy systems. Townsend et al. (2020) take the view that national government must play a greater role in setting policy and legal requirements and allow local government to enact and enforce such directives, currently there is a lack of connection in this space. Legislation and policy arrangements needed to support alternative ESCO arrangements, financing models, financial bodies in order to underwrite long-term, low interest loans for investments which target greenhouse gas reductions. A requirement for Local authorities to create arms-lengths financial bodies such as ESCOs, development trusts or similar may be a crucial first step in mobilising investment. Finally, the paper mentions the need for a cultural change and awareness of geothermal opportunities, to encourage sharing of energy infrastructures and heat and cooling demands in a localised context. including energy investment communities. Assurances to housing developers that low-carbon heat network in newbuilds will increase the value and attractiveness of houses to customers.

7.3.1 Overview of existing minewater energy projects

Globally, MWT systems have been established in a range of suitable sites where energy was recoverable from abandoned coal mines. Several have closed and others are active or in development (Walls et al. 2021; Peralta Ramos et al. 2015; Menéndez et al. 2020) (Walls et al. 2021). In the UK, all geothermal schemes, encompassing minewater, ground source heat pumps and deep geothermal generate around 1,330 GWh per year or 0.3% of annual heating demand (Waitzman 2023), though up to a quarter of UK homes sit on coalfields (The Coal Authority 2020) . Whether in the UK or anywhere else, the large resource potential available from minewater has yet to be extensively drawn on (Monaghan Alison A. et al. 2022). Again, the appropriate models and frameworks to support development are not sufficient, in an regulatory and economic sense, with the business case remaining a central challenge (Townsend et al. 2020).

To provide an insight into the MWT state of play relevant to this research thesis, an overview of prominent UK-based projects along with other notable examples is presented in the following section. A summary of the findings is found in Table 3.

In Scotland, there have been two minewater schemes to date, both of which were small scale and have now ceased operation. In Shettleston, eastern Glasgow, a colliery was operational from 1872 to 1923. In 1999, the Shettleston Housing Association used a borehole to abstract minewater at a temperature of 12ºC (Peralta Ramos et al. 2015). The water was passed through two heat pumps for a total heat capacity of 65kW, which was able to supply heating to a 16-home social housing development. As the water was reinjected through a different borehole, the configuration can be classified as ‘open system with reinjection’. The system closed for several reasons relating to the operation and maintenance of the system, including finding contractors able to manage the issues (D Banks et al. 2009).

In Lumphinnans, Fife a minewater scheme was constructed in 2000 to supply heat to a newly refurbished 18-home social housing development. Again, this was an open system with reinjection, accessing minewater at 14.5ºC, with original savings projections on heating costs as high as 80% on an annual basis (Watzlaf and Ackman 2006). The system worked well for some time until a persistent issue of clogging at the borehole forced the closure of the system, the heating was replaced by gas boilers (Walls et al. 2021)

Gateshead council are at the forefront of a wave of UK MWT developments in which the local authority inhabits a central role. The council-owned Gateshead Energy Company was set up to develop and manage the Gateshead District Energy Scheme operational since

2017 and currently supplying energy to the equivalent of 5,000 homes (Gateshead Council 2022). The council secured public funding through the UK Heat Networks Investment Project (HNIP) to expand the network and integrate a minewater heat source which upon completion will be the largest MWT scheme of its kind in the UK. Providing heat to a range of domestic and non-domestic customers, bills will include a price guarantee at least 5% below the market rate. The heat resource is extracted through 150m boreholes, in an open-loop system with reinjection with a constant water temperature of 15^0C year-round. This will deliver an additional 3MW of heat to around 1,250 new private homes and a range of council-owned buildings.

Within the Gateshead area there are two further, private schemes which are operational and provide heating to beverage warehouse facilities at Abbotsford Road and Nest Road (Walls et al. 2021). They are the first large-scale schemes to begin operating in the UK, with a combined heat pump capacity of 3.6 MW (Banks et al. 2022). Technical challenges for the scheme are varied and include pump maintenance, slowly declining and insufficient yields. The Nest Road scheme operates on a temporary licensing agreement from the Environment Agency and is yet to obtain a full heat access agreement from the Coal Authority at time of writing.

In South Tyneside, the council are developing three separate heat network schemes which will draw upon both minewater and river water heat resource, investing over £40 million in total. Securing £4.7 million funding from BEIS, the Holborn Renewable Energy Network in South Shields will harness heat from abandoned mines and the River Tyne to distribute heat through the town centre, powered by solar panels, a combined heat and power system and a lithium ion storage battery (Ground Engineering 2021). An energy centre will distribute the heat to different buildings including a residential tower block, further details on the user base is currently lacking (Ross Robertson 2021). The Hebburn Renewable Energy scheme uses a similar power configuration, though without the river water heat source and at a smaller scale, acquiring £3.85 million European funding. However, after initial feasibility stages, the minewater element of the project is unable to proceed due to stability issues with the drilling. Instead the scheme is likely to use air source heat pumps (South Tyneside Council 2022) . Finally, the Viking energy network will extract heat from the Tyne using a river water source heat pump in combination with other renewable systems, including solar photovoltaics for a total cost of £11.8m.

Within County Durham at the former Dawdon Colliery, a MWT scheme is under development which will provide heat to the new ‘Seaham Garden Village’ through a heat network. The Coal Authority have a treatment plant at the Dawdon site which pumps, treats and

discharges minewater to the sea as well as providing drinking water (The Coal Authority 2020). A small pilot MWT system has been active since 2011 at the treatment site, and following its success a partnership between Durham County Council, The Coal Authority and Tolent Construction are developing a proposed scheme to utilise the full pumped flow from the treatment plant (Walls et al. 2021). The village will include 1,500 new houses, a school, shops, and medical and innovation centres all connected to the heat network with a potential heating capacity of 6 MW. Further, the project has received public funding in the region of £3.9million, technical support from The Coal Authority and claims to have stimulated over £170 million of private sector funding (Abesser and Walker 2022) .

Two notable European cases are also worth exploring for their scale, success and longevity. Firstly, in Northern Spain in the Asturias region a 3.9MW system operates in the town of Mieres, exploiting the minewater heat from the flooded Barredo and Figaredo mine shafts (Jardón et al. 2013) (Walls et al. 2021). Since 2012, an open loop system provides space heating and cooling to a hospital and two university campus buildings within 2km of the coal mine, after the heat exchange the water is discharged into a river (Menéndez et al. 2020). The state mining company Hunosa co-financed the €1.5 million project with support from EU development funds.

In the Netherlands, the Heerlen scheme was established in 2003 and has now advanced to a second phase of development as a 5th generation district heating and cooling network (Peralta Ramos, Breede, and Falcone 2015) (Walls et al. 2021). Coal mines in the region closed in the late 1960s, by 2003 holes had been drilled into the old mines as the Heerlen municipality to provide heat to a significant number of local buildings. The project evolved into a social enterprise and expanded to integrate thermal storage capabilities to the system, balancing cooling and heating demand throughout the year, for example the local college runs on heat from a pension fund data centre (Eijdems 2019). This also allows excess electricity to be stored by channelling through a heat pump to be stored as excess heat underground. In its current iteration as a 5th generation network, the risk of resource depletion is significantly reduced, and it is able to deliver heat to a range of building types including residential, commercial and public institutions using a consumer cluster approach (Walls et al. 2021). Relying on local and European public funds, the project was originally owned by the city municipality. However, Mijnwater B.V. is now wholly owned by the province of Limbourg as the wider region recognised the central role of the network in advancing its energy transition agenda. Users connected to the system typically get energy at a price 10% lower than a conventional solution, independent on fossil fuel price volatility and without the need for gas boiler investments. The project offers an Energy Service Company (ESCO) fabric improvement service, in order for buildings to be upgraded to standard and installed

with the appropriate equipment, the users then have zero operation and maintenance costs. Total investment costs from local public funds and European and wider research programmes is estimated to be between €45-55 million (Cuvelier 2020).

Project Name	**Company**	**Location**	**Commissioning Date (or future commissioning date)**	**Description**
Shettleston	Shettleston Housing Association	Shettleston, Eastern Glasgow	1999 - Ceased	Small-scale, several technical issues and lack of contractors for repairs
Lumphinnans	Social Housing Development	Lumphinnans, Fife	2000 - Ceased	Small-scale, several technical issues, replaced by gas boilers
Gateshead District Heating Network	Gateshead Energy Company Limited	Gateshead, NE England	Under Construction	An extension of the existing Gateshead District Energy Scheme. Using minewater to supply heat to new built homes, a care home and Gateshead International Stadium and a council owned building
Abbotsford Road and Nest Road Warehouses	Lancaster Wines	Gateshead, Northeast England	Operational since May 2021	Private scheme heating warehouses, licensing agreement difficulties
Holburn Renewable Energy Network	South Tyneside County Council	South Shields, Northeast England	Project expected to be completed 2024/2025	Using minewater from the abandoned Holburn Colliery and river water heat pump to provide heat to energy network in town centre
Seaham Garden Village	Durham County Council	Seaham, Northeast England	Housing development from early 2023	Utilising Coal Authority treatment plant at Dawdon Colliery to provide heat network for new development of residential, commercial, public buildings
Mieres District Heating	Hunosa	Asturias, Spain	Commissioned in 2009.	Minewater geothermal scheme using heat from the Barredo Colliery to heat two public buildings and around 245 dwellings
Heerlen Mijnwater	Mijnwater B.V.	Heerlen, Netherlands	Pilot began in 2003, 2014 commissioning of the smart grid structure.	Heerlen is a district heating scheme in the municipality of Heerlen, using water from abandoned mines in the area. The system is seen as the model project for minewater geothermal heating

Table 3 Summary of prominent MWT projects

7.3.2 Chapter Summary: minewater energy state of play

This context section has demonstrated that MWT is at the centre of several cross-cutting areas of research and is directly shaped by policy and governance histories as well as existing regimes. The end of the coal mining industry is an important consideration for the development of MWT, particularly with respect to dimensions of justice and fairness, as well as ensuring the complex socioeconomic and cultural legacies of former mining areas and their communities are understood as part of any development. Further, this section explored UK heat policy has been somewhat neglected and continues to suffer from a lack of coherent and sufficient policy attention as contexts have changed. Minewater energy clearly has a large potential to deliver for low carbon heat demand in the UK, though committed policy support is lacking and a fractured. A laborious legislation process may also be proving difficult for developers to navigate. The financial pressures and lack of a support system from government historically have made minewater systems difficult to get off the ground, however there are signs of change with several heat network funding mechanisms, viable for minewater and potentially key in overcoming the large upfront costs, though the public funds available are relatively small. The Coal Authority has also signalled its support for minewater schemes, which may be crucial in giving projects the guidance and access required for them to be successful. There are also learnings from existing projects which can inform any future development of the industry. Technical and operational issues are present throughout different system configurations and occur even in projects which are often considered to be successful. A multitude of economic, planning and legislative challenges remain across different contexts, and though there are case studies to draw upon, what is clear is that there is no off-the shelf solution for MWT as the technical, environmental, social and economic complexities are significant. Emerging and recurring themes from the review of projects suggest strong public support is essential, both nationally and through the local authority. Relationship building between communities and stakeholders is key as trust and the ability to make coordinated actions when opportunities can make or break projects. The context explored here sets the scene for the following chapter, in which a future MWT industry in Scotland examined.

Chapter 8 - A Future Minewater Energy Industry in Scotland: Imaginaries, Strategies and Delivery

This chapter presents the findings from the first phase of the data collection, which have emerged following the qualitative process outlined in the Methodology Chapter. It structures the findings through thematic analysis, utilising the analytical framework and the insights from literature in previous chapters. Firstly, in section 8.1 the chapter analyses the political economy as visualised in the analytical framework in Chapter 5 and Figure 18, which critically shapes all imaginary processes. It then follows the imaginaries process as outlined in Chapter 5 and in Figure 18 through three stages:

1. Imagining a MWT industry and alternative energy economy in Scotland in section 8.2
2. Strategising a MWT industry and alternative energy economy in Scotland in section 8.3
3. Delivering and actualising MWT imaginaries in 8.4

Participants are referred to according to their designation in Table 1 found in section 6.5.1. Chapter 9 compliments the findings of this chapter by presenting the results of the second phase of the data collection, in which the case study based around a former mining community is analysed; offering a complimentary and ethnographic based perspective from communities who may engage with this yet to exist socio-technical energy system.

8.1 The political economy of energy in Scotland: shaping imaginaries

As described in the analytical framework, the imagining of MWT and a wider energy economy is Scotland is shaped by the existing political economy, which is understood from a historical materialist perspective. Before any imaginaries, strategies or delivery approaches for MWT can be made sense of, the political economy and its development must be explored. This section explores the development and characteristics of the political economy, it critiques the present-day energy economy and economic development approaches which dominate the energy economy, tracing the historical roots of political economy to the present. It delves into the history of period of deindustrialisation of which the end of nationalised coal mining was a significant part of, signalled a shifting in the political economy away from ideas of public good and national interest towards the neoliberal market led political economy we still live with today. The data collection process began with an interview with a prominent historian of energy histories, P14, from which much of the analysis is formed, as a result of their expertise. Some of their work, and of others was explored in the context chapter on deindustrialisation and thus it was deemed useful as a starting point to

explore the context, history and political forces which shaped the situations facing the coal fields, and the national energy system today.

In sum, this section analyses the characteristics and makings of the political economy in Scotland's energy sector. It begins by examining historical deindustrialisation and the shift from an era of nationalised energy industries to neoliberal market structures, a shift which shapes contemporary energy system governance as well as imaginaries, strategies and delivery of MWT futures. Insights from participants highlight the decline of public governance and public good towards private gain. Despite observing limited workplace democracy amongst other challenges, much of the thrust of early post-war interventions focussed on public good, regional economic diversification and forms of just transition for workforces. In contrast, the market logic which dictates energy systems governance and design in the present disregards workforce and community input and outcomes. The structural legacies discussed here influence how a MWT industry is imagined, with the shift to market led energy governance makes it easier to imagine energy companies ending fossil-based production than even minor alterations to the workings of capitalism in the energy sector.

Beginning with the story of deindustrialisation and changing political economy in the UK, P14 emphasised it as one starting in at least the middle of the 20th century. Coal was nationalised in 1947 in a strategic technocratic move to secure a resource that powered post war economic reconstruction as well as being a response to a coal shortage over a particularly cold winter of the same year. Electricity generation had increased around 5 to six times over by 1973, from when it was nationalised in tandem with coal, mostly through coal fired power generation. It's important to think about the kind of political economy that allowed for such drastic intervention and action, and the conditions which created and subsequently dismantled it, as it can offer insight into why alternative and necessary action feels impossible or so difficult in today's political economy.

P14 explained how the coal industry was identified as being important for the interests of the nation and the public. At the time of nationalisation, the private sector was deemed to have failed, and coal was not profitable, and in the face of huge challenges of post war reconstruction and the growing energy economy, decisions were made beyond the silo of profitability and government debt considerations to strengthen public and national prosperity at the expense of the private owners. One could draw parallels to challenges facing the national and energy economy today in the face of climate change, energy crises, pandemic recovery and growing material and social inequalities.

As the need for coal diminished with the contraction of the railways and the shift to oil fuel both domestically and industrially, alongside consolidation and efficiencies in the coal industry, the number of miners fell drastically in the 1960s, more so than in the 1980s. P14 considers this process to have been "responsibly managed", where trade unions were consulted, unemployment did not rise significantly and miners who wanted to stay in the industry were offered alternative employment. To summarise, the increase of productivity of pits and effective use of labour drove miners into conglomerated coal operations and emerging advanced manufacturing in a strategic move, enabled by the post war political economy.

The shift then observed in the 1970s from a national coal, steel and steam-based economy to one that is multinational, and oil based. As oil prices skyrocketed in the latter part of the decade, miners won significant strikes over pay and conditions which had fallen behind other industrial employment. That success was down to the temporary re-emergence of coal as the most important national fuel. However, that picture changed again in the 1980s. Discussing why miners were defeated P14 expressed the following:

> "You know, firstly, miners were singled out for defeat because the unions were strong, and they had power over a crucial part of Britain's energy economy. So, there was an aim to take that power away from them within the nationalized mining industry. But also, this was part of the wider reconstruction of the energy economy, and also of industrial relations. I think it's important to say that I'm not convinced that in the mid-1980s the idea was there would be a future without coal. It was that there would potentially be a future without British coal, or certainly that British Coal wouldn't be given a privileged access to the British coal market. So, in the 80s, Polish coal, Colombian coal, Australian coal, is important in defeating the miners' strike, but also becomes part of the energy mix. I think there is an expectation that with the privatization of the gas industry and then the privatization of the electricity industry that, you know, gas fired, would be the future. I mean, I think we can think back now to what a pivotal decision that was, and what a bad decision that was in terms of our recent experiences of oil, of the gas price instability, but also that the decision was made to go for gas, not to invest in renewables, and as large a way as could have been done in Britain, and we're paying for that now as well." – (Global Inequalities Historian - P14)

The imposition of liberalised markets affects both the labour and energy market as the national and globalised economy changes in a political programme, embedded in power structures. As Bluestone and Harrison stated "Deindustrialisation does not just happen"

(Hearn 1983). Despite the growing importance of the role of private multinational corporations over this period and the drive for liberalised markets, such developments absolutely required the state for their creation, as P14 said in our interview “I don’t think we should be naïve enough to think that liberal market economies arise naturally”.

Indeed, P25, who works for a local authority similarly felt it was important to address the political decision making which led to deindustrialisation as this particular ideology directly shaped the present-day challenges found within the former coal field areas. They explained how through their decades long career in planning, they experienced the lingering effect of this approach and ideology that is short-term, and market orientated, making it ineffective in transforming former mining communities.

> “I think it was the finance system. Clearly getting rid of the coal mines was quite political so it was, and I think that political resonance is still there in the economic processes, that certainly would be my interpretation of it all.” – (Council Climate and Energy Lead - P25)

P14 discussed how the period of pit closures described in the 1960s, were not necessarily experienced negatively for the former mining communities. This approach towards economic diversification was in response to previous experiences such as the Great Depression which exposed mining regions dependent on a small number of heavy industries. Economic security and new opportunities emerged alongside the mining closures, signalling a level of interest in public good and regional equality in stark contrast to development approaches post 1980s “Unfortunately, we didn't learn from that, because we then built an economy that was heavily, heavily exposed to financial services and related activities” – (Global Inequalities Historian - P14).

The post war period political economy was described as being part of a rise in a national identity in Britain, as an industrial nation centred around electricity and the coal industry; “I think it's quite helpful to think about the energy economy, the coal mining industry and electricity generating industry in particular, as it emerged out of the Second World War and even public ownership was part of our nation building exercise in Britain” – (Global Inequalities Historian - P14). The conclusion from P14, is that this period of political economy was a comparatively just transition within the energy economy, as priorities for regional diversification, workers living standards, alternative and new employment were led by political structures. P14 pressed that the strength of trade unions and organised labour was essential in delivering a more balanced bottom-up perspective operating with the top-down national government in socio-technical transition and change.

> “So, I think there is a history of overlap between workplace and community that is very, very important, and the shaping of the just transition idea. I do worry about it becoming a generic term used by policy elites, which doesn't have the idea of class conflict and worker interest that is central. I think that's a real problem, actually, because otherwise it can become quite abstract.” – (Global Inequalities Historian - P14)

Living in an era defined by the lack of collective strength in the form of bottom-up movements and in the form of a strong democratic state, P14 was concerned that smaller issues will become the main preoccupation of collective struggles for improved, fairer lives. They acknowledged the benefits and importance of community energy projects, especially for particular communities, and were positive about maximising community benefit payments, however they drew attention to the scale of the issue in the face of huge economic activity.

> “I am all for community owned energy projects. I think they do important things for relatively small-scale communities, usually, or places in cities that badly need them. I'm all for getting as much community payments as you can out of wind farms, but I think those in particular, when you look at the amount of money that's being made out of wind farms, is really quite telling about who holds power in this economy. Until that changes… I think there can be as many just transition reports as we want - but, you know, this is ultimately a question about power in two senses, like, power in the sense of, like, actually producing power and energy infrastructure. And power as in political power over how that is shaped and who has control over it.” – (Global Inequalities Historian - P14)

Mark Fisher said in Capitalist Realism, it’s easier to imagine the end of the world than it is the end of capitalism. Such is the strength of the current paradigm of financialisation, P14 discussed how it was easier to imagine the end of carbon production than not even the end of capitalism, but just an alteration to the workings of capitalism. “I think that's quite important, that we don't live in an era where the state feels confident enough, you know, we live in an era where a key economic infrastructure is in the hands of usually foreign owned multinationals, which is completely different from that earlier era” – (Global Inequalities Historian - P14).

In a discussion around structural challenges, and the difficulties in envisioning alternative economic development approaches, P1 who is a co-director for a social enterprise, and has

previously worked in the community and co-operative energy sector, strongly emphasised the effects of a neoliberal political economy paradigm:

> I think I bring a fairly strong perspective that is firmly rooted in the idea that something changed dramatically in the 1970s. And ever since then we've had an accelerated downward trajectory in our societies, in particular in the Western world. That thing has got a name and is called Neoliberalism. So, unravelling 40, approaching 50 years of heading in the wrong direction is a hugely complex project that society needs to be tackling, you know. On a number of fronts. Unravelling it is as complicated as creating the project in the first place. We almost need to think about it in those terms. This 50 years of bad is going to take 50 years of remediation. Right? - (Retrofit Co-op Co-founder - P1)

This perspective resonated strongest with the analysis and findings undertaken in the literature review, identifying strongly with the long-term impacts of the radical shift in political economy from the 1970s towards neoliberalism.

Having followed the historical threads and comparing today's political economy with that of the past, the next section begins to explore the imaginaries process, where political economy, hegemonic and counter hegemonic ideas interplay to determine the kinds of collective futures imagined. With this political economy understanding, the process of imagining a future MWT industry and alternative energy economy is now explored.

8.2 Imagining a MWT industry as part of an alternative energy economy in Scotland

In this section, the social, political, economic and cultural imaginaries of MWT development are discussed in the context of Scotland's energy economy. A range of perspectives from the interviewees contribute to the findings here, from policy experts to council employees, private developers to community organisations. It explores MWT as a socio-technical object, and a contested site of different kinds of meaning according to different participants. Tensions are highlighted between structural economic constraints and governance approaches, and futures that build upon just transition and community wealth building platforms. Former mining communities themselves are examined, with symbolic and material imaginaries placed upon them, shaped by legacies of deindustrialisation and at the heart of different visions of MWT and energy future development. The section foregrounds how imaginaries of energy transition and MWT are weaved together with broader debates on ownership, fairness and the purpose of economic transformation in Scotland, laying the way

for strategic and deployment perspectives discussed in the following sections of this chapter. A conclusion section at the end summarises the key findings.

8.2.1 Imaginaries of a different energy economy in Scotland

P1 has direct experience of developing and implementing renewable energy solutions, working under collaborative and inclusive approaches, particularly relating to ownership, which run counter to the neoliberal paradigm and thus they would have a strong understanding of the challenges. Other participants did not reference the current political economy in such terms or indeed discuss historical perspectives in this way. However, an understanding of structural and ideological constraints was articulated across the interviews. P2, who works for an Economic Think Tank and Public Policy group had much to say on systemic challenges:

> "So, I think the kind of existing power relationships and the politics is like at the moment and I don't know whether it's true or not. But at the moment, politicians don't feel like they can seriously challenge and do transformative action because they are afraid, which I think they're afraid they're shut down by the media and by various other voices. And just going to be, I guess, to lose the next election or whatever." – (Alternative Economy Network Policy Lead - P2)

Here, we get a perspective on the inhibition felt by political actors due to a perceived power dynamic which stops alternative and transformative action occurring. Often, this feeling is not related to the legal and political powers as they are written, instead it is an effect of the hegemonic grip neoliberalism constructs. As such, we are dealing beyond materiality and political organisation and management as it actually exists, and instead project into a collective socio-technical imaginary. This theme was identified in the literature review, as a theoretical home in which the future of former mining sites could be imagined by different actors. Here, its importance as a way of understanding the present and the interconnectedness of the past, present and future are notable, as existing power structures are effectively self-replicating across new industries and possible futures. P2 goes on:

> And then related to that, the other big barrier I think is risk, so even if there are people who wanted to do that, trying something new is risky for politicians. It's very, very risky at the moment for civil servants as well. So, there's especially I think in the public sector and maybe in some other areas of businesses as well … like, yeah, not a lot of appetite to actually do something different … I mean, even if the UK Government wanted, there would be probably restrictions on what they could do. And yeah, especially around energy markets, we had last week, a cross-party group

> meeting on climate change and a politician was speaking … she was very much talking about that, how like, you know, politicians actually have very little power over the global energy system because it's global. And a lot of it is out with democratic control. Yeah. So that's definitely a factor as well." – (Alternative Economy Network Policy Lead - P2)

It is noticeable that someone involved in the machinery of governance and policy making would note this inability to fundamentally change course or effect structural change and speaks to the hold in which the political economy, as it is experienced, has over decision-making apparatus. Not only this but, the recognition of globalised elements of the energy system being out with democratic control poses further questions around who does shape systems. If democratic governments are risk adverse and afraid of upsetting anyone too much, one possible result of that is that democratic voters are not particularly empowered. This is supported by data which suggests increasing levels of discontent and distrust in democratic institutions. Whilst reports of the reasons behind this trend are numerous, complex and interlinked in various ways, economic inequality, corruption, as well as a perceived lack of responsiveness from governments are cited as key. Failure to address climate change, social justice and economic stability are also drivers feeding into this surge, in which democratic processes themselves are now under question. As a result of these contemporary challenges, P1 was convinced that the energy transition must also address and fix the ever-increasing inequalities experienced in society.

> It's where that fundamentally comes from, that blending together of democratic ownership model, and some a vague sense of fairness. A recognition and awareness that the current economic system and the broader social context in which our society is operating has gotten itself to a place which is inherently unfair. So, we have statistics like the divide between how few people controls such a large proportion of the wealth, we've got growing inequality. We've got backwards progress on many measures of wellbeing in our society. So, for me a just transition is not just about how do we ensure that we make the transition something which is yeah, achieved in a way which is fair as possible. But it's also about, how do we take the opportunity to fix some of the problems that exist in our society already? "- (Retrofit Co-op Co-founder - P1)

In understanding the challenging circumstances facing transformations to sustainability P2 felt that by tracing backwards to first principles, it is the economic system, or more importantly, the political understanding of the economic system that holds back progress. Using heat networks as an example, which is a common infrastructure in many countries, we

discussed the need for public investment and community engagement. There was an acknowledgement that whilst the Scottish Government doesn't have the money to do that kind of large investment, the UK government does, but isn't doing so primarily because of political choices:

> Either because they have a wrong understanding of how public debt and the monetary system works, or because they don't feel like, you know, not happy to raise taxes on rich people or something. But you know, they definitely could finance that kind of thing across the UK, if they wanted to, but they don't. – (Alternative Economy Network Policy Lead - P2)

Throughout the interview, P2's main argument was that energy projects that serve environmental and public good are always unlikely to flourish at scale without addressing structural problems in the economy; "we have kind of baked inequality in other bits into the system and that we kind of really need to redesign that on a fairly fundamental level" – (Alternative Economy Network Policy Lead - P2).

P25, who works for a local authority also provided pushback on the functioning of the monetary system and the commonly reported idea that the state doesn't have enough funds to finance infrastructure. They spoke of their own experiences working within the public sector, with an array of partners to leverage funding from the offices of the state.

> "It's not true that there isn't money in the system. I've found in my career it's about how you ask for money and who you ask is as critical, because I've done a lot of reading about money and how the monetary system works and essentially money effectively gets created by the Treasury and put into the system and then gets taken out the system through taxation. And it's not actually true that taxation pays for everything, that's just a front they put up, but it's not how it works in reality. And the funding of the grid and things essentially comes through a process where we tell what we think we want the DNO's spend, then go to OFGEM, then go to the Treasury and the Treasury says yes or no and then they create some money, and it gets paid for. That's essentially how it happens. And so, if we are clearer about what we want in an area (it can be done). We will fund some things ourselves, you know, in the local context, but also that central funding can be brought in to deliver some of it." – (Council Climate and Energy Lead - P25)

As was discussed in the literature review, and has emerged in the data, the source of funding and the monetary system remains perhaps the single most contentious and vital element of the equation which unlocks socio-technological developments at scale, such as

MWT and heat networks that work for public and environmental good. P2 had more to say on this issue, emphasising how many of the issues found in the UK's are driven by the way in which the UK economy is set up to focus on "short term GDP growth". Providing more context, they criticised the ways in which the narrative around public spending is framed:

> "This is a kind of current economic story that's very strong around well, we need growth because that creates the wealth to pay for our public services and that means we need to like be supportive of a lot of private businesses because they are the ones who create the wealth, which then creates the growth, which then pays for our public services and we better not rock the boat because. Then you know what happens then." – (Alternative Economy Network Policy Lead - P2)

They spoke to the importance of an interconnected understanding of the economy. Where a recognition and consideration of the inequalities of the energy system, alongside issues such as land ownership concentration and rent would enable more appropriate economic strategies. An element of the challenge to this approach is the current way in which government structures operate, and the particularly critical role of the financial sector in economic centres of power; this was described as "siloing within government" by P2. This is illustrated by the fact that the community wealth building unit and minister within the Scottish Government, which attempts to view the interconnected nature of the economy at a local level, does not sit within the economic department for government, sitting instead within community development. The economic unit is reserved for traditionally GDP growth orientated elements such as productivity, investment, innovation and finance. The result is that without a better understanding of the interconnectedness of the economy beyond traditional economic measures, ideas that the government has signalled verbal support for, such as CWB, wellbeing economy, and just transition, will never be realised.

> "I feel like if we really wanted to just transition, you would really have to tackle that power imbalance in the economy… and there's just a very little recognition that it's there and very little appetite to challenge that. Like you know for example the finance sector is hailed by the Scottish Government as great for growth and great for like, yeah, we need the finance sector to finance the just transition, and you know the private finance is super important. There's absolutely no recognition or willingness to be like from my perspective, I think big finance is more part of the problem rather than the solution. And there's like no recognition of that like really anywhere." – (Alternative Economy Network Policy Lead - P2)

When it comes to the political economy dictating Scotland's resource wealth, P10 observed that greater public debate was needed to answer questions around what actually the public good and public interest constitutes. They questioned whether to view resources as a national asset or a community asset and thus asking whether the value should be spread more widely or focussed in geographical areas where the resource is located. As this question is so underdeveloped, their organisation is using the political space that exists within the community energy economy to bring in some of these discussions "through the back door" as they put it. They were frustrated that political leadership on economic issues fails to address these kinds of bigger questions and face up to structural challenges.

> "So, these are some of the kinds of big questions that should that need to be tackled. But from our point of view, it comes down to the Scottish government lacking the courage to set up something like a sovereign wealth fund where they would administer that. And the terms of doing business in Scotland is that these developers have to put 20% into a sovereign wealth fund, which then maybe goes to local authorities or whatever it may be. If there was a sovereign wealth fund based on some of these renewables, as they should have done with oil back in the seventies. But that's kind of a much bigger kind of policy idea, which there is definitely no traction for... it's just a shame that we have to go for a backdoor approach to a sovereign wealth fund rather than having some kind of actual political leadership on this." – (Land Policy Manager - P10)

As mentioned, whilst they believe that the political will for a bold restructuring of the economy is lacking, P10 was confident there was space for approaches that build upon community wealth building and just transition policy agendas, and pressure to actually develop them. Despite the agendas being clear, the configuration of legislation in these two critical areas is much less so. Whilst there are sympathetic individual voices and actors and within the government, the constraints at the cabinet level, the UK government level and within international markets means that developing a strong will to take community wealth building to its "natural end point" of localised economies, minimal economic leakage, place-based investment and equitable ownership of land is critical. P10 summarised their scepticism of the situation by stating, "I'm constantly pleased with the rhetoric from the Scottish government and then disappointed by the actions".

The international dimension of the Scottish political economy was also explored with (Land Policy Manager - P10), where Scotland's governing establishment positions itself as an international player in the making, open for inward investment and ready to engage in the global financial systems. This contributes to the situation where business interest often

surpasses community interest. Though this was acknowledged as a real challenge P10 felt that fundamentally “it's like if the Scottish government's going to back up its potentially radical policy agenda, it has to have more regulation to lock it in”. They cited governments around the world where this is the case, and that the value of Scotland’s energy resources was high enough that legislation creating a sovereign wealth fund, or meaningful shared ownership would not scare developers off:

> “They aren’t going to find another country with so much potential for renewables such as a stable political and economic system, relatively speaking, [and] such a relatively stable medium-term future in terms of climate change. Scotland's a very attractive proposition to a lot of these developers and I think the government needs to acknowledge that and therefore think we've got a stronger negotiating position than they seem to think.” – (Land Policy Manager - P10)

The energy system as it exists takes a huge toll on the wellbeing of the UK’s population, paying some of the highest energy prices in the world. Much of the community wealth building agenda looks to tackle this issue, which beyond producing fuel poverty, also weakens local economies chances of success in a global market, and takes the value generated locally away into the share price of international energy companies. P25 passionately summarised this when discussing their frustration working within a local authority, with the continual rejection of funding and investment plans to make the most of local resources.

> “'I’ll give you an example in [place redacted] at the moment, gas, electricity, just domestic, just the fuel bills are just shy of half a billion. Half a billion pounds of [place redacted] money goes out of our economy every year. And we are tearing the heart out of our economy by not making use of our energy. And so, I'm very passionate about this one and just banging on about it and going, we have to have an energy system that doesn't destroy the economy. Although what's the point, you know?” – (Council Climate and Energy Lead - P25)

This section has explored the economic development approaches and political economy landscape that dictates minewater, heat and energy developments. As one which requires a significant level of infrastructure, medium and long- term planning, and provides lower rates of return on investment, the expert data broadly concludes that a greater role of public institutions is absolutely necessary to advance heating projects at scale which improves environmental and social wellbeing. It demonstrates the somewhat nebulous and significant ideological challenges which result in commitments to medium and long-term visions being

so rarely made, thereby quelling an energy economy with an appetite to get on and do things, as summarised by P18:

> “I think you just need a bit of buy-in, you need formal collaboration. So, we're going to pilot this project and we're going to run it until it works. And if it doesn't work, we'll just bin it, and we'll move on to something else and we’ll have learnt quite a lot. It's almost like people are too scared to actually do that. They're quite happy looking at corporate governance and you know running the funding applications, saying no, but they’re not actually willing to say, let's get on with this and try this.” – (Housing Development Manager - P18)

8.2.2 Challenges within former mining communities shaping MWT imaginaries

P21 works in community development in a former mining area, as well as being from the area themselves, and felt that they had a grasp on the area’s contemporary challenges:

> “It's a former Coalfield area, 30,000 in terms of population. In terms of its economic context, you know, heavily reliant on retail, public sector and third sector. Historically, really reliant on mining and textiles and obviously the demise of these major industries created this structural unemployment that in turn you know, left us with the symptoms that we have today, such as high levels of youth unemployment, high levels of substance and alcohol misuse, reduced economic activity, antisocial behaviour, and the biggest challenge we have is apathy.” – (CEO Community Energy Consortium - P21)

P18 is a developer working in and around a former mining community in Scotland. They are interested in future low carbon energy opportunities for their own estate and how that may benefit the community in the future. The mine at Dalquharran closed in the late 70s, and so there are still people living in the village with experience of working in the mine. P18 explained that the housing quality in the village was of poor stock and that unemployment is a persistent issue in the wake of the mining closures to this day, describing the area as “impoverished”. They also described the former mining village as still having a “strong sense of community”. P18 talked about having done a range of community consultation events around the housing needs of the community, and most recently about the test drilling they were planning to carry out. This demonstrated the lingering impact felt from the mining past, and that at the forefront of the communities minds was safety and health.

> “There's still a wee bit of reticence when we mentioned it. Last year there was a bit of people talking about, you know, there was a very bad, what they call a 50-year fire in one of the mines that spread for years and years, so people still remember that. And also back in the I think I could say the 80s. There was a very bad contamination in the local river… That was still remembered by the locals as well. Which is why we do have to make sure that for doing anything on site that people know enough that they're aware of it, and they've got a chance to kind of make their views known.” – (Housing Development Manager - P18)

Whilst former mining communities are filled with hard working, skilled and resourceful people, they also face challenges associated with what might be understood as a kind of professional bureaucracy. Community organisation and public funding schemes, as well as negotiations with private developers require a level of capacity and understanding relating to legal and political language, developed by a professional class. P18 was under the belief that this put his community at a disadvantage to more affluent communities which contain many retired professionals, with both time and experience of how to operate within such professionalised support systems.

> “Its fine if you go to somewhere like Fintry, but this is a working class community. There isn’t lots of doctors, lawyers, you know to be able to make kind of rational decisions.”– (Housing Development Manager - P18)

P14, referencing the case of developments at Monklands Hospital, where consultation responses were received from the local community demonstrating concern about the risk of accessing former mining sites. Through their own research they explained that people who had memories and experience of an industrial past retained that strong connection, which sometimes resulted in positive associations with redevelopment, but often negative; it was less clear how newer residents and younger generations felt. Particularly as populations in Scotland’s former coal fields have grown and migration between areas has occurred.

> “I think there's an awareness of this past, and sometimes it's positive and celebrated and it's memorialized. But when it comes to the remnants of industrial working, particularly in places where the benefits of those processes, the economic benefits, are long gone, I think there's a there's a suspicion” – (Global Inequalities Historian - P14)

The level of trust felt by communities towards developers and local authorities is an issue regularly discussed in not only the context of renewable energy, but of all planning and developments facing communities. This was confirmed by multiple participants living and

working in former mining communities, with one describing the strong sense of apathy felt in the decades since deindustrialisation, where the state was ultimately deemed to have failed them. P20 was new to working for a local authority in a former mining area and felt that regaining a sense of trust remained one of the critical tasks for the council.

> “Yeah, I mean prior to starting this job, I hadn't worked directly for a local authority, so it was kind of a new experience for me. But in terms of the public engagement for various points you can get that, you can feel the distrust and I think overcoming these barriers is one of the major you know, kind of challenges in the transition to net zero for local authorities.” – (Council Energy Lead - P20)

Most participants who work and live in former mining communities expressed a great deal of sympathy and understanding for the levels of distrust and apathy observed in former mining communities. P24 who has worked in planning for a local authority for decades spoke with frustration about the evolving agenda on sustainability in planning circles, where social elements are often spoken about but remain structurally unaddressed.

> “Don't forget the social side of it. Don't forget the socio-economic side of sustainability and this narrative that I'm always acutely aware of having worked with the mining communities for so long. That they constantly get the crap end of the stick and it's like, right from the beginning they get the dispossession of the land for the industrial development. They then have the benefit. Well, that's on the metric of having jobs out of it. When that is immediately, almost sometimes overnight, taken away. There's nothing put back into the place it held and now we've got the desolation of the land just lying abandoned in some places.” – (Council Minerals Planning Lead - P24)

P24 spoke about the collective history felt within mining communities, referencing the historical periods of serfdom all the way through to deindustrialisation. Despite this history of challenge, and perhaps because of it, former mining communities were described as being amongst the strongest communities remaining in the local area. They felt that this strength, and shared historical experience provided understandable reasons for the suspicion and wariness that can be found in former mining communities towards outsiders and that it was important to recognise this history when collaborating with such communities, to overcome the sense of being treated as objects, detached from powerful historical forces.

> “You can understand why they, you know, put the barrier up sometimes and how they treat outsiders. You've probably seen it as well going in to speak to these

communities that they treat you with, you know, the barriers are up and you've got to show that you're, you know, not just some idiot a suit and tie on that comes in doing some academic study, and then this is real life experiences for them" – (Council Minerals Planning Lead - P24)

8.2.3 Reimagining former mining communities through MWT development

Across the phase 1 data collection, participants regularly mentioned the need for a reimagining of former coal areas, and that minewater heat technologies provided an apt opportunity for this. Different actors clearly project different futures and imaginaries onto minewater opportunities, for developers it was often part of environmental and techno optimist framing, for those at the community development or policy level it was observed as a part of a bottom-up civic nation building programme towards socially just and sustainable futures, as summarised in an interview with P10:

> "There's something really important about the kind of cultural imaginaries of this post-industrial wasteland and the imaginaries of what all the old coal mining areas actually are. Cause they have such a negative reputation. I mean I mainly know about in England, but even the places we were just talking about Fife elsewhere, it'd be quite cool to think how can that be re-imagined as actually something very kind of forward looking and exciting with new technologies, especially if the communities are a part of it and they can see themselves in it." – (Land Policy Manager - P10)

P24 who is a planning professional with a local authority, emphasised the need to restore land formerly used for mining, and raised how often the site of brownfield sites is raised by communities, who see it as a huge scar. They believed that rehabilitation of land needed to be geared towards redevelopment that served local communities, and that the impacts of this would be felt deeply in former mining communities. Along with others, they spoke to not only the difficulties experienced within communities themselves since deindustrialisation and the lack of opportunities, but also the increased reliance and difficulty in connections to other places as local services such as transport have been reduced.

> "You're looking at potentially an asset back for the community, not just for the environmental benefits of putting the land back which speak for itself, but in terms of using that as a as a platform for development, you can then seek to bring in employment to that site, which goes a long way to replace, you know, some of the stuff that was never been replaced. People are getting two buses from Oakley and

> Comrey to go for a minimum wage job in Dunfermline. You know two buses to get to Dunfermline from there." – (Council Minerals Planning Lead - P24)

Amongst the challenges deeply felt and experienced in former mining areas, brownfield sites and a dwindling local economy are amongst the most prominent, as industries and business have left in the wake of the end of industrial employment. P23, who works for a council stressed that from their experiences using brownfield sites for both solar PV generation and the minewater system they have installed, local people have responded positively to seeing development in their area, and that the council is usually met with optimistic responses such as, "does this mean new businesses and houses are to follow?". In the case of Gateshead this has indeed been the course of action, where new homes being built on former brownfield sites will be mandated to connect into their heat network. In these discussions between the council and community, P23 explained how aspects such as air quality, building dampness, system maintenance, consideration of gas leaks, and a general interest in health outcomes were spoken about equally as the price of bills. They also spoke about the assumptions they had made about former mining communities, and were surprised by their knowledge of topics such as net zero, and environmental health. Describing one interaction with a community member, P23 described how they were open to the positive role heat networks could play in the local area:

> "(They said) … 'I don't need to know how electricity is made, but I know that I need electricity'. And that's kind of what we've taken from the process and we're using now to inform the residents that we're coming through with a heat network. One thing the residents liked about our energy centre and the mine water actually was that it's using disused brownfield and before it was just rubble weeds. But now there's actually something on it and. I've shown them a couple different energy centres around the country. They're all pretty good looking buildings to be honest with you. So that aspect of regeneration makes them think, OK, some progress is coming." – (Council Net Zero Innovation Officer - P23)

Some participants also expressed a scepticism about the development of minewater resources, by tapping into the past in such a literal way, whether it may cause different kinds of harm to former mining communities. There is clearly a lived experience of harm in the way in which former mining communities were deindustrialised and altered in such significant ways. However, the varying technical challenges for minewater can make it a risky proposition for communities wary of industrial and development activity, as has been touched on already in this chapter. The history of mining is filled with disasters, environmental damage and loss of life, and different participants expressed a concern that

as a result, to this day former mining communities are more wary of development and potential harms. Since minewater may involve the movement of minewater containing pollutants, it has to be dealt with extremely carefully to avoid former mining communities facing a further experience of industrial harm.

> “It's interesting about when and where to bring it up and what because coal mining heritage is so sensitive still. But it always struck me that the minewater heat under the ground was a new source of energy and that they could again be a community about energy. But again, it's that nervousness that there's such pain tied to the way the coal mines were lost. is that a good strategy to take? I don't know the answer to that.” – (Council Minerals Planning Lead - P24)

Despite acknowledging nervousness P24 and P25 as local authority planners had general optimism that minewater heat could indeed be one of the best opportunities for former mining communities, “a huge positive could come out of this”. They described the former mining communities as facing huge socioeconomic impacts since the closure of the mines and their impoverishment being politically motivated.

> “Yeah, it's like it's a moral payback almost. It's like getting something tangible back for those years, you know, the difficulties and the destitution of the land”. – (Council Minerals Planning Lead - P24)

P9, who works in community land issues, had supported a former mining community in Lanarkshire with their purchase of land formerly containing a mining colliery. In the time since its closure, a play park and green space had been established in its place. However, the landowners were aiming to develop the land into new housing and the former mining community organised to purchase the land, despite the challenges associated with maintaining such land that has no financial revenue in and of itself.

> “You know, how is a community group going to maintain the play park and the unadopted roads and the bits of verge? So, on the one hand it's a horrible community purchase, and we've said that to them, and I'm sure many people have said that to them like, how are you going to pay for this? On the other hand, they say that's our pithhead. We want to buy it. We should own it. It shouldn't be, you know. You're like fair enough. You know what no one is going to argue with you, but what they need is an economic system that is going to support them in creating a community led approach to this which isn't in place now. So they are battling on and trying to deliver

this. Hopefully they'll develop a business plan that will allow them to purchase things. – (Community Urban Hub Manager - P9)

They recognised the need to develop a proposition around minewater that would resonate with the communities within the areas of potential:

> “But yeah certainly before we would kind of get to that point we'd need to have the community consultation but I think you know the general kind of feedback you know around the local authority for it is something that people would be keen to have. You know its reusing an industrial asset that's obviously been a major source of employment previously and you know, but when the coal mining industry declined it, it really negatively impacted on our communities. So if there was a way of reusing that and there'd be economic growth generated from it, that I think it's going to be received positively you know, but it's getting to that point to deliver it.” – (Council Energy Lead - P20)

8.2.4 Infrastructures and investment imaginaries for MWT & heat networks

The nature of heat networks, and minewater technologies present unique challenges as a relatively new entrant to the UK and Scottish energy economy. Compared to electricity, gas and oil, the most common energy sources, heat itself cannot be transported or utilised with existing infrastructure. P4, who works for an energy consultancy, was keen to stress the unique challenges associated with this new energy proposition. As much as it is a heat transition which is unfolding, it is also more akin to a heat transformation, such is the level of infrastructure and investment needed. These elements shape the political economy debate which dictates investments and is discussed further on in this chapter.

> “Heat is an entirely different thing in that … heat cannot be transported over long distances viably. You're competing against a counterfactual of fossil fuels where the cost difference between electricity and gas or oil, is somewhere between three and five times. And that means that economically, it's incredibly difficult for you to achieve cost parity in operation terms. And that doesn't even take account of the significant capital costs in installing infrastructure.” – (Energy Consultant Co-Director - P4)

Such is the level of change required, P8 was convinced that at the policy and wider industry level, there was a reluctance to seriously engage with heat networks beyond rhetorical signalling. They felt that industries such as hydrogen were prioritised overheat networks, believing that the “oil & gas lobby” see heat networks as a threat to market dominance, and

alternatives such as hydrogen as a way to maintain it. They felt that it was more likely for the government to pay for a new hydrogen network, than a low carbon heat network.

As MWT requires heat network infrastructure in order to deliver the heat, there is significant overlap in some of the challenges faced in deployment. In effect, any challenge related to heat networks is also a prerequisite for MWT. P19 explained some of the difficulties, including the variety and number of stakeholders that need to get on board with heat networks to make them successful at scale. For every section of piping installed, the more stakeholders around it that sign up, the more connection costs are reduced, though success in ensuring stakeholder connection is challenging and unprecedented in the UK. *

Whilst council owned non-domestic buildings which represent one stakeholder are ideal, often these buildings are spread out. Strategies that anchor around large public buildings are being explored in the Gateshead project as explained in previous sections. Perhaps surprisingly, it is the cost of the pipe installation that may be the biggest economic barrier to MWT, as P19 stated, these costs in fact “dwarf” the cost of drilling boreholes for MWT systems. Perhaps giving more credence to the idea that MWT systems are most likely to come into development after a heat network is already established. Further, P19 explained how from the developer perspective, the priority and value is in large single use customers for MWT, where public roads aren’t required to be excavated, and all heat is dispersed within one site.

> “That's where you start to really focus in on your anchor loads. That are like big significant single users of heat that have a demand. If you can get it all year round because they're the ones that are going to be, you know, paying for this heat the whole time. If you have people, domestic properties, for example that only switch they're heating on from October right until March six months a year that they don't require any heating. So your payback's going to be twice as long compared to if you have someone who runs it all summer. So it's like finding Users that have the full time equivalent, close to the full year and use it that full year round, but then also ones that are densely compacted enough to make the trade-off of spending a lot on pipework valuable.” – (Geothermal Energy Specialist - P19)

Heat network systems are constantly evolving, with the latest 5th generation utilising lower temperature heating, which is boosted at the demand source. This is an advantage from a piping infrastructure perspective, as the costs of these pipes is much lower, requiring less insulation to maintain the ambient loop which delivers to heat pumps to be used as needed. However, heat pumps at individual demand sources will require more maintenance, and other marginal heat opportunities may be more difficult to integrate without a thermal storage

solution. This demonstrates the need for strategic planning around what kind of expertise is developed to support the system design and operation. P25, working for a local authority claimed that from their experiences interacting with industry, developers are slightly more optimistic about the abilities for different systems to deliver all sorts of benefits, without accounting for such potential disadvantages.

P22 discussed the fundamental challenge to the derisking of heat network proposals, that despite opportunities where big anchor loads are present and thus creating a strong case for pipe connections between anchor loads, the connection of existing buildings is still deemed unattractive. This is despite the critical role heat networks will play in the decarbonisation of existing buildings. Interestingly, the sentiments expressed here from a developer perspective, very much align with earlier discussion on political economy, strategy and vision, and the need to start actually doing things, rather than waiting for more reports or information.

> “The role that they are expected to play is to decarbonise existing buildings, to replace the gas network… Now it's very tricky, not nearly enough projects have come forward to demonstrate how it works and how it doesn't. That's kind of what the problem with district heating, because you can't truly know what it's like for a building to be connected to a heat network until there's a heat network there. The capital and complexity of delivering unique networks to some places goes back to that circularity. It's not going to be there until you figure out other bits to draw in.” – (Heat Developer - P22)

As an unestablished or new technology, in the current political economy in which councils operate, minewater was deemed a more difficult proposition to actually get through funding systems in the public sector, beyond feasibility project level. P20 who works for a local authority was clear that the timeline for heat network technologies would flow from theoretical feasibility and modelling to a small scale pilot before any scaling up to alter local heat systems. This would likely involve council buildings in the first instance, as was mirrored by participants in other local authorities. They felt that of the different heat transition technologies being investigated by the council, minewater felt by far and away at the earliest stage, compared to other options like heat pumps and retrofit which are closer to the demonstration phase, and that minewater would come “further down the line”. This was reasoned primarily against the higher uncertainties associated with the technology, despite seeing its potential as a winning solution from an economic growth perspective and a community perspective.

Another risk that was discussed in further detail related to the resource itself and the certainty of supply. In most cases, some form of back up supply is required, whether it is gas boilers or air source heat pumps; this is so that the contract of heat supply is upheld. Ensuring the resource itself is effectively 'useable' is a costly process which further adds to the risk and apprehension, where upfront costs for the intensive period of drilling, completion of boreholes, pump testing, and installation of heat exchangers and pumps are necessary before the selling of any heat is achieved. Maintenance of the system is also a challenge that has affected pilot projects in the past such as the system in Lumphinnans and can significantly impact the economic model. This risk is the same for whoever takes on the project, and therefore it is fair to imply that ultimately it is whoever is more willing to take on risk that will drive forward MWT development.

> "But keeping that system challenge free or issue free is obviously going to speed up the rate at which you get your money back on that project. If you run into a lot of challenges operationally, then the revenue you're making is going to be spent on keeping the system running, and they're not going to return a profit. So the risk is always, I think, going to be that early onset stage of proving the resource developing the boreholes' to a big enough size that you can pump test them, installing that hardware. Before you actually see any benefit."- (Geothermal Energy Specialist - P19)

P19 was confident from industry consensus that drilling costs would come down, and that there may be instances in some of the active projects of "over engineering" contributing to higher capital expenditure. As there are only a couple of schemes globally from which any kind of total cost estimations can be made, currently estimated at around £1.5 million per MW, question marks remain over the total cost. It was suggested that going for the lowest hanging fruit options would be sensible, in order to build the case studies and establish the industry further, this could be done through enhanced screening that focussed on the mines suitability, the minewater potential and the heat demand. This could end up being at the Coal Authorities treatment facilities, where boreholes are already pumping minewater to the surface, which would then only need a heat exchanger before being sent out as heat to users. In these cases the capital expenditure is reduced as the necessary MWT infrastructure already exists with the Coal Authority, and they will be able to provide a minewater access guarantee of up to 40 years of around £3 per thousand metres cubed.

> "Yeah, I think any funding which helps get over that CapEx hurdle, it's going to be so valuable… But yeah, I think overall in order to get more systems up and running, is either, find more organisations to become developer-operators and take the risk on

themselves or some sort of cushioning from funders that will, you know, give them a bit of slack if things don't go so well." – (Geothermal Energy Specialist - P19)

8.2.5 MWT & heat network technical imaginaries

P19 works for a geothermal heat developer and primarily discussed the socio-technical challenges related to the development of MWT during the interview. They are amongst the leading experts in Scotland for MWT, having created a map of minewater resources, classified by accessibility and energy potential, available on the Scottish Government GIS system. As they, and other participants discussed, and was overviewed in the context chapter, there are various technical conditionalities attached to the successful deployment of MWT systems, and as a resource vehicle for piped delivery of heat, it may not always be the best option. This can relate to factors such as the sustainability of the heat resource once accessed, including the regional flow of minewater, as well as the ease of boreholes use, proximity to anchor heat demand sources, and efficiency of alternative sources. Recent research has aimed to explore the integration of MWT with other energy technologies, where the minewater is used as a thermal buffer, storing excess heat either from waste heat processes, such cooling of data centres, or from the conversion of renewable electricity to heat at times of low demand. As P19 explained, this may enable possibilities for alternative business models, where the heat is essentially provided as a service to users, and the cooled return pipe provides cooling as a service.

> "Using wind power to heat up minewater probably held in a shaft to then use that heated minewater in a district heat network, which is more efficient than just using minewater…. (The idea) to heat up part of the shaft to then understand how that heat is retained within the shaft, and you know what that means going forward, how much heat shafts could potentially hold and then benefit the low carbon development of such sites." – (Geothermal Energy Specialist - P19)

The range of expert opinion on the viability of MWT systems varies, and was discussed with P19. Some state that MWT is only viable through integration with the evolving storage and advanced 5th generation district energy systems, in part due to an understanding that the rate at which you take heat out of mines would be greater than what is provided by the heat flux of the earth. P19 was confident that there is still an appetite for 'traditional' MWT systems and cited the lack of case studies and proven successes as being the main barrier to overcoming risk apprehension from public and private investors.

> "That's why the coal authority are so keen to push the Gateshead scheme is because actually it's a great scheme. It's got great flow rates. It's six megawatts, which is

> massive, and we see the COP in our system at Lanchester Wines are well over 4 sometimes about 5. So the efficiency which we do bang on about is realised. If the system is kind of set up to optimise the heat pump that's installed there, that is significantly better and therefore cheaper running costs than if you're using air source which seems to be currently the best counterfactual." – (Geothermal Energy Specialist - P19)

Whether through borehole drilling, accessing surface outflows or utilising the existing minewater treatment sites, there is fundamental uncertainty over the minewater resource that is being researched by technical actors. As mentioned, this primarily concerns the recoverability of heat and how it affects connected resources. P25, who works for a local authority in their climate and energy team, had gone through various levels of planning and feasibility exploring the minewater options. They were candid about the lack of certainty over MWT use at this stage of technical understanding, leading them to believe that in a comparison with counterfactuals, minewater makes most sense in cases where its already quantified and other heat solutions are lacking.

> "You still may be only looking at 5 degrees of actually usable heat. In these processes, now that is good enough to make a heat pump work better. So that is a positive thing but what it does also mean is that if you've got a big source of water like the coast of Fife. It may be cheaper and more stable to take the heat from the river or the sea than it is from the mine. We're still trying to understand that. So the big minewater opportunities where everything comes together, are where it's slightly further away from the river where it's already coming out the ground anyway."- (Council Climate and Energy Lead - P25)

Fife is one of the only places in Scotland which trialled a minewater system in the past, delivered by the council for social housing units. The system was installed in 2000 and decommissioned in the time since. It was described as broadly successful by interview participants from Fife Council and failure was in most part due to the heat pump system as opposed to the minewater technical dimensions, though there were some corrosive problems which have since been researched and better understood. They described the system failing because at the time "the technology wasn't really there".

> We couldn't get someone in to fix it. It was basically Christmas Eve and imagine having all these houses cold on Christmas Day. You can imagine politically what that was like, you know? So they basically couldn't find anyone to deal with it. They put in gas boilers. I mean, I would have probably done the same thing, you know. So that confidence in whether it could work, the other system there to make it work, I think

it's really important. We have to put everything in place to make sure it does what it says on the tin. So that people get the houses warm or whatever." – (Council Climate and Energy Lead - P25)

8.2.6 Regulatory regimes imaginaries for MWT

Further challenges to MWT development exist within the permit and licensing arrangements, where permission from the Coal Authority to drill into mines for minewater heat investigations take up to six or seven times longer than for drilling under other guises. P19 suggested that while Coal Authority legislation is becoming clearer, it is made difficult by the fact they do not have the rights to manage the water or heat resource, creating further complications. The Environmental Protection Agencies are charged with water resources, with P19 explaining that if a MWT taps into other users water source, and overall removes water of more than 10 cubic metres a day, the agency will not grant access. Therefore, any water abstracted must be returned safely.

> "(We)… do that sort of modelling of what we expect to find when they put heat in there, where the mines are, where the shallow mines are, where there might be a risk, what's flooded, what's not flooded… but the Coal Authority need to see it captured and very clearly laid there in front of them. So that just adds an extra layer of work, it's often the case that we don't know what the Coal Authority wants to see. So, we find it hard to provide them the right information even though we've done, we think, our due diligence on you know, finding the best site for these things." – (Geothermal Energy Specialist - P19)

Several participants emphasised some of the challenges raised by P19 in relation to the Coal Authority data and permits, meaning that even when there is a project development pathway, aligning that with resource access is difficult. This is in part because of the novelty of the minewater systems and the new role required by bodies such as the Coal Authority. At this predevelopment stage of the industry, the regulatory bodies appear to be taking a very cautious approach, which was understandable from the perspective of some developers, yet frustration was also expressed, as the challenges out with this particular element are already significant.

> "One of the challenges of this, is that the resource has not been put into realise this opportunity. We're still struggling a little bit of how to sort of do it, and even the stuff that we did with the Coal Authority on the maps, no one had done that before and because they were saying, well, if you pay us the money, we'll create you some, you know we'll create maps, but then you can't keep the data and we're going to keep

that and you have to keep paying us for data each year you use it. And I would be like let's just get on and define some solution with this idea."– (Council Climate and Energy Lead - P25)

The assurance and sustainability of minewater resources was also considered a challenge from a technical and regulatory perspective. The measurable limitations of minewater extraction at different sites is critical, the testing of which is a challenging process. The regulatory and planning framework guarding this, managed by the coal authority and the environmental protection agency is also unsuitable. As discussed by participants from the Coal Authority, local authorities and developers during the interviews, many of the former mines are connected across regions, meaning that the level of leakage is currently uncertain. That is to say if the heat is taken from one mine, will it drain the heat resource from another? As such, the Coal Authority has created zonal mapping of former coal mining areas, and for now is only allowing one borehole to be drilled per zone, a zone could be as large as an entire local authority or transgress authority boundaries. However, this has not been the case in northern England, where multiple boreholes have been allowed around the Gateshead area for example, though the characteristics of the mines are different and may allow for multiple extraction sites. Whatever may be the real case regarding resource availability in light of mine connections, this regulation for now puts a very real limit on the pace of minewater development in Scotland.

8.2.7 Conclusions: Imagining a future MWT Industry as part of an alternative energy economy in Scotland

In this section, initial imaginaries relating to a MWT and a future alternative energy economy in Scotland were explored. It showed that a future MWT industry in Scotland is contingent upon navigating structural political economy barriers, while meaningfully engaging with communities whose histories and futures are entangled with its development. Structural challenges in Scotland's energy economy were then explored in further detail, where the influence of global energy markets and institutions place governance issues in Scotland outside the realm of democratic control to varying degrees. As a result politicians are unable to contemplate the challenging of incumbent regimes, or the ability to transform the energy economy towards alternative configurations. A misunderstanding of the monetary system in relation to public debt, taxation and spending seriously limits any alternative energy economy fruition, particularly at local levels of government. There is a lack of acknowledgement and political leadership on the inherent friction between the interests of finance, community wealth building and a just transition and that contestation between each necessitates a give and take approach.

Contemporary challenges relevant to interactions between former mining communities and MWT was discussed and summarised here. First, structural unemployment and a range of social, health and economic challenges remain in the wake of deindustrialisation. A strong sense of community and association with coal mining remains in many cases, although younger generations and migrated populations make this picture less clear. Suspicion of new developments, outsiders and professional systems of management is prevalent in areas where benefits from the industrial past are long gone, and decades of state and market failure has been experienced. Structural limitations in professionalised sustainability and planning circles under addresses socioeconomic challenges in these areas, and the language and bureaucracy of process leaves communities apathetic and distrustful. Different sectoral professionals put forward a range of energy imaginaries tied to the development of MWT. Developers, technical and economically minded professionals profess environmental and techno optimistic visions of MWT systems. Alternatives such as bottom-up community centred futures place energy and innovation back at the heart of former mining areas, as a ‘moral payback’. Civic and nation building visions were also prevalent in which former communities contribute to socially just and sustainable futures. The redevelopment of brownfield and derelict land provided critical learning to bring communities along, as well as investment in local infrastructures that serve community needs. Finally, former mining communities have already demonstrated their ability and desire to take ownership and get involved in the management of their local areas and mining heritage, and systemic reform could enable acceleration of this.

In this section, imaginaries which explored the socio-technical dimensions of MWT were also presented and are briefly summarised here. Of most prominence were challenges related to the infrastructure required for MWT, and the investment necessary. Large anchor loads that use heat year round are critical, as well as concentration of connections in order to make any MWT heat network viable. Difficulties managing the range of stakeholders required for these networks is observed. Piping infrastructure to transport the heat is more expensive than any borehole drilling for MWT exploration. Strategic planning is therefore necessary in order to balance the priorities and configurations of infrastructure investment across areas. MWT may be most suitable after the successful installation of a heat network, or in cases where it is easily accessible and other heat sources are lacking. MWT should also integrate with other opportunities relating to cooling, storing excess power or waste heat, which may involve providing heat as a service rather than a commodified utility. Lack of technical understanding on sustainability of MWT resources, leakage between seams and difficulty in measuring this presents a real challenge which is producing regulatory caution. The incumbent regulatory regimes are not designed for MWT and must be reformed and

streamlined, improved sharing of data and mapping would ease the burden on public and private developers. Finally, the current energy market players are pushing for investment in hydrogen infrastructure as opposed to heat networks, in order to maintain market dominance.

Fundamentally, imaginaries of MWT represent far more than a technical solution to decarbonisation - questions of ownership, fairness and democratic control are all contested by its potential development. Shifts in public investment, regulatory reform and economic decision making towards social and environmental wellbeing are necessary for more transformative visions of a future industry and energy economy. Former mining communities are not passive recipients of technological change but receptors and producers of various energy imaginaries, and could, through a MWT industry play a significant role in reimagining Scotland's energy economy. The next section, explores the strategies that were imagined by participants, formulating how such imaginaries would be approached in real terms.

8.3 Strategising a MWT industry and alternative energy economy in Scotland

This section explores how different actors envision and strategise the development of a MWT industry within the broader context of Scotland's transition to an alternative energy economy. Using the analytical framework and data from a range of interviewees, public, private and third sector in background, it examines how the participants articulate strategic opportunities and barriers to the development of MWT. The interplay between structural constraints, risk-averse governance approaches and contested narratives of public good, ownership and fairness are in focus. The role of the state, local authorities, social and economic regulations and public funding are all discussed in turn, providing insight into strategic visions of how to mobilise MWT imaginaries, and how they are embedded in wider debates on just transition, political economy and community wealth building. A conclusion section summarises the key findings at the end.

8.3.1 The state must play a stronger role

In the previous section it was shown that a wide array of participants articulated an understanding of the effect of political ideologies and structures, which function both materially and in the collective imaginary, creating difficulty for new, innovative and alternative types of development. Many of the participants continued this phase of the discussion by focussing on the national level, and in particular the role of the state. Some other participants who did not directly address the political economy theme, spoke

specifically to the practical challenges found working with and at the state level, including local authorities.

Most participants discussed the role of the state, at all levels, with a sense of dissatisfaction relating to current practice and a desire for urgent action, and I will go on to dissect this. P4, however, who directs an energy focused consultancy and social enterprise, was more accepting of the current approach and thus current political economy. Discussing the change observed from the national energy industries of the past:

> "Now it's a different delivery model, but there is a heat network delivery unit. There's a green heat fund. You know, there are these ways in which government is intervening to deliver capital infrastructure but [they are] doing it on a project-by-project level. And probably rightly so, focusing on the locations of highest impact and prioritising those first, because it's not like there is a magic money tree and they can just sort of put it out everywhere and you know, kind of immediately. But I think that there's perhaps an opportunity for the bolder you know, for local government to step in or for, you know, kind of Scottish Government to step in and take some strategic decisions, some investment decisions that are about longer-term infrastructure and so on." – (Energy Consultant Co-Director - P4)

As someone involved directly in project development, with particular experience on heat networks and minewater assessments, P4 is as aware as any of the strained realities of working with government and developers. Their language suggests acknowledgment of a shift in wider economic conditions away from direct state involvement to support and capacity building, and even with this measured perspective they continue to highlight the need for greater local authority involvement. Later, in a discussion around the creation and success of a Scottish heat network industry, which would be required for MWT, they were even more affirmative to a stronger state role referencing the political discussion around the creation of a national energy company and stating "…that's the sort of thing that might be able to start delivering the kind of infrastructure that would be necessary for heat networks, And then if the heat network is there, there's no reason why, if there's a mine in that vicinity that that couldn't be the supply source for that heat network and so on." – (Energy Consultant Co-Director - P4). P2 also spoke positively to the idea of a national organisation delivering and financing strategic infrastructure around heat: "…there are proposals to get like Scottish National investment bank more geared towards these kinds of things [heat networks], and other countries have found solutions for that. So, there are ways to do it." - (Alternative Economy Network Policy Lead - P2).

P11 felt that the nature of private capital accumulation, and the long-term returns associated with heat projects meant that there was an obvious role for public organisations to take the lead. They also felt that a shift to long term policy signalling would be essential to provide assurances for direction of travel over periods of 30 years as opposed to 5-year cycles, and that a public energy company would be one potential tool for enabling this.

> “I don't know whether the right way round to put this is a developer or supplier of first resort or last resort, but where you have a district heating mine workings type project where you do need a lot of upfront capital investment. The returns on projects like that over time are good, but you obviously put in a huge amount of capital up front and it takes quite a few years for that to start generating any incoming return and if you're a big private company looking for a quick big payoff, it's not going to be very attractive. But if you have a company that is effectively public, you can make those long-term investment decisions.” – (Fuel Poverty Researcher - P11)

The use of the term “bolder” in relation to the role of the state was echoed across the data collection, perhaps most firmly in a joint interview with Participants 5, 6 and 7. All work within the political system, with 5 being a sitting MP, 6 their Parliamentary researcher, and 7 a former MSP and minister in the Scottish Government. A sense of inaction, connected very much to the themes discussed in the previous section on political economy, was present throughout this interview. The former MSP, who has worked directly inside government, had the following to say:

> “The problem is getting the government to do something to take it forward. And you know, we find there's a lot of research but with all due respect, a lot of people involved in the University sector, some very good reports. A lot done by Scottish Enterprise and all the rest of it. But so far none of that has led directly to a project.” – (Parliamentary Researcher - P7)

This joint interview was scheduled after reading a policy paper advocating MWT in Scotland, published by the three participants. They claimed that the primary motive of the paper was in essence to spur on action at the level of the Scottish Government and to encourage alternative futures and possibilities in our political systems. The previous quote exemplifies a theoretical understanding relating to the stasis found within contemporary politics, where there is considerable information out there for technocratic management, and knowledge of issues and what must be done is widespread, and yet no action is taken and no real alternative feels possible, resulting in further research and information gathering. Theorists such as David Graeber and Mark Fisher have commented on this phenomenon in their writing, including the popular ‘Capitalist Realism: Is there no alternative?’.

In this policy paper, the authors had set out a vision for greater involvement of the state more broadly within the energy sector, using MWT as a case. I was able to interrogate this further in the interview. P5, a sitting MP, stated:

> “So, what we are saying is that you know, we should be trying to push the Government in their position in Scotland, where they can actually use their devolved powers as they exist at the moment to focus on heat. And, you know, bring forward schemes or support schemes, or you know, as [(Parliamentary Researcher - P7)] said, maybe this should be to raise the profile of you know, making something available that actually makes it much more attractive for either communities or companies, or whatever the entity is, to actually go ahead and introduce these schemes. But for me, I'd love to see it, so it was local communities that were actually getting the benefit of not just cheaper heat but also sharing in the proceeds that come from that, you know. Like 50 years of oil, and not much of that money is actually going back into the communities again that have provided that resource. So, you know, we need to change the paradigm here. And you know, make sure that people in Scotland are actually benefiting from our own resources, that we hold.”- (MP - P5)

The position articulated here, could be understood as representing a form of civic resource nationalism in which the devolutionary government is the central actor in the delivery of an energy system, tied to that ideology. Invoking a critical, historical energy story around the oil resources found off Scotland’s shores within the context of a discussion of MWT, brings associations with Scotland’s nationalist movement, for which oil resources have played a significant role in its economic manifesto development. By tying together communities of oil and coal, and current socioeconomic challenges facing these communities, it is the levels of fairness and wellbeing in the communities themselves that are drawn into focus. Whilst localism, and a turn towards community and participation is found in energy literature, and policy in the rest of the UK and globally, here the involvement of the devolutionary Scottish Government as it exists today is seen as a key enabler and vehicle in order to ‘change the paradigm’. There is an allusion here to the wider set of dominant economic principles which guide energy resource use, which as P5 sees it, extracts value elsewhere for private gain. Here, the devolved state is identified as being sufficiently equipped to change this paradigm and the political economy in Scotland around economic development.

The granularity of this vision was also discussed in further detail. The participants proposed various ways in which the state can be more involved ranging from the creation of a public energy company, which would invest in a public and community sector - not only in MWT,

but all renewable developments such as wind, to local authority owned energy companies, and generally improved support relating to risk and upfront costs. They cited their research in other countries that have successful MWT schemes and heat networks, in which the state had played a role in managing risk and the big upfront costs associated with MWT, describing this as “a big piece of the jigsaw that we’re missing in the UK” – (Former MSP - P6). (Alternative Economy Network Policy Lead - P2), whose comments on the restrictions politicians and civil servants face in altering a globalised energy market were analysed in the context of political economy challenges, also had more sobering reflections on the national situation in Scotland:

> “I think then there's a realistic thing that the Scottish Government hasn't got powers in a lot of areas to actually do the transformative stuff. Like they don't have power over finances, they can't borrow, they don't have power over work legislation like minimum wage or anything. They don't have power over wealth taxes. So actually, there's some real limits on what they can really do.” – (Alternative Economy Network Policy Lead - P2)

The limiting powers of devolution granted to the Scottish Government, without financial sovereignty, means that the possibility of more direct involvement in the creation of a MWT sector is difficult. Applying a sense of realism to this picture, despite the expert evidence in this research data promoting the idea of state involvement as a positive approach, it is only through coordination with and under the wider UK state that this larger role will be realised in Scotland.

P18, who works for an energy and land developer, discussed their frustrations with the public support they receive. Their plans involve the investigation of minewater resources, in combination with other renewables to decarbonise their estates, which could then lead to a village wide heat network. They also spoke to the lack of willingness in the public sector to commit and act upon ideas that are talked about positively.

> “They don't really deliver very much for us, you know. There's nothing really. Lots of very nice words, but they don't actually produce anything and talking to the Council, again they are blown away with this, really very excited talking to their energy team. They are very excited, but are they contributing anything? No, nothing… So, there's a distinct lack of action I'm finding with any public sector body. There's really no incentive. They talk a lot and say there's lots of funding available. But no one grabs this and says, let's just run this and see where we can get to. And we're quite clear that we're not going to either heat or feed the whole of the country. But if we can prove we can heat or feed a local community, that means that this can run, this

> technology can run. But until the country actually gets some things that are working it's not going to go anywhere. I think that's the big problem." – (Housing Development Manager - P18)

Further, P18 was convinced that it was strategic oversight and planning where public authorities could have the most impact, by bringing together different stakeholders. They used their local situation as an example of this, in which a large number of wind farms are online but have no integration to wider plans, such as the need for heat networks and the broader decarbonisation of heat locally. Upon exploring the developer appetite for different business delivery models, P18 was enthused about scenarios where the state, either at the national level or through local authorities, partners and invests in the delivery of heat schemes:

> "100%, I don't think we will be in a position to run this ourselves because of all the barriers with the different, you know, the different authorities and housing departments, and even just the funding. We would welcome partners in this, and whether it's the local authority or whether we start approaching Dutch companies or Belgian companies that are more experienced in this, asking them to get involved." – (Housing Development Manager - P18)

As echoed by others, P18 felt that a lack of political will from the public sector meant that for action to happen, private developers would have to drive it forward. As private owners of land situated above mine energy potential, they also stated that while they believed any district heating system had to have an element of public sector ownership and management, they had no preference on their final role, as long as they were able to "make something happen", providing environmental and social good, whilst making meagre returns. In the following section, the role of local authorities under a more active state in developing an energy economy for MWT is examined.

8.3.2 The role of local authorities

The role of devolution and local authorities in Scotland's energy governance was explored in the context chapter and political economy section of the literature review which demonstrated two important insights. First, that local authorities are an increasingly suitable and appropriate actor within the energy transition, owing to the unique place-based nature of socio-technical infrastructure such as heat networks, smart grids and decentralised renewables. This has been demonstrated as a viable approach in other countries, particularly in Europe. Secondly, local authorities are disempowered and lacking in their ability to engage and democratically manage energy developments from a place-based

perspective. This follows decades of hollowing out public sector capacity in a move away from municipalism towards centralised neoliberalism, in which councils are made to compete with each other for funding, increasingly from the private sector to form partnerships which often contain little ownership or long-term stake in developments.

Speaking to the role of local authorities in particular, P6 envisioned a more entrepreneurial role, with local authorities becoming active developers and suggesting there could be regional companies owned by the public and communities which may specialise in different energy technologies; the “Fife Energy Company” and so on. P7 was adamant that authorities should return to a more direct operating approach as in the past “not so long ago local authorities actually were able to issue mortgages for people buying the houses, the local authorities we're very entrepreneurial, and it used to be like that. But Thatcher, in particular took away a lot of that. Unfortunately.” We encounter another reference to the political turning point of the 1970s and the ushering in of the neoliberal paradigm.

Overall, these participants presented an optimistic case relating to the economic capabilities of the Scottish Government in having a more active role in MWT development:

> For example let's say, let's do 5 pilot schemes across the Scottish coalfields and put X amount, and to actually support that process, it wouldn't take much at Scottish government budget to try and kick start that process. And then let's measure the benefits in terms of what's doing for communities. What's it doing for individual people? How would it be helping these communities today actually either reinvent themselves and have a different economic model that actually takes them forward, or, you know, are we just gonna say more of the same? Or is what we're doing just now is good enough, and I don't think it is. – (MP - P5)

P2 agreed that in terms of control and delivery of a MWT project, as with all larger heat infrastructures, the local authority was the best candidate as observed in other nations utilising district heating systems. However, they were sceptical of the ability of local authorities as they exist in Scotland to be able to deliver, due to a lack of capacity, resources and skills. Further, whilst P2 felt that the elected nature of local authorities would provide a degree of democratic legitimacy to the MWT sector, they were also critical of the structure of local authorities in the UK:

> “How do you really democratise that process I guess is then the big question… Like I don't think local democracy in the UK is working particularly well at the moment because you have very, very big local authorities. There’s basically a complete layer of local government missing. Like if you go to Germany like the smallest

> authorities…I think for the smallest kind of local authority in most European countries, I think the number of people is something between like 20,000 on 50,000, whereas in the UK it's often more around 200 to 500 thousand people. And I think there is a lack of capacity for democratic engagement and control and development of things at local level and a lot of places like." – (Alternative Economy Network Policy Lead - P2)

This criticism interacts in many ways with the interlinked political economy challenges wrought by the neoliberal, financialised agenda which hollowed out the UK's municipal institutions, revealing that MWT development strategies, in which many have sought a greater role for local authorities, is curtailed by structural and political challenges in the wider landscape. P11, a researcher at both a university and a think tank, also highlighted the need for localised approaches to MWT development:

> "…but yeah, you would expect to have local authority involvement, you would expect community involvement. You would expect for things like mine workings multiple private companies involved because they're the ones with the skills and the capacity to develop it. And I'm not convinced we need national level involvement, I mean there are government proposals there to strategically plan, but that would require quite a big shift in the Scottish Government's thinking because we get told time and time again, we don't pick winners which is rubbish, because it means that you're effectively saying competition is going to favour those communities who are already, you know, better off than others. So that I think that's a fundamental problem if we addressed it a national level, it doesn't mean that we can't go ahead with more local proposals." – (Fuel Poverty Researcher - P11)

Though partnerships between a local authority and a commercial partner are more common, I discussed with P29 what a more active partnership with the state would entail. They believed in the importance of regional scales, but that a Scotland-wide approach would be beneficial and that the state could be facilitators of this, while acknowledging the challenges of finances and collaboration between public bodies.

> "Given that Scotland's not that big and you've got the central belt and whatever else, yeah it might make sense to have more of a kind of across Scotland approach to some of these things. I guess, you know there's I know that there's issues in terms of Scottish Government borrowing and stuff like that.... But a wider scale, where perhaps even a regional kind of level. You know councils working together, but actually you know it's quite difficult to get one council to work with itself, then you know, getting a whole load of councils to work together. But yeah definitely because these things are done at a regional scale. It probably would make sense with

> hindsight, and if we had plenty of time to look at setting up something, some structure that would work across the central belt, certainly." – (Council Energy Project Director – P29)

An important emphasis in this perspective highlights the dangers of the inequalities associated with centralised blanket approaches to state intervention. It speaks to the importance of recognising that state involvement can produce or reproduce different issues, for example where places with capacities and skills to engage with general policy support can benefit and thus increase regional inequalities. Whilst state involvement is encouraged here, facilitated through local authorities, the way it is planned and implemented is also of concern. On the other hand, inequalities relating to who can afford to pay are also likely to occur for the roll out of heat infrastructure if the government allows the market to dictate its roll out. This idea was echoed by P8 who works for a community energy organisation.

> "So the gas network was you know, a national infrastructure project paid for through the government. Are heat networks the same? They probably should be cause they're, you know, critical infrastructure, from my perspective. But who in government's going to make that kind of decision that we're going to go down the heat network route, and most places that I'm aware that are doing heat networks are doing them with commercial investors. So, the potential with that is that it focuses on the like, the people or the organizations that have like willingness or ability to pay for that heat will get connected and the rest won't. There's a danger in that." – (Community Energy Director - P8)

P11 had further concerns about the implementation at the local authority level under current political arrangements, highlighting the challenge around workforce skills and capacity within local authorities; "it's difficult for local authorities to retain those sorts of people cause you know they could be on substantially better money and better terms and conditions in the private sector" – (Fuel Poverty Researcher - P11). They deemed that whilst a local authority was potentially the right public body to deliver projects, a national body which could provide coordination, expertise and support was essential in ensuring councils are able to effectively develop MWT and heating projects.

> "You would have a team of experts who would be assigned to a number of local authority projects. So rather than just working for one local authority, you are part of a central hub where you've got knowledge exchange with the other people that you're working with and that means that local authorities don't bear that cost. You know that then should help retain those people, because if you're in the civil service in central government, you get fairly decent pay... So you retain that central hub and

> knowledge rather than having it dispersed over a number of local authorities, who, yes, they do talk to each other, but it's not quite the same thing. And hopefully better retention, better development knowledge and better, you know, keeping in that knowledge within government." – (Fuel Poverty Researcher - P11)

P20 works for a local council as a lead on energy project development, I questioned whether innovative or larger scale energy and infrastructure projects represent a level of risk and way of doing things that council bodies struggle with. Fundamentally, they articulated a sense of apprehension with the ability of the local governance system as it exists today to fulfil a more active role. Their case centred around the level of risk that councils are unable to take on in their current economic situation, affecting the appetite and ability to get involved and deliver energy projects, and emphasised that this was even more so the case for emerging technologies such as MWT.

> "I mean, I think to be honest, it's huge. I mean if you want to do something kind of large scale, around like minewater for example… it would probably require more funds than we have set aside… for the demonstrator projects. And so it's a major kind of challenge. And then the other you know, kind of conversations and investigations have been around the delivery models for that, so if we're providing, if we're generating energy through the minewater, how is that then actually distributed to residents? For example, would the Council be the energy provider? Would it be in partnership with a private company? Would it be through a community group that would be set up if you like? So that's a question, for example, that's probably not yet answered that we need to, if you like, before we can actually get to the point of delivering that energy to residents." – (Council Energy Lead - P20)

Discussing alternative delivery models further, P20 stated that while difficult within the boundaries of council operations, entering into new arrangements is possible. However, they saw the most likely path forward for new energy developments being smaller steps, through a risk averse approach, which would begin with the council supporting feasibility projects and small-scale demonstrators with their expertise, rather than putting capital directly into a project, with a private developer as partner. A significant factor in their reasoning was the processes within the council that must be navigated before getting approval to reach a point of delivery. This includes the council cabinet, various committees and wider regional boards amongst others depending on the specific project.

> "I think that's one of the kind of big barriers to developing and starting that kind of larger scale for example, geothermal project and why it's probably going to be a lot more kind of palatable, you know, for the Council's decision makers if we've taken

> kind of smaller steps and move then get evidence from, for example, the feasibility element and then the initial small scale demonstrator before then, but maybe trialling it to a council building for example, so I think it's taking those smaller steps. Collecting the key kind of learnings in data from each point to then basically support our argument to develop and deliver a kind of broader project, you know." – (Council Energy Lead - P20)

Any time the council considers the use of capital funding, the level of scrutiny is huge, in part because of the challenging financial situation councils find themselves in. P20 stated that despite it being a key question, exploring the type of delivery model for any energy project the council is involved in is at a very early stage and only those at the top of the council hierarchical structures would be able to comment further. P12, who works for the Land Commission, also stated that it was the delivery and policy approaches at the local level which are of most importance and the biggest hurdle in change occurring.

> "I think there's probably something about capacity, so quite a lot of what we've recommended in terms of housing development or land re-use it relies on the public sector playing more of a role and being more confident and muscular. But I'm conscious we'll be saying that at a time when, you know, I haven't worked in the public sector for about 20 years, and it wasn't that well resourced then and it's definitely a lot less well resourced now so there's that tension." – (Land Policy Lead - P12)

At the time of writing, The Gateshead District Energy Scheme, is the most successful UK MWT project and is entirely local authority led. P3 who works for a government regulation body praised the approach of the local authority and broke down some of the particular reasons for its success. Importantly, the project went from inception to generation in 3 years. P3 attributed this to a range of factors such as the time pressures of government funding deadlines, including generation subsidy and capital funding. However, they also, importantly, outlined the role of champions within the local authority driving the project forward. "The council had a very proactive person in charge that really wanted to get it done, which I'm sure helped a lot as well and had a good team of people that kind of knew what they were doing" – (Minewater R&D Lead - P3). Expertise and drive were attributed to passionate local councillors working for the local area, and the learnings from past experience developing the original heat network before including MWT. Demonstrating that with a strong commitment to a vision of local improvement and given time expertise and proficiency within local authorities can be developed. Further, P3 also raised the importance of keeping the project fully inhouse, comparing Gateshead to a similar MWT project under development in Durham:

> “When you compare it to Seaham which looking at it just really bluntly, the water's already there and it still hasn't developed. So, it's interesting to think of why that's the case. Part of it is because Durham haven't chosen to do the design and building operation themselves. It tendered for a concessionaire, and that's taken a lot of time, I think, to get the tender documents together because the concessionaires wanted certain guarantees and certain information that we might not know at this stage. So that's taken a lot longer when they're choosing to kind of outsource all of that stuff. Then Gateshead, who chose to do it through their own energy company, which had to be set up. In order to get the grant, so they had to set up a special purpose vehicle, but they already had that from operating the scheme previously.” – (Minewater R&D Lead - P3)

Gateshead set up a limited energy company, fully owned by the council which owns and operates the MWT heat network, as well as acting as the utility provider for its customers. This was already in existence from the previous heat incarnation of the heat network which utilised gas through a combined heat and power unit. The Gateshead case demonstrates that given resources and time, local authorities can develop and snowball their initial activities to produce innovative and proficient solutions to infrastructure challenges.

P23 works for a council with a minewater system in England and provided insight into their operating model as well as the rationale behind certain decisions that were made. They spoke in terms which promoted and articulated the idea of an entrepreneurial council. Discussing the full council ownership they said: “…one of the benefits to that is that the profit is absorbed into the Council, so that supports other Council activities, such as the increasing social care expenses, you know, it helps for other green initiatives and so on so forth.” – (Council Net Zero Innovation Officer - P23). Following this I queried if there was a reasoning behind the choice to make a small profit for local investment as opposed to lowering the cost to customers to keep money in their pocket. P23 was open to this alternative as a suitable approach, however they believed it was important to residents and for the betterment of the local area for the council to generate income in this way, particularly in light of austerity politics and the hollowing out of council budgets. In their contract with customers to supply heat, the council agrees to set their tariffs around 5% below the market rate on a gas boiler alternative. P23 believed in some cases this had gone up to 10% and that this was all done by decision makers in the council aiming to foster goodwill and recognising the need to incentivise people to “get on board” with heat networks and MWT. They believed that recent experiences in the energy market had affected people’s perception of the nature of ownership and management within the energy system:

> “When we've been talking to residents, they also kind of have this sentiment. Not everybody but a strong majority and it stems from the fact that within the recent two energy crises, they were very wary that the big six energy companies might not even be based in the UK, for example, EDF I believe is French. So their money is not only leaving Gateshead, it's leaving the country and going elsewhere, and then, you know from that their opinion is that it goes into two or three people's pockets and they live like big fat cats at the top. So a public energy scheme really kind of people liked the idea that the money's kept locally and it's spent locally.” – (Council Net Zero Innovation Officer - P23)

P23’s rationale for the public ownership of heat networks included the investments made by the public sector, and the long-term payback schemes associated with them. Further, they believed it put the public and residents as the stakeholders of the project, conceptualising that public money was put into the project and so the public should be owners. Finally they stated that protection from volatile energy markets was lessened when local resources are owned locally. In summary, P23 followed a rationale closely associated with community wealth building and energy justice principles, particularly around fair distribution of benefits and burdens and the retaining of wealth locally.

The unique success of the project within a UK context is particularly interesting with respect to the role of local authorities. P23 highlighted several reasons for this within the council’s workforce. Firstly, they emphasised the importance of setting missions to achieve, which guide the whole organisation. One of these missions is relating the climate to energy, and embedding that understanding throughout the organisation. This has been managed with the work of a climate officer who has worked with in every department of the council to embed knowledge.

> “Everybody's pulling the same truck down the road. Other local authorities that I've seen, they have specific climate teams. And my personal opinion is that those climate teams are struggling more than Gateshead because they've set up a team, and if you went to the housing Department, for example, and knock on their door, it's kind of like, well, you're the climate team, you sort that out. That's your role. Whereas at Gateshead it's everybody's role. It's part of appraisals. It's part of the procurement.” – (Council Net Zero Innovation Officer - P23)

The council’s leadership was also mentioned as a driving force, for their commitment to climate and energy issues. In terms of the replicability of Gateshead’s success, P23 emphasised the importance of working with the characteristics of place. Gateshead are working with the challenge of not having a high number of anchor customers, and being a

suburban populated area, more pipes are required in the ground to service the less densely populated area. “When we were all first starting out, a lot of them ran over to my table and said, oh, we like what Gateshead’s doing. We want to replicate that and that's a massive red flag. Replication doesn't really work. You have to adapt it to the place” – (Council Net Zero Innovation Officer - P23).

Finally, I discussed with P23 the future of the heat network and MWT system, what a path of expansion may entail. The plan involved primarily expanding piping out to the biggest anchor customer in reach, which was a hospital, and thus incorporating another 7,500 residential properties to the network that are on that route to the hospital. This was estimated to cost up to £250 million, a sum well beyond the resources of the council, and such, P23 expected partnerships, joint ventures, franchising and concessions in order to achieve this full development. The homes were majority council owned, making it much easier to connect them, however P23 was keen to stress that this did not mean that an inclusive engagement process would not still be required to support residents switching over energy source. Finally, they were concerned that as heat networks become more established through projects such as their own leading the way, that future market orientated policies and a lack of funding pushing them to form private partnerships would put them in direct competition with the large energy companies.

Specifically focusing on the potential for MWT development in Scotland, P14 felt a local authority led approach that aligned with Community Wealth Building principles was most appropriate as has been trialled elsewhere in Scotland. The high funding requirements could then be met from local authority pension funds, providing a community asset with stable backing.

> “The picture I get is this is going to be expensive. I wonder why local governments aren’t more involved. The sensible model here seems to be one around Community Wealth Building. In North Ayrshire, a former mining area, the council owns solar farms and wind farms and it powers council buildings off that. Why don’t we get municipal pension funds to buy investments in these minewater sorts of projects? That doesn’t seem to be part of the discussion when it comes to community, and that says a lot to me”. – (Global Inequalities Historian - P14)

8.3.3 Economic and social regulations for energy development

The need to widen the scope of regulations for projects emerged as a theme from respondents when interview questions were asked relating to regulation and the planning system. Presently, planning and regulations are geared so heavily towards the bottom line,

and are light touch with regards to sustainability obligations, particularly social dimensions. Consultation requirements are regularly critiqued and often leave communities feelings unheard and part of a mere box ticking exercise.

> “I mean, there's already requirements within the planning system for consultation, but what I think is necessary is for certain aspects when reviewing economic viability of a project there are measures like your return on investment and so on. But there are also other measures like the there's one called the net present social value which is one that factors in the social benefit of a project and puts a figure, an accounting figure into that when making an assessment.” – (Energy Consultant Co-Director - P4)

Alternative measurable indicators were discussed earlier with respect to the GDP short term and non-strategic growth orientated approach found within the economic heart of political structures. In project development, or at the micro level, as opposed to the state level macroeconomics, alternatives such as net present social value aim to capture the value experienced by people in their lives related to changes. Social and environmental impact assessment and health impact assessment tools are also geared towards altering capital and investment decisions, providing frameworks on how to conduct project development on the ground with respect to community and environment, and also how to measure and estimate the wider impacts on wellbeing from investment decisions.

P24 works for a local authority in planning, and has experienced changes within the planning system over the years. They spoke of their experience working with developers who plan to utilise MWT as part of a wider development that includes renewable power, housing, tourism and retail. It also aligned well with the local development plan for the area, which was created with input from the local population. However, the introduction of National Planning Framework Four in Scotland has made the redevelopment of more rural, brownfield, former mining sites difficult to prioritise. The framework places an emphasis on developing the most sustainable sites, as well as accounting for car-borne emissions and connectivity to other places, meaning remediation of former mining sites scores low. Evidence has shown that living near brownfield sites such as those in former mining communities has significant negative impacts on the wellbeing of communities, describing some of the sites they work with in Fife as “moonscapes”.

> “It just basically pulls the rug out from you, you know. On the surface of it, looking at the policy you would say well, you can't have that there because it's not a sustainable location. My view strongly is that you can't just deal with it from that point of view, you've got to take into account all these things that we've talked about that happened before, you know, the years of the degradation of the land. And then just leaving it,

> you know, abandoned and all the rest of it, and that there's a moral imperative, you know, for us to do something with that and to try and get that land back together." – (Council Minerals Planning Lead - P24)

P10 who works for a community land policy and advocacy organisation has developed a set of community orientated, social regulations that would dictate development in similar ways to environmental regulation. This would be a first port of call in terms of the scoping for a project, in either the pre planning stage or when licences are being granted and mandate a negotiated partnership between developers and communities. They argued that by making this mandatory community interests would be protected, and developers could genuinely say they are "taking the community with us", creating mutual co-benefits.

> "It's just like this is the terms of doing business in Scotland is that you have to have a meaningful community partnership and here's a range of options for what that could look like, which could include shared ownership or community growth shares or that you have to put in some infrastructure, you have to build some housing, you have to give the community some land that you've purchased, whoever it might be. Here's a suite of options, but you need to draw up an agreement between yourself and the community and that will be part of your terms of doing business. How that gets locked in existing renewables is trickier, but hopefully if there was that kind of guidance, then when these negotiations are happening, there can be some kind of memorandum of understanding signed between community group and the developers to be like, well, here's our kind of terms of business." – (Land Policy Manager - P10)

The concept of regulation which stipulates meaningful shared ownership was shared by many participants. P8 advocated for introducing a minimum percentage of all commercial renewable energy ventures to be in shared ownership, seeing it as a huge part of any transition in Scotland, and that in the long-term it should be as high as possible, with different investors more ready to invest in communities under an established regime of practice.

> I think it should be 50% at least. But like maybe start at 10. Cos that also depends on the communities ability to buy in actually raise that kind of capital, which I wouldn't think would be a problem and as time goes on you'd get more kind of different investor types." – (Community Energy Director - P8)

The direct role of community is explored further in the delivery models section of this chapter. P2 was concerned about land inequalities and the issues that can give rise to in the

context of MWT development. Much of the former coal mining land was broken up and sold off, meaning that simply by holding the land, in light of MWT development its value could rise significantly, negatively impacting community and public interest related to socioeconomic and environmental goals.

> “Like, for example, if we have that, develop that kind of mining (MWT) scheme. The moment you propose that, the value of the land is going to go up because suddenly it's like, beforehand, it might be really rubbish land and there's not really anything they could do with it. Like suddenly you have this profitable piece (of land) and suddenly the price is going to go up. So other countries have mechanisms to capture that for the public. So basically, they're like… you know, the government decides, the local authority decides to do this heating scheme, so we're going to buy the land off you at the price it would have been without the scheme… which has just gone up because they made the announcement.” – (Policy and Engagement Lead – P2)

The following section focuses briefly on public funds in more depth than previously discussed in the sections on the state, before this section on political economy concludes with a summary.

8.3.4 Public funds

The significant challenges of community finance were explored in an interview with P10, an advocate for meaningful community partnerships in the context of development. They felt that a level of strategic decision making in the public sector would be necessary in order to enable communities to participate, citing the co-benefits of wealth building in the community, and a more harmonious relationship with developers. As part of the social regulation and terms of business approach suggested by P10, they suggested that community share offers for stakes in energy projects would be lower than the market price and would be reliant on state organisations like the Scottish National Investment Bank. This would then translate through a seat on the board, voting rights and a way to raise the voice of the community in project governance.

> “But ideally this is seen as something for the national good. This is a way of stopping some of that economic leakage or the money that's been made by developers can actually be locked into Scotland a bit through these kinds of schemes. So there is a role for a loan at a reasonable rate, say from something like Scottish National Investment Bank which is not spending its money wisely at all. So it could actually be using it for something that's in the public interest, but there does have to be some

kind of mechanism, but also locking in the fact that this needs to be below market rate. And this isn't just buying shares in that project, it's buying a share of that project. So 20, 30%, whatever it might be, and it's not valued at the current share price of that multinational or the current share price of that project based on the billions it's going to make in the future. This is a negotiated price that would have to be figured out between some kind of public bodies or some branch of the government and the developers. But the point is it's like this is not developers making more profit. This is they're giving something here so they can't be getting the market rate for it." – (Land Policy Manager - P10)

Other participants suggested pension funds could be used to fund community involved heat projects, whether through local authorities, universities or private ones as it aligns with the long-term returns and low risk once the project is developed. (Community Energy Director - P8) was frustrated that after decades of minimal private sector investment into heat networks, public investment was still lacking which they believed was critical in unlocking any private finance. P4 stated how state loans were important in the scaling of their community energy projects.

"Loans that's available from like a state organisation, or state affiliated organisation Yeah, I think we borrowed, I think it was at 5% from them and our share offer was at 4%. So that's kind of why we wanted to pay off that loan, but yeah, it was a 20-year loan and it was secured against the leases that we signed with the building. Yeah, it definitely was helpful. I think like Welsh Government and Scottish Government are very supportive of Community energy. So I think in Scotland there's similar kind of lone mechanisms in place. It was important, maybe not critical, I mean maybe in our case because we could always like raise money through a share offer fairly quickly because we had a track record." – (Energy Consultant Co-Director - P4)

As a developer working in the MWT space, P4 was extremely eager to stress the importance of overcoming the capital hurdle. In part because MWT projections have such a small track record of implantation, risk and cost estimations are not taken with much certainty, the public sector could be heavily involved in de-risking this, but as other participants expressed only with the guarantee of public and community benefit.

"You know, there's still so many question marks, but there's still so much range on how much that's gonna cost to commission a mine water scheme because it's been done only three times on that scale and none of those costs really should be taken as gospel because they all come out about £1.5 million per MW, and Gateshead was £9,000,000 for a six MW scheme, Lanchester Wines with all the iterations are kind of

now up at that benchmark as well. But there are ways that the cost could be brought down. But those are all we have at the moment, so it's hard to say that for definite. I think." – (Energy Consultant Co-Director - P4)

8.3.5 Conclusions: Strategising a MWT industry and alternative energy economy in Scotland

Looking forward to an alternative energy economy of the future, the central message emerging was that the state must play a stronger role, stepping up to take long-term investment decisions and thus de-risking energy transition pathways. A national energy company or investment bank could be one vehicle to do this, particularly as the nature of heat projects and MWT with long-term return rates on investment are suited to state financial capabilities. A regional approach may be most appropriate which empowers local authorities within a national wider framework of support. Local authorities are critically under-equipped for this role in heat transitions, that theoretically they are the appropriate body to facilitate. And regional inequalities exist between them, which a state system could address through capacity building programmes. Stopping the current flow of wealth leaving local communities should be prioritised, and this ultimately comes down to ownership. Regulations can also enable a different political economy, by prioritising social factors, wellbeing and local needs in the project planning and appraisal stages. The terms of business in Scotland for exploiting energy resources could and should require meaningful community partnership, which could range according to community need from shared ownership to infrastructure and housing investments. Finally, in order to alter the funding landscape, public funds such as loans must prioritise increasing community and regional ownership models, in order to de-risk projects and accelerate the heat transition.

8.4 Delivering and actualising MWT imaginaries

This section explores in depth the facets of the delivery models for minewater thermal energy as well as a more in depth look at the role for communities in such models. It covers elements of governance, business models, place-based engagement, and co-design, with a consideration of outcomes tied to social justice and community wealth present throughout.

In the previous sections, it was shown that the participants and stakeholders relevant to MWT have a broad understanding of the dimensions affecting the deployment of the technology. An explicit focus on the ethical, normative and moral aspects was undertaken with the participants, as within literature, policy and institutions, these play a growing and pivotal role informing energy development and transitions. As described in the literature review, inclusive development and forms of social justice theory are utilised often in

scholarship, policy and law to guide and evaluate practices of development relating to energy. Furthermore, my own positionality within this research as discussed in the methodology chapter, draws me to these normative theories and manifestations. This section will explore MWT development as it relates to these concepts to better understand what a picture of fair, equitable, democratic and intergenerational resource use and governance looks like in this case. First, the case of Midlothian Energy Limited (MEL) is explored as one of Scotland's only major heat network projects that is exploring MWT integration. It also involves local authority joint venture governance and business model arrangements which can connect many of the political economy and socio-technical considerations together through a delivery model lens.

8.4.1 Learning from best practice: Midlothian Energy Limited heat network

The example of Midlothian Energy Limited (MEL) can provide many learnings for potential heat network delivery models in Scotland. The findings here draw heavily from interviews with P29 and P22 and their expertise as individuals heavily involved in the creation of MEL. In Midlothian in Scotland's central belt, the local authority in partnership with Vattenfall has created a joint venture company, MEL. Each party has a 50% stake in the company, and it is the vehicle being used to drive forward the local heat transition, with the early focus being on the development of a heat network. The heat network will provide heat to a "new town" housing development at Shawfair, with plans to expand further to other anchor loads such as hospitals, universities as well as the surrounding villages, some of which are former mining communities. The energy for the heat network is supplied through an agreement with a nearby waste plant, which local authorities have played a significant role in developing. There is also minewater energy potential in the surrounding area which could be tapped into to develop the heat network at a later date.

The initial waste plant, which now provides heat to the heat network and may at a later date use the mine shafts as heat storage was delivered with no local objections, according to P29 The site sits on a former mining colliery, and they described the extensive community engagement work done on behalf of the council, including using the local mining museum for meetings.

> "I think it helped a lot that the public saw that this was a local council that was bringing forward a proposal on an ex-mining site in an area that needs improving. And it wasn't just, you know like the big bad industry trying to make a fortune out of,

you know, you know putting an incinerator next to their houses." – (Council Energy Project Director - P29)

The MEL project is something of an outlier in Scotland, where the local authority has taken a much more committed role to delivering heat projects and indeed, partnering with the private sector on equal terms. I discussed the origins of the project with some of those involved, and what was clear from the start, as was similarly discussed in the case of Gateshead, was the critical role played by particular individuals within the council, with a vision and the commitment to deliver on it, championing the project idea.

> "So, a champion, yeah, I mean, if there was a (Midlothian Council Project Director) in every council. You have the experience, vision, clarity, calmness, to bring this all together. I'll tell you what I'm sure most councils would pay him a fair return to try and do something similar." - (Heat Developer - P22)

MEL has no employees, it is the legal body in which projects develop under, and is instead made up of three committees, a project origination committee, a project management committee and a finance committee. After decisions are made through the committees they are then signed off by Midlothian Council and Vattenfall's respective governance systems. Further, the unique location is at the meeting point of three councils, with high demand sources going towards Edinburgh including large anchor buildings, as well as waste heat ready and available under a long-term contract with the council.

P29 provided the Midlothian perspective on the creation of MEL, and how the business case meant that the rates of return were too low for commercial actors, and that a solely council led project was financially not possible. P29 discussed how a full-time position was created at the council to fully focus on finding energy projects and making use of resources, whereas other councils often struggle to set time and people aside.

> "…the internal rates of return that we are making on MEL projects are the sort of internal rates of return that you would never hear of for a private sector organisation delivering it just wouldn't happen. It's maybe partly because our partners are, you know a bit happier to take a kind of long-term approach on a low risk because once the heat networks are in place, these tend to be low risk or viewed as low risk by you know, financial institutions and everything like that. So they may be quite happy to take up a lower rate of return." – (Heat Developer - P22)

After significant capability and feasibility studies, a multi-million-pound grant from the Scottish Government was approved. At this point, they began to look for an industry partner.

They wanted to find a position where they wouldn't always match capital funding with the partner, so dilution of shares would be used to cover the council's side of the investment, which would not affect the decision making.

> "…we realised that what these organisations really valued was a Council that wasn't just in it with an exit strategy and wanted to just facilitate it and then move on. They wanted basically a partner that was there for the long term…I proposed to our Council that look we need be in this assuming we're in it for the long term and we need to have a 50-50 say at the table and be a full partner and put everything in a 50-50 basis…we decided just to make that a hard and fast rule that you know in the competitive dialogue we're not dialoguing on that you know, that is the position it's a 50-50." – Participant 29

P22 spoke about the importance of strategic decision making in the long, medium and short-term simultaneously and how critical this approach was for the success of MEL, requiring the local authorities and the developer to work together. P29 echoed this, and stated how critical it was to start with a small, robust and deliverable project which had enough commercial viability to bring in wider investment, which subsequently unlocked future expansions. The location of the scheme is close to several large heat demands sources, and a relatively densely populated area. When the original project development commitment was made, the energy centre was built to be able to handle up to twice the current capacity of heat agreed with the waste plant. Meanwhile, the team at MEL are in the process of securing connection commitments from the anchor loads for 5-10 years down the line, all while the piping and connections are being made for the agreed supply to the new build homes that serve as the initial point for the project.

P29 explained how the business model initially targets new build connections, and is to recover the capital expenditure from the developers rather than the household users through connection fees for every house in advance of it being occupied. The householder is then just paying for the heat and will not have to maintain or replace the system. MEL is responsible for everything up until the heat reaches the heat exchanger in the house, so the cheap waste heat and maintenance of the plant and its back up system is covered by the relatively low cost that Midlothian charges users. Through this business model, and by operating partly as a public body, MEL are able to socialise the heat cost.

> "…and one of the things we want to do is to make sure that as we build out new projects that we're able to socialise costs for consumers. So for example, there might be let's say we were able to connect to an existing settlement nearby. But you know

> that project only just washed its face and then there was maybe another expansion where there was a reasonable profit margin in it. What we would look to do is to socialise the costs and have the consumers paying the same. We wouldn't just you know, if there was an opportunity to connect somewhere, even if there was a small development and it was actually going to lose money, we would probably still look to connect. But having that economies of scale allows us to socialise across them all." – (Council Energy Project Director - P29)

As part of the medium- and long-term strategic thinking MEL are engaging with, P22 explained the emerging challenges for the heat network expansion as it moves beyond new build and public connections into existing mixed ownership domestic properties.

> "What is our replacement heating proposition? And it ain't the same as building on a green field, because it's people's homes. It's lives and all the rest. So, there's a whole disruption piece. So I am part of a team that's working on that proposition. And what we realize is that it isn't a technical solution, the technical thing is done. We all know how to put pipes in the ground, and they're going to connect them up. It's how we get this amazing coincidence of timing basically, we're putting the pipes in the ground in the right place at the right time, based on some level of off take certainty in the future. Based on consent and support from the local population as much as your more classic planning authorities, etc. The Midlothian council is our friend, they've already said, yeah, sure, you can connect up to all our council houses but they're lived in. We still need to treat everyone with dignity and with respect." – (Heat Developer - P22)

P22 spoke to the importance of partnership from a local authority perspective. That when councils have a strategy in mind for decarbonisation or any other objective, rather than moving straight to solution and implementation, they should look for partners in which to co-develop the solution. That could be industry, local institutions, the state, or local communities.

> "Make sure it's a heat network, partner that you choose, and make sure you do not come to them with the solution. Select the heat network partner with whom you are comfortable, to start thinking about how to get to the solution. That way you haven't tied yourself up. We've already figured out that we're getting our heat from here, and it's got to be this etc" – (Heat Developer - P22)

The cost that potential minewater schemes entail means that communities are going to struggle to own the mine in more direct models, giving more credence to the involvement of local authorities. In order to understand why this feels unrealistic in the UK context, one

again must engage with a political economy analysis. If industry does not take the involvement of the local authority seriously due to monetary reasons, there's political reasons why local authorities in this country, and in this period are in the financial situation they are in. Looking ahead to how MEL could expand, P29 discussed the risk associated with further pipe installation and the uncertainty of connections, and that this could be where the government steps in to cover these costs until connections are made.

> "… but it's not guaranteed and you've got a customer at the end of it and you're not going to put that pipe in just for one customer. You know, you want two or three there, so that there's a point about how the whole funding thing works and whether there's potential for government to fund risk. So basically they fund a pipe and then we get connections, they get the money back, so it you know, it doesn't need to be a grant that they don't necessarily get a return on it. But it's just that risk that sometimes that's the main reason that a lot of these things don't happen is because of the risk of the contractor would be holding. But yeah, no, absolutely more of a regional approach to certainly regional, even as I say across central belt approach to these things would probably deliver better results." – Participant 29

Reflecting on the potential learnings from MEL and tackling the huge difficulty of funding that councils often cite, P29 discussed how Midlothian council teams were able to commit and take the project forward, in light of their partners expertise. Despite the fact the internal council appraisals and expertise meant that heat networks were a risk, the commercial partner in Vattenfall had also ran their own risk appraisals and were happy to go ahead, this then gave the council confidence to go ahead and invest. P29 discussed the ways in which public partners are brought on board, be it in the council or other institutions they are aiming to connect to the network, boiling it down to risk management, value for money, carbon reductions and the counterfactual. They described the strategy as "spend to save".

8.4.2 Whole system and staged approaches to MWT & heat networks

By envisioning development as part of an interconnected web of socio-technical systems that make up modern economies, energy resources can be more effectively deployed and utilised by all actors across sectors and society in the long term. By integrating different energy sources together as well as different social networks and institutions, co-benefits are maximised. A whole systems approach was considered essential, for any heat network or minewater delivery model, that integrates the wider energy system. Again, the primary pushback on this approach is one of funding and political economy, as has been discussed.

However, when setting out to build the most effective and empowering energy system of the future that meets environmental and climate action requirements, then a whole systems approach is paramount. It provides space for everyone to buy-in to the delivery model, as it serves the interests of communities and councils, by affecting the local economy and the burden of energy costs, and meets the wider goals relating to public good set by national governments. The private sector is able to use its technical expertise as a partner in the delivery of such projects. P25, who has worked for a local authority developing energy and climate strategies typified this approach in the following statement.

> "If you can link in solar, link in heat pumps and you can link in heat from the mines and district heat that and if we partly own it as a community, as a Council, as well as business support in there, something like that, then that that should provide economic benefit to that Community by reducing the amount of money they spend on energy." – (Council Climate and Energy Lead - P25)

P25 was keen to stress that the nature of renewables impacted strategic approaches to development, further cementing the need for a whole systems approach. Solar for example means that while it may prove a good use of land in a former mining area, it will not provide employment or necessarily lower bills for residents. Hence heat opportunities are required to work with solar, where the electricity could be used to power heat pumps and thus providing a more complex chain of employment. A heat network could then promote business opportunities through lower energy costs locally. Opportunities could range from heating greenhouses to grow produce locally, or data storage facilities. In turn, this provides the possibility of multiple co benefits even beyond local economic wealth, such as reduced pollution and environmental harm and social cohesion through the space for entrepreneurial activity.

P19, who works as a developer gave insight into some of the delivery models they currently operate and are considering for MWT heat development. Often, as technical consultants they are expecting the client to pay the capital expenditure and for them to earn the money back from the saving on energy costs across the duration of the scheme. Alternatively, they spoke of scenarios where there is an existing energy provider that has a district heat network and wants to buy heat at a certain price for that network. In this case, the developer may invest in the capital expenditure, such as the boreholes to install the MWT system, under the conditions that the price the energy provider is offering to buy back the heat will allow for the eventual profit on the capital investment. As several participants from local authorities and regulatory bodies explained, the successful approach taken in Gateshead was of the "build it and they will come" variety. It also utilises a staged approach, that is reliant on initial

connections before moving onto the next high heat demand source, such as a hospital, which then allows for the piping to connect into other demand sources, either residential or commercial along the way.

> “Up until this point, you know Gateshead council they funded the boreholes. Lanchester wines, they funded their boreholes, so it was very much sort of insular. I will do this, then we'll get the rewards later. But I know Gateshead Council. Their logic was build it and they will come essentially. So they are getting more people to sign up to their heat network because they can offer net zero heating. And then that becomes a bit of a draw if the infrastructure's already there and you just have to connect to it. But again, it's slightly different finances for the local authority versus a private entity obviously. So there's a couple different business models that you could go ahead with and that we're weighing up whether or not it's worth, you know, putting our efforts into trying it differently to have more of an impact and build more projects, but it's something we've not really fully explored yet.” – (Geothermal Energy Specialist - P19)

P22 who works for a heat developer, spoke to the ways in which heat network pricing currently works for developers.

> “The central point you need to know about the way we approach it, and I think most large serious operators will, is that it's about the counterfactual. It's not cost plus, it's what is your lowest cost, low carbon alternative? And then we essentially say, our aim is to beat that, at the very least basically be the same. But being able to guarantee a lot or being able to present a strong narrative towards lots of upside, i.e. the fixed charge that you'd be paying it might all end up being equal today. But as we grow, the fixed charge will drop… So, we're going to be doing lots of extra connections, making the denominator a lot bigger and the numerator i.e. the cost of you know maintaining the heat network doesn't go up proportionally as quickly. Then we can pass those savings on to maintain a fair and just sort of IRR.” – (Heat Developer - P22)

The counterfactual was also a strong factor in the Gateshead scheme, one of the UK’s other few major heat networks, actively using minewater heat.

> “So heat pumps are thought to be the cheaper alternative for heating your home and then heat networks would be kind of benchmarked off that. At Gateshead, we kind of go a little bit further… We aim to set our tariffs at least 5% below what a resident would pay for a gas alternative... You know, it might be pennies more, might be a couple of pennies less, but that's what we aim to do. In some cases where it's been

> an individual heat network such as deep geothermal. I do believe we have been able to get up to 10% cheaper." – Council Net Zero Innovation Officer – P23

Beating counterfactuals on price is a common way transition projects aim to incentivise users to switch fuel sources, and it is suggested as a successful option for heat networks and MWT technologies also. The next section explores the role of community and shared ownership in potential MWT schemes.

8.4.3 Community-led shared ownership

Ownership was explored in previous sections relating to the wider landscape and role of the public sector, however, a more in-depth look at this issue is covered here. In particular, what the role of community actors may be in the ownership and governance of delivery models.

P10 who works on community development policy was certain that a more holistic and empowering model was necessary in order for policy ambitions to be achieved around a just transition and community wealth building. This would necessitate a stronger, genuine community partnership between developers, landowners and communities in the context of renewable energy developments, or any case involving "significant land use change where the community who live in that area are going to be impacted by the change that's happening". This was qualified with the explanation that the partnership models suggested would be more to do with the significance of the development as opposed to its size, where sites may actually be small or less visible, but may have a significant impact on surrounding areas. They were keen to see shared ownership models that formalise an empowering community developer partnership developed at the national level and explained that the main drivers for pushing for these models comes from the desires of communities themselves. The Scottish Government has now included shared ownership options in community guidance for developers but hasn't fleshed out what it looks like or provided any standards or obligations.

> "The shared ownership models that exist in terms of renewables at the moment in our view are pretty weak. Local Energy Scotland are kind of leading on some of this, and that might be the community are offered shares in a particular project. It's not clear if those shares are market rate or if they get a reduced rate, which they should because it's part of that kind of community benefit package. And they end up owning a couple of percent of a project, which sometimes can translate to quite a significant amount of finance, but it means they don't have any kind of meaningful voice in terms of governance and sitting on the board. They can't actually influence that much. And then in terms of community benefit, this baseline of 5,000 pounds per megawatt has

> just been rolled out again, same as it was 10 years ago. So no increase for inflation, nothing. And we just think that's a kind of ultimately flawed model." – (Land Policy Manager - P10)

They suggested a whole suite of options that should be on the table in community developer negotiations from an early stage, way beyond the currently accepted community benefit package. These range from a share in the project with meaningful voting rights, to land assets, or have infrastructure built by the developer. A local governance board was suggested so that issues relating to development can be discussed openly and in the public eye. When pressed on how this would work for communities low on capacity, P10 suggested mediation could be provided by non-departmental state bodies such as the Land Commission or Local Energy Scotland, this would ensure developers aren't "steamrolling over communities". Further suggesting communities that lack existing organisations such as development trusts are vulnerable to being taken advantage of.

With developers being increasingly aware they need to demonstrate a form of community buy-in, P10 was increasingly concerned about "community washing", claiming the offer of £5000 per MW with "lots of warm words about communities being at the heart of it" was often insufficient. They went on to suggest that current shared ownership options may also amount to community washing, as a small percentage share alone provides little meaningful community governance or participation, although it was acknowledged that even 2% turnover on certain projects would provide a significant sum to communities far above the standard benefits packages.

P10 felt that there is an appetite from Government, the third sector and developers to engage on innovative community partnership models, but robust and meaningful outcomes were not guaranteed. For P10, empowering the community to feel like equal partners in a project is the only way to guarantee a heat project's success as a vehicle not only for decarbonisation, but for positive social, economic and cultural outcomes. They believe the community owned model is the most assured way of achieving this:

> "These projects are only truly sustainable and endurable if they take local people and communities with them, people to get buy-in. So if you look at community owned renewables, that's when you actually have genuine buy-in. The community sees the benefit, they produce electricity while they still operate in a globalised market, but at least it's their peers, the people that they elect onto the board that they can have a say in that are running this and money's coming back into a community benefit fund, which they all manage together, which they can all apply to and get access to. So it's really important. It's like the money's important, but actually being able to see

> yourself in the project and feel like you have a meaningful stake in it, it's just as important as the money." – (Land Policy Manager - P10)

The establishment of community energy organisations and their operations gives an insight into models of ownership. P8, discussed the experiences of an urban community energy group, whose model includes share offers, loan and grant funding for capital. On the revenue side, they primarily install solar panels on public buildings such as schools. Initially the share offer was unrestrictive, however they prioritised investors based on a postcode assessment and put in effort to connect with active local community groups, as they felt the value generated by the energy should be distributed locally as a priority. Eventually they were oversubscribed and had to cut back on shares bought by those living further away. Their model is so heavily reliant on local authority policy and the challenges they have overcome to get through the council's procurement policy. They described other cases, such as in Swansea where the council altered energy procurement for their buildings to favour community energy groups, which they characterised as more transparent and equitable. They stated the procurement was weighted 60% towards engagement with the buildings ahead of the usual financially led weighting, taking into account other value such as the education outreach offered by the community energy group.

> "We raised money through a share offer, we got 170 odd members, people invested in it, we also received grant funding and a loan from the Scottish government. So the various funding streams enabled us to like actually to develop the project. And it's now been running 3 years, we're generating income by selling electricity to the council and that money that is used to provide community benefit. We have annual meetings. It's democratic kinda ownership, and you know, members can become directors or get involved in volunteering parts. And we're kind of going through a process of like few different changes. So we're looking at can we open our membership, so you can become a member anytime not just when we're raising shares, capital, and we're looking at developing new projects. – (Community Energy Director - P8)

They described how their initial approach of working with the local authority, meant that they would be concerned with one owner and one building at a time, and P8 was open towards the challenges associated with community energy organisations taking on a level of responsibility to distribute energy more widely to mixed ownership and building types simultaneously. In the context of heat networks and MWT, wholly community owned models were deemed generally unlikely due to the extensive capital costs, technical understanding needed and the infrastructure requirements. P8, despite being a community energy

practitioner, acknowledged the critical role shared ownership models could play in the heat transition. P10 explained why their organisation had pivoted to providing more focus upon shared ownership models for renewables, despite past success in Scotland with community energy owned projects.

> “Communities that are trying to set up renewable projects are really struggling because the cost of everything has gone up and the scale at which things are happening is just not including community. So, what's happening is it's kind of like a fudge, a meaningful shared ownership model would be good because it builds community capacity, it gives community some governance oversight, it brings in a meaningful amount of money. And our view is then five, 10 years down the line that community is going to be in a fantastic position to do their own project or buy some land or do what they want. So, we see it kind of like seed funding almost, but it is a compromise. It is a compromise because I mean what the best thing would be, not the best thing, but a good model would be if there can be some kind of shared ownership which sits alongside community benefit be that money or infrastructure or housing being built with meaningful governance and the community is also getting cheap electricity.” – (Land Policy Manager - P10)

On the final point discussed around cheap power, P10 explained that from experience, disdain towards energy transitions is the result of the increasingly high cost of energy experienced by communities living right underneath turbines, paying a market rate set by in part by global gas markets and technocrats far away. They felt that localised energy supply mechanisms would not only improve local economies at the community level, but it would also increase support for further renewable development, or at the very least remove a key criticism.

8.4.4 Why a culture of partnership is necessary for heat delivery models

This section aims to add extra emphasis and summary to the analysis around ownership thus far, primarily the role of collaborative partnerships. Participants discussed at length the advantages and suitability of a public led model for minewater thermal energy, with communities of place and interest firmly at its heart. However, the role of the private sector as a partner was also raised, with the technical expertise and capabilities of private developers considered by some participants as crucial. Others saw the role of the private sector as important in the short to medium term, with community and public expertise

building over time in its place. P4 saw the entire heat landscape as requiring a blend of public and private input, with a strong role for both communities and local authorities.

> “I think there's a recognition that there's expertise that the private sector can bring and there's technical investment potential there as well. So a lot of the urban energy heat network projects are kind of being supported by International Development partners and that's sensible. National government has a role to kind of set the framework and to provide some of the capital support as well, and then at the community local level. That's really on individual project delivery, and well community can be driving a project, and own the project, but then perhaps partner at the critical investment stages, forming a partnership and perhaps not getting sole ownership but maintaining representation and benefit from it. And I think particularly local projects the local authority has a role in there too.” – (Energy Consultant Co-Director - P4)

Also discussed in the interview with P10 was the role of the local authority in energy developments in relation to the community. In contrast to many other participants, they were less convinced the local authority needed to play a significant role. This perspective was in most part over concern that the local authority representation may end up replacing community representation, and even becoming the recipient of the benefit funds, managing their use in the locality.

P21 had similar concerns and cited this very reason as the underpinning motivation to develop the alternative 9CC Group model. P10 did see the local authority as a potential mediator in some cases but felt that their use as a stand-in for community would be counterproductive and would allow developers to bypass the community engagement work required.

> “Does that actually achieve the kind of localised governance, the actual kind of community empowerment, community wealth building that we're looking for? Yes, local authorities should probably be given more funding and be able to do more, but are they the best drivers of community wealth building? Because my understanding of community wealth building is much further down the hierarchy. It has to be much more grassroots… If you could have a meaningful partnership in which developer, local authority and community were represented, something like that could definitely be explored, that would make more sense. But it's just the local authority can't replace the community” – (Land Policy Manager - P10)

P25 observed that the existing heat networks in Aberdeen and Midlothian have community, local authority and private involvement, demonstrating the need for collaborative approaches

that do not come at the expense of one another. P8 discussed a future in which shared ownership becomes a norm, initially funded by what they label a community energy tariff, which would enable the development of a heat industry at which point risk is reduced and other investors come in.

> “I think some of the mechanisms mentioned I think could work would be like the community energy tariff, that comes out of the profits of large generation companies, like Scottish Power. I pitched that to them at one of their sessions and said you should be paying us a feed in tariff, and the other option is I think shared ownership is a huge part, and I think this may be too difficult to do, but like mandating a certain like minimum percentage of all commercial like renewable energy ventures being in shared ownership. I think it should be 50% at least. But like maybe start 10. Cos that also depends on the communities ability to buy in actually raise that kind of capital, which I wouldn't think would be a problem and as time goes on you'd get more of different investor types. You know, people interested in putting their pension in there, or like, putting in different funding costs like. Yeah, universities will have huge like investment pots and things, and divesting from fossil fuels. That kind of stuff would be like, why not put that into community energy? Because that's kind of is the perfect thing, it’s like a low risk, long-term returns strategy of like minimal growth is that we want for that type of investment.” – (Community Energy Director - P8)

Beyond the role of community as owners, there is a better need to understand how to engage with communities as a fundamental part of energy delivery models. The next section explores effective and appropriate engagement.

8.4.5 Engaging with communities in heat projects

As demonstrated earlier in this thesis, the involvement of community within the energy sector is increasingly observed within policy and wider transition discourse, as well as in the number of projects on the ground. There can be a range of drivers which predicate the role of community in energy developments on a case-by-case basis, however research and policy increasingly highlight that across the spectrum, participative and inclusive practices that begin at project inception are important in securing more holistic positive outcomes for all involved. Thus, it was deemed important to investigate the ways in which community involvement may manifest for MWT developments, and to gain understanding on the unique elements as it relates to this socio-technical, and cultural ecosystem, with the unique history of the former coalfield communities particularly relevant to these kinds of questions.

Early in the data collection process, P4 provided a straightforward, practical justification for the central role of community, stating: "… because heat projects by their nature are geographically specific, they lend themselves well to having the community as a key stakeholder, if not the key stakeholder and driving them forward". MWT development, as a heating project with a locational and geographical character even more intrinsic than in other kinds of heat networks, due to its reuse of the mine workings as they exist, is qualified by this reflection. Further, former mining communities may have an additional layer of attachment to place because of the social and historical significance, meaning that more consideration is required in the dialogues which determine the role of community as a stakeholder. P4, explained the ways in which this may manifest for heat projects, and why they believe it's an important consideration:

> "And there are different ways in which you can have community stake in projects, though, whether that be like, sort of representation on the governing body that owns and operates the system or you know the sort of tenants groups or however it's done, but I think it's very important to have some form of community representation in there because by their nature heat projects will be a monopoly and therefore sort of having appropriate protections, representation is important." – (Energy Consultant Co-Director - P4)

The involvement of communities in these terms could be understood as representing forms of democratic inclusion, and in the social and energy justice literature falls under recognition and procedural justice. The reasoning observed by P4 here centres upon the geographical aspects of heat development. They also discuss representation and mechanisms which enable it as important in order to protect against monopolisation. This is not a factor often discussed in the literature on procedural participation, which tends to rely on normative and ethical framings around the tradition of democracy and the right to shape developments that directly affect life, resulting as being part of a community of place or interest.

P1 was equally convinced communities had a critical role to play in the energy transition, particularly in light of the reduced role of the public sector as explored in previous chapters. Up until the 1980s, the state orchestrated huge campaigns which were able to change to material and imaginaries of populations, such as the construction of the grid or the use of gas in homes.

> "And so if governments aren't going to do it, which agent in our society is going to fulfil the role of inspiring people, giving people confidence and trust, all of that stuff I just mentioned. And I think the most obvious answer is, communities themselves. People take a stronger cue from people in their own communities, family, friends,

> neighbours, colleagues, than they do any other type of organization." – (Retrofit Co-op Co-founder - P1)

Throughout the stakeholder data collection phase, participants from varied backgrounds were proponents of a community led approach. P5, a sitting MP at the time of interview felt that the community involvement was crucial, particularly in the context of former mining communities, stating:

> "One of the big things that we keep coming across all the time is, you know how important public engagement is and having community involvement in the bottom up with project that that comes up so it can properly benefit the community, and you know every aspect, and that this their voices are heard and as part of that development." - (MP - P5)

There appeared some disconnect in this interview between the favourability of the community led approach stated here and the national, state-led solution championed elsewhere in the discussion. P5 described a delivery model in these terms: "you we can actually take it down to almost community level just the same way, as you know, maybe somewhere in the Western Isles and elsewhere have their own wind turbine or something like that, it doesn't have to be big business that are involved in this." – (MP - P5). This reference to models for wind energy in the past, in rural community contexts, and wider support for national led MWT industries speaks to a theme throughout, where public and community good opportunities are identified, yet novel mechanisms to realise them, recognisant of the relevant ecosystem factors, are lacking.

Prior to the data collection, it was clear from the literature that the level of community involvement in collective heating solutions, such as MWT and heat networks more generally, is an unclear proposition. This is due in part to the fact that there is a lack of examples of renewable heat networks in operation in the UK and more broadly, and that in the countries where it is established, it has been more state, and technocratically managed. P8, who sits on the board of a community energy organisation highlighted nuances of community involvement in heat networks:

> "I think for heat networks, the complexity of those things, and you know the safety standards around developing them means that yes, communities could own them, finance them, but they probably wouldn't operate them. And at the end of the day, they've got to figure out how to make money out of it, or how to make it, you know, break even unless it's got significant grant funding." – (Community Energy Director - P8)

However, they were also keen to stress that the nature of heat networks being lower profit enterprises aligns with the position of community organisations, who are not looking for the same rate of return as corporate developers.

> “We're about ownership and community democratic participation and then for us to benefit. Like there's no stipulation for a heat network to provide community benefit and that would be a real shame if that happened.” – (Community Energy Director - P8)

The level of community involvement described above chimed with the perspectives of some developers, P22 in particular was convinced that the most important thing communities can do is to become prosumers and figure out a way to own energy producing assets. They were less sure of the realism of that proposal with minewater energy and heat networks but saw it as a viable approach more broadly. In this arrangement, the developer would offer a contract to the community with an energy asset to operate, buy and sell either electricity or heat back to them. Some mixed governance models explored in the research involved the community owning shares in projects, P22 was less convinced that this approach would appeal to developers.

> “On the community involvement piece, that's an open question. As I say, I suspect what would probably happen is that the energy company would be like, we're happy to do a deal with you as a community organization to buy and sell heat or energy from you. But we won't actually share any of our equity with you. I think that's probably a cleaner way of doing it. But we're offering them a contract right? A 10-year contract, which is like liquid gold in terms of that doing the finance, to actually make their project happen.” – (Heat Developer - P22)

Whatever the structure of partnership or arrangement there are underlying principles of meaningful engagement that must take place from the start. P10 was confident that this would only be a certain outcome once it was national policy and an obligation for development.

> “There has to be meaningful community engagement from the start, the developers have to actually have meaningful engagement. And part of this is capacity, there needs to be some kind of guidance so communities know what they can negotiate for, what's happened before, what they can push on. Because at the moment there’s a sense of developers can pick off communities. There's no standardised approach, there's no statutory guidance from the government. So communities get approached by developers and they just think, well, how are we going to negotiate with the

> multinational when we’re like the community council or let alone some of the trusts who are also kind of like, whoa, we've got to negotiate with the Canadian multinational. It's happening off Lewis at the moment, so it's intimidating. That's why we need some kind of statutory guidance that's set down.” – (Land Policy Manager - P10)

With the relatively significant level of funds now in the hands of communities, either through benefit models or community ownership of energy, one touted approach is where communities pull together finance to fund other community energy projects. This is a relatively untested model, and so there are few real world cases to draw upon to understand the different configurations it would operate. P10 revealed that community groups had approached their organisation, interested in community finance partnerships. Not only would this allow for the resources of one community of place to unlock the resources of another, but it could also provide experience, capacity and knowledge. Whilst community energy is most closely associated with communities of place, these cross-pollinating community financing models would allow for communities of interest to engage and facilitate further aspects of a community wealth building agenda.

> “Particularly say communities we work with in Glasgow who are really excited by what our members in rural Scotland are doing and thinking, oh, is there a means of them clubbing together if the finance was available to set up for their own renewable projects? And then you've got communities in Glasgow who've got access to an income stream, which they wouldn't otherwise have.” – (Land Policy Manager - P10)

The challenges of community involvement as it relates to democratic structures and capacity was explored with P10. They concurred with widely reported perspectives of democratic disenfranchisement, where power is too centralised and people do not feel like they have meaningful say over what is going on in their communities. Community councils were acknowledged as sometimes delivering democratically led benefit for local communities, but P10 was critical of their democratic credentials, their lack of funding and legislative power. They felt that community capacity would have to be supported in order for more democratic local governance to flourish. If it is only volunteers that can take part, who are able to economically then the fairness of the system is rightly called into question. P10 called for more paid meaningful democratic positions at the local level, to counter the influence of developers and landowners who are not elected but arguably wield the most amount of power in decision making.

> “If you don't have the kind of regulations we've been talking about and is a free for all, where does the power actually sit? And in terms of local democracy, maybe it would

be good to have some kind of layer of local democracy that can negotiate with these developers. Yeah, okay. It's great that communities get to negotiate directly with developers in some ways they get their voices heard, but think that power imbalance is phenomenal, absolutely phenomenal. If something became a legal battle, it's like, God, who's going to win that? The Scottish government would shy away from going to court against developers… There's a huge local democratic deficit everyone talks about, and they're right in terms of the structures, the democratic structures we have, but there's also, in my view, a kind of bigger or connected point about the impact of the socioeconomic situation upon our democracy that weakens it tremendously, I think." – (Land Policy Manager - P10)

8.4.6 Reflecting on community benefit funds: the 9CC group

Community benefit funds have been utilised as the main mechanism in which energy developers engage with and distribute financial benefit to host communities. The model has attracted both support and criticism and is worth exploring in the context of the future energy economy, as to its suitability for minewater thermal energy, and its existing status to contribute to further forms of community investment. The 9CC Group is a body managing wind turbine benefit funds that operates across local authorities of Ayrshire, made up of 9 different community councils in former mining communities. The group governs, negotiates and distributes all elements of the wind farms existing and planned across these areas. The governance board is made up of community councillors, with advisors from the council and wind farm companies also present. They present themselves as a more effective way of leveraging funds and value from energy resources at a community orientated level. This section draws heavily from the insights of P21 who has expertise in this topic.

P21 was critical of the ways in which community benefit funds from wind farms had been managed in the past, and believed support and collaboration was necessary to support communities with the burden of appropriate governance structures. In the past, community benefit funds were administered by the local authority, with a main consequence being that the fund became tied to political motivations and 'vanity projects'. They described scenarios where communities in the orbit of the wind farm were 'played against each other', investing exclusively in one community at the expense of a neighbouring one. Access to the funding was another barrier under local authority management, where a risk averse approach was taken. They championed the model in which they operate, as a collection of community council groups.

> “We are 9 separate communities who were willing to collaborate and work as a collective for the first time in living memory. Down here our communities are rife or were rife with territorialism and tribalism. So this was a unique concept… In terms of that approach. The opportunity to genuinely manage those multimillion pounds as opposed to other authorities being parachuted into communities and telling us what to do, it was attractive. It demonstrated that community empowerment could actually be practiced as opposed to just spoken about.” – (CEO Community Energy Consortium - P21)

The challenges associated with the opportunities of community benefit funds was also emphasised. Where communities are often suddenly expected to form governance structures to manage significant sums. The approach of the 9CC group was positioned as an alternative by P21, where its democratic legitimacy relies on the elected community council members from across the region. Turnouts at community council elections are infamously low, and tend to involve a small subset of society, meaning its true local representation is typically low. The 9CC board also contained positions for senior officers from the local authority as well as the wind farm developers themselves, to provide strategic advice, although decision making power is concentrated with the elected community councillors.

> “The volume and amounts of money involved with developers throwing at communities some sort of community benefit. Some communities don't have the capacity or are under prepared for this. They may well get support from Development Trust Association Scotland, or Coalfield Regeneration Trust. I am sceptical of things like Foundation Scotland parachuting in and then saying, we'll help you, but first we'll take 10% off the full grant. Look, they need to make a profit, they need paid to do something, but I think there is better models available, rather than just giving it to vulture organization who sees an opportunity to make cash”. – (CEO Community Energy Consortium - P21)

It was reported from P21, through discussions with the Scottish Government and Ministers that the perception of community benefit funds was that “they were continually painting the scout hut”. They claimed that a major challenge is the focus on “low level, non-strategic projects”, and that whilst these expenditures have their value, it was not delivering on the potential and scale of the funds available. As a result, the group split the income from energy related community benefits into two different funds, a strategic area fund and a local community fund. Where a large percentage of the fund is ringfenced for strategic, economic, social, environmental legacy projects in the area. Through community consultation, they were able to develop key themes in which the fund would deliver, including active

communities, entrepreneurial activities, net zero and young people. Again, the governance of the strategic funds, and the allocation to projects is managed by the community councillors and the board.

The funding model also explored commonly sighted challenges around the distribution of community benefit funds, namely what is fair in light of geographical spread, community size and perceived impact. As a fairly unique case of multiple areas pulling together on a small regional level, the 9CC Group has been confronted with the need to develop a model which accounts for the complexity of fair distribution, considering some areas with smaller populations may be bringing in relatively higher level of funds against other areas which may have higher socioeconomic needs. The model they have developed includes consideration of population, distances from turbines, and the Scottish Index of Multiple Deprivation. This then relies on confirmation from local community councillors for the locality selected through the evaluation using the model.

The origins of such a group and collaboration was wrought with challenges and difficulties. P21 revealing that the first meeting on the idea lasted “under 14 minutes”. It was only after 2 years and the assessment of the matrix model, alongside careful patience and the building of trust across the area that support grew. At this point, the group proactively approached energy developers in an “assertive” way to sign up to the concept and commit their respective benefit funds. P21 was also candid that the formation of the group required a significant amount of voluntary work. A primary motivating factor was the idea that the council would end up receiving the funds, as discussed earlier this was viewed critically with attachment to past experiences of so-called vanity projects.

> “The consequences of not grasping that opportunity, are that the funds will directly go to the Council to be managed. You know, we keep saying that we're fed up with organizations getting parachuted in and telling us how to spend our money. If we can't demonstrate that we can simply talk and agree, then the developers have every right to get somebody else in to tell us what to do.” – (CEO Community Energy Consortium - P21)

When queried on the validity of the groups claims of democratic governance solely through the elected community council members, P21 was eager to defend the community council governance, and did not suggest any future in which more participative, citizen led governance was on offer. Citing the statutory status of community councils, P21 felt that this made them accountable, and that resolving their under-resourced nature through schemes like the 9CC would allow them to fulfil democratic potential. They stated that the process would be reviewed internally on an annual basis to ensure good governance and

accountability. Further, they highlighted the inclusion of local authority and energy developer employees on the board to contribute to the governance process.

As an established organisation with buy-in from the local authority and developers, it felt natural to enquire about looking beyond community benefit to more direct approaches such as shared ownership, or investment in local community energy projects. P21 suggested that from experience developers are not favourable to shared ownership, and that it's unclear whether it would become more of a liability than an asset. The role of Local Energy Scotland, and the government was highlighted to better inform on the benefits and risks associated with shared ownership. They observed that when shared ownership had been mentioned by developers in the past, it was a "tag on at the end of a planning application". Overall, this suggested that the group was hesitant to alter the ownership dynamics of the evolving energy industry in the area.

Exploring the idea of investment in local energy projects, and in particular the idea that the income governed by the 9CC group could be used to invest in the renewable heat transition, including technologies such as MWT, P21 felt it was beyond the capabilities of the group at this stage. They reinstated that the role of the group was to manage and administer community benefit, not to be the owner of assets or provider of local services.

> "When we mature, I do believe that we will be commissioning projects that are of a renewable energy theme. I know one of the things that's been rooted here is housing insulation solution and people mention heat pumps and things like that. We're a few years away from that in terms of what our resources are that can actually deliver, what our knowledge is of that and how we actually plug into that… That attention is exclusively sorry, predominantly turned towards community benefit. At this stage you could, I would come back in about 3 years, and ask me that question, and I would be able to give you a more positive answer on them." – (CEO Community Energy Consortium - P21)

This reluctance to engage more commercially, or as community finance to plug gaps, was considered in the context of a need to engage and build trust with the communities as a benefit fund manager first. The exploration of the 9CC model provides insight on how delivering on a regional level has many strategic and capacity associated benefits. It may also demonstrate some of the limitations of the benefit fund model, and why the findings from previous sections suggesting inclusion of public or local ownership could be more effective at achieving a just transition.

8.4.7 Conclusions: delivering and actualising MWT imaginaries

In this section delivery models were explored through the findings of the data collection. First the case of Midlothian Energy Limited was examined through participants involved with the project, as an exceptional case in Scotland learning on heat network delivery was highlighted. First, the role of a designated heat network role and champion in the council was examined, where the role allowed for full-time focus on the vision, clarity and detail required to bring all aspects together. Furthermore, co-creating solutions together with partners in industry or the council is critical, risks are reduced and shared in this case. Starting small with a robust project that can gain enough interest and be successful on its own, with potential for expansions later, was identified as important. The council felt that a 50/50 decision making arrangement is critical, even if shares are diluted in the future, the governance remains even between the local authority and the commercial company. Partner contracting was also deemed key in order to avoid profit leakage through internal company accounts. In the MEL model, capital is recovered from new connections, this could be a housing developer, or new institution, commercial or residential, not from heat sales. This model allows the council to socialise the cost between profitable and loss-making projects and recover capital quicker than in the case of wind farms for example, as connection fees are received immediately.

The need for a whole systems and staged approach was also discussed, where other forms of renewable energy should be integrated with MWT and heat networks to most effectively meet needs and complement one another. A solar farm may not provide many jobs, but alongside a heat network with storage capabilities, low energy costs can attract and encourage entrepreneurial activities, such as food growing, creating social cohesion, as well as environmental good. Staged approaches mean that depending on arrangements, borehole drilling associated with MWT may be recovered by energy savings across project lifetimes if used internally, or by a heat purchasing agreement that relates to drilling costs. Gateshead, as was the case for MEL, began with a successful initial project at a smaller scale, that will roll in phases to reach new anchor loads, gaining new connections along the way. The pricing offered can also be influenced by a staged approach, where maintenance costs are reduced over time as more connections are made per pipe quantity, this saving is then passed onto customers as part of a guarantee.

The role of community was analysed in depth, beginning with shared ownership models. In order to empower communities, legislation that mandates share offers and is supported in negotiation by non-departmental bodies was suggested. However a distinction was made between financial shares and a governance role, with the latter being more important for

improving democratic controls and bringing communities on side. Community owned models have genuine buy-in and being able as a community to see yourself in the project can be as valuable as any monetary benefit. Postcodes can be utilised to prioritise locals in share offers, and making contact to local groups such as sports, art and education groups can support community-ownership aims. Further, council procurement policies favouring community energy groups could provide huge upside for both parties. The scale and complexity of MWT infrastructure means that wholly owned community projects may be a challenge, however shared ownership has the potential to empower communities, giving the possibility down the line for them to invest in their own projects. Partnerships were emphasised as being key in the development of heat projects, as private sector expertise compliments communities and local authorities driving the project, and a government framework that facilitates. A community energy tariff on energy companies was suggested as one way in which shared ownership could be enabled, driving down risk as the community heat model is de-risked.

Beyond ownership, engagement with communities was discussed at a broader level in relation to heat projects. As heat networks and MWT are geographically specific and local monopolies, they lend themselves to the community being a key stakeholder and determinant in their development. Places are most influenced by fellow community members, making them an obvious key player in heat transitions, particularly in a world where the state is not trusted or unwilling to engage. Meaningful community involvement must be present from the start, and statutory obligations could be developed to support these processes. Communities may wish to invest in other community groups through forms of community energy finance partnerships, sharing skills, capacity and knowledge as well as financial investments. Finally the role of community benefit funds was explored through the case of the 9CC group in particular. Communities are often pitted against each other through benefit fund processes, and local authorities may manage them for political motivations. Further, the amount of money involved may be overbearing for some communities, who suddenly need to set up effective governance bodies. Benefit funds also prioritise low-level non-strategic projects too often, whereas areas such as active travel and transport connections, entrepreneurial activities, net zero energy, young people and housing should be spending priorities from a strategic perspective. Finally any distribution model needs to account for the complexities of an area beyond distance to energy such as population and multiple deprivations.

This chapter presented the findings from the sectoral interviews conducted, traversing themes of the energy economy landscape and regimes of today, and the specific

considerations of MWT, as well as pointing to alternative approaches which point to different political economies, imaginaries and models of development. The following chapter presents the community case study findings, before these two chapters are brought into dialogue with existing knowledge in the discussion chapter.

Chapter 9 - Community Case Study Findings

In this chapter the results and analysis of the second phase of data collection are presented, which involved a focussed case study on the former mining town of Cardenden in Fife. A detailed account of how the research occurred was provided in the methodology chapter, including the phase 2 data collection and is summarised again here. The sensitivities of extractive research practices generally and the particularities of former mining areas were of high concern as this phase of research was planned. Distrust and disinterest were encountered in several potential case study areas, despite all attempts to be as transparent, accessible and reflexive as possible, considering the baggage afforded by my representation of what might be deemed an elite-institution. Eventually the relationships built with those Cardenden proved fruitful and appropriate enough to pursue the case study.

The chapter is presented differently to the previous results chapter 8, as the analytical framework was deployed with a different emphasis. Whilst the relationship between different imaginaries, political economy, hegemonic and counter-hegemonic ideas as well as conceptions justice and fairness were at the heart of the case study analysis through the use of the framework, the different expertise and priorities of the participants provided a different and complimentary focus than that found in chapter 8. Whereas as the sectoral professionals interviewed in chapter 8 whereas focussed on the stages of imaginaries relating to strategic thinking and delivery, in the case study the communities were more focussed on imaginaries relating to place, and the kinds of interactions they felt were important between a MWT and wider energy industry, with place. Thus, the narrative flow and structure of this chapter follow the way in which the workshops unfolded, beginning with a broader reflection on characteristics of place, emphasising what was important, before relating it to political economy, energy systems and finally MWT.

The chapter begins with a discussion of the background information relevant to the case study and the workshops in 9.1. In 9.2 imaginaries of place where first discussed, before working towards the wider economy in 9.3, the wider energy system in 9.4 before narrowing in on MWT in 9.5. Finally in 9.6 a selection of postcards from participants which reflect on a future Cardenden are explored.

9.1 Background to the case study: Cardenden

Before exploring the findings from the data collection, context to the case study is necessary to better understand the community being researched. Today, Cardenden is the name given for the general area of the town located in south central Fife, which is comprised of the four

historic mining villages of Auctherderran, Bowhill, Cardenden and Dundonald, known as the ABCD villages locally, Figure 24 demonstrates Cardenden's position within Scotland and central Fife.

Figure 21 Maps positioning Cardenden within Scotland and Central Fife (taken from Google Maps)

Records indicate coal mining began in the area as far back as 1532 and continued until the 1968. Figure 25 below demonstrates the volume of pits in such a small part of Fife. At its peak, Cardenden's coal mining sector employed up to 2,670 men which was around a third of the local population. The population had increased rapidly as coal mining and rail transport were developed in the area and today demonstrates the enormous influence of

industrialisation on Scotland's rural communities.

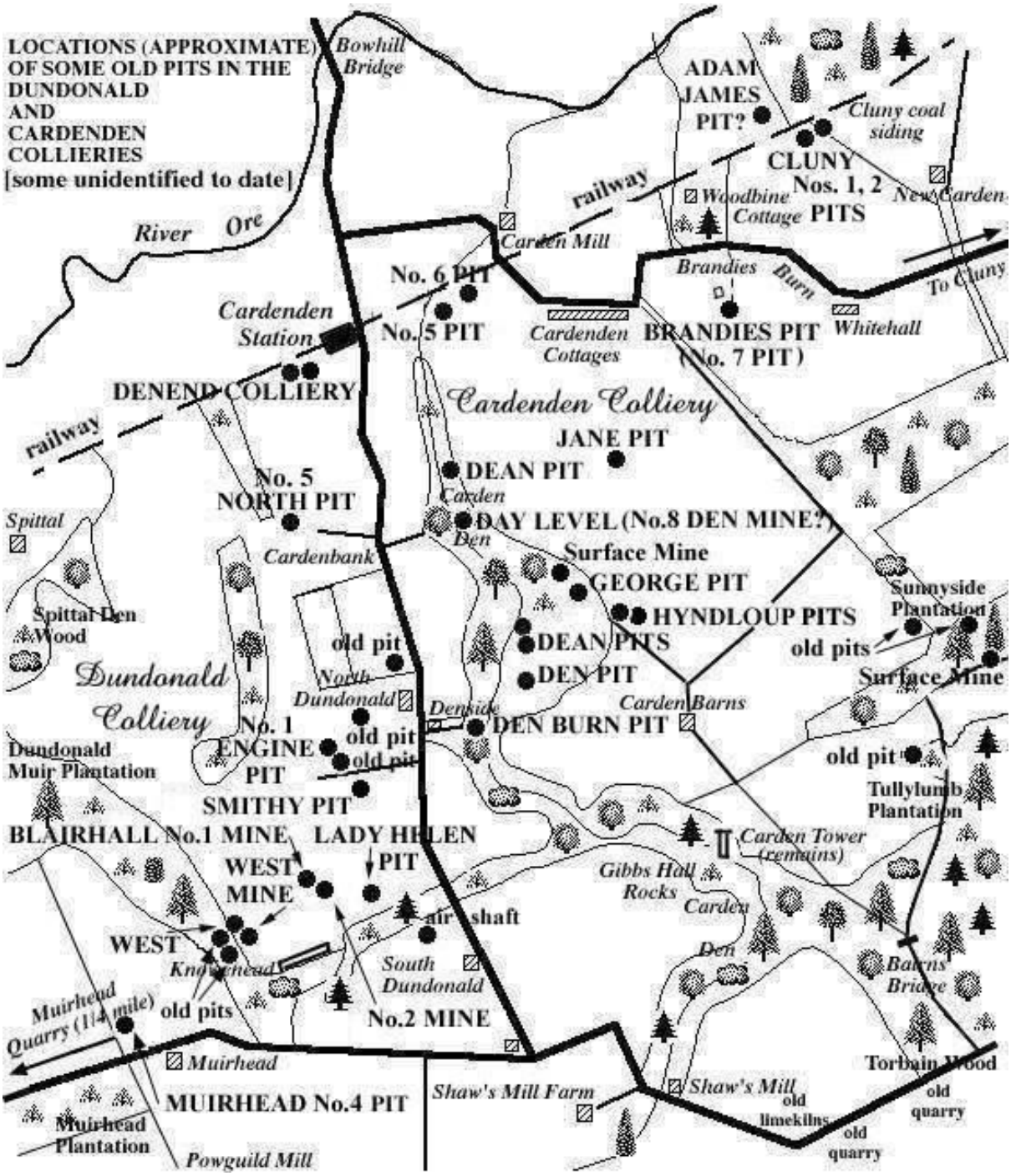


Figure 22 Map demonstrating the volume of pits found in the Cardenden area (Taken from Central Fife Times – Some early pits of Cardenden)

The last disaster in the area was at the Bowhill colliery in 1931, all in all over 300 people lost their lives working at this colliery. In surrounding areas to the west around Lochgelly and the nearby town of Kirkcaldy, coal mining continued on with the final pit at Frances around 7 miles away from Cardenden closing in 1995. As discussed in the context chapters, the closing of smaller pits and the consolidation of the workforce into larger, modern collieries

was a driving force behind these shifts observed in the area, as well as the overall contraction of the industry across these decades.

According to the National Records of Scotland (2022), the population of Cardenden sits at just over 6000 as of 2020, with 60% of the population of working age. Half the households are owner occupied, and 42.3% are social rent, with the remaining 5% privately rented. The population is above the Fife average in child poverty rates, working age employment deprived, as well as total population income deprived, at 17.7% for the latter as per the Scottish Index of Multiple Deprivations (2020). There are no major industries in the town, beyond a recycling facility on its edge, with the high street suffering from many of challenges observed in the UK over the past decade. Therefore, the nearby major towns of Kirkcaldy, Glenrothes and Dunfermline are the source of much employment locally, requiring locals to leave the town for work.

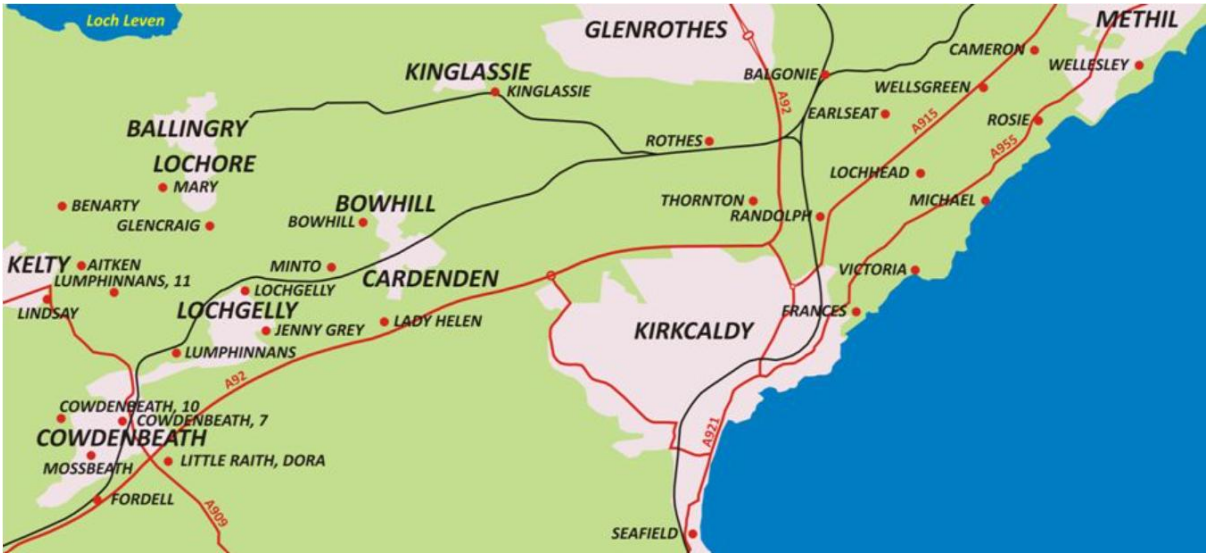


Figure 23 Map showing all major Fife Coal collieries denoted by red dots, including Cardenden. Grey areas show major population centres (retrieved from Northern Mine Research Society Webpage)

Cardenden sits amongst a rich history mining in Fife as demonstrated in Figure 26, MWT is generally unexplored and there is no history with the technology, beyond the pilot scheme that once existed in Lumphinnans decades ago.

The Cardenden Development Forum is the main community led group in the area, and functions similarly in many ways to the traditional development trust model, though it is not a legally defined body. The development forum has initiated several activities in the town, underpinned by fiver year action plans which were co-produced with wider community participation. They have created subgroups, such as the Cardenden Environment Group and opened their own charity shop, where proceeds go towards various improvement projects in

the town such as path, green space and playpark restorations. The community bonfire, Christmas lights, and village fair groups all play critical roles in organising important events for the community, that where at one time delivered by the council.

The Cardenden Community Council consisted of 12 members at the time of the data collection and operate in a similar fashion to community councils found across Scotland, aiming to express the views of the community to public bodies relating to the local area. They are the most local tier of elected representation in the area and are run as a voluntary organisation. The group work in tandem with the development forum on many of the issues mentioned and also offer their own micro-grant fund of up to £250 to locals.

Ore Valley Housing Association is the major provider of social housing in the area and is very engaged locally with the community. Ore Valley have invested in many local projects over the years and are behind the redevelopment of the former Bowhill Miners Institute, which was lying derelict, of which the History group were also involved. Ore Valley own a single wind turbine and own a subsidiary in which they replace gas boilers for their properties locally. They are exploring heat transition options for the town and are leading on a feasibility study for a heat network for Cardenden, which could involve the use of minewater but initially explores waste heat opportunities from a nearby recovery facility. At this stage, exploration of Cardenden's heat transition is being led by professional from Ore Valley and has not gone out for wider community consultation as yet.

The Cardenden History Group has been active since the 1990s and is a well known part of the community. Noted as having a particularly strong community of history enthusiasts, its appeal 'stems from its authentic connection to the coal mining industry'(Callum Fraser 2025). The history group meet weekly, give talks and presentations locally, publish books and pamphlets and engage locally with community orientated activities. As mentioned, they are often consulted on by partner organisations when developments occur locally where their expertise is valued when discussing the future of the town.

The first workshop with the Cardenden History Group and friends was held at the Corrie Centre, a council run community multi-purpose space. The history group hold their regular meetings in the space, which has remained a vital venue for the area since its opening, hosting day trips for the elderly as well as for kids. It is named after a local poet Joe Corrie,

and I was informed that it was affectionately thought of, the building is shown in Figure 27.

Figure 24 The Corrie Community Centre where the first workshop was held (authors own photograph)

The second workshop, in which participants from the Development Forum, Community Council and Ore Valley Housing Association took place at the Bowhill centre, formerly the Miner's Welfare Institute, shown in Figure 28. The council run the venue now as a multipurpose community space and the Development Forum hold their meetings within the venue. Thus, the workshops took place in a familiar and comfortable setting for the participants.

Figure 25 The Bowhill Centre, where the second workshop was held (authors own photograph)

The findings from the two workshops are now outlined below. They begin with an exploration of place, community and history. Following this, community perspectives on local energy developments and the wider energy system are discussed. The chapter then focusses in on MWT technologies and what kind of development of the minewater would be most appropriate and desired from a community perspective. Finally, it explores the visions of a future Cardenden through a post-card exercise and concludes with a summary of the findings.

9.2 Reflections on place: identity, community & history

This first section summaries the reflections of place given by the participants of both workshops. As discussed earlier in this thesis, bottom-up, grassroot and justice informed approaches to energy development embody co-production as a central pillar. Meaning that rather than fitting community needs to a preconceived energy development, community context, understandings and ways of being is a more appropriate starting point. Therefore, at the beginning of these community workshops, participants were invited to explore the dimensions of place and community that were important to them, eliciting a range of stories, knowledges that ground and contextualise the energy and MWT specific insights that follow.

9.2.1 The community in general

As one might expect, the participants were nuanced, informed and passionate about life in Cardenden, tracing historical, political and cultural threads from past to present. Across both groups there was unanimous agreement that in spite of the challenges the town has faced, a strong sense of community remained. Various groups were mentioned that bring together the community such as the development forum, a bonfire and a Christmas lights committee.

> "I think in sense of community, Cardenden still has quite a lot of community spirit about, there's quite a lot of various groups still in the village… there is a sense of some of the groups starting to dissipate as folks get older… in years to come that might not be as visible as its been in the past" – Community Development Group Participant

Throughout the early parts of the focus groups where we focused on what about living in Cardenden was important to them, participants highlighted the leading role of community champions and or leaders, generosity and sacrifice that many individuals give in the service of community cohesion and local wellbeing.

> "…my memories growing up in Cardenden are really fond memories and that sense of community that existed in the fifties and sixties still exists today. We've got a good number of stalwarts that keep the community groups going. And the generosity, to be honest, is legendary." – History Group Participant

Participants spoke to the evolving sense of community experienced across their life as the area of Cardenden changed. The town was originally four villages, which then became Cardenden, and those from different villages still consider their identity on these terms. The relationship to areas of the town permeated throughout conversations on identity, nature, place, the local economy and the experience of the coal mining industry. One might suspect that a degree of this localised identity would also be present in future energy developments that are placed by particular areas of the town.

> "We had our own experiences of the mines, because I couldn't have told you anything about Bowhill, but I could have told you about Dundonald because even when it shut down we were in about it seeing what was going on, but I couldn't say that about Bowhill and I don't know what Cardenden did at that time" – Community Development Group Participant

9.2.2 Community links to coal mining

Throughout the workshops, a nuanced and complex picture emerged relating to the legacy and experience of the coal mining industry. Two former miners were present in the workshops, one at the community development group meeting described it is “not a pleasant job. It put money on the table and that's basically what it is”. They talked about how at the time in Fife, employment options were not wide ranging, stating that you either worked in the mines, farming, fishing or a furniture shop down the road in Kirkcaldy. Another participant, who did not work in the pit himself explained how their father, a miner, was against following in his footsteps and was keen to not present a romanticised image of the mining past.

> “My faether, was a fireman in the pit, when we were born. That's the first thing he said when we were able to talk, if there's one thing your no gonna do, it’s go down in the mines. (You) can do what you want. You're not going down the mines.” – Community Development Group Participant

Across both focus groups, participants spoke at length about the influence and importance of the legacy of mining closure. In the history group, a discussion emerged around the ways in which Cardenden, as a mining town, gave them an international perspective and identity that had been lost. They described how over various periods, there was cultural exchange and solidarity between people in Cardenden and places like Russia and France, including visiting bands, dancing groups and miners themselves. In light of discourse around ‘left behind places’ which focusses on areas of deindustrialisation, its notable that the mining industry was able to provide a sense of global citizenship that has been lost under the neoliberal and green energy regimes which have replaced it thus far.

> “And in 1984 during the miners’ strike, the Russians reciprocated the support. So come Christmas, the Russian Trade Union movement and the French in particular made sure that every be miner that was on strike had presents because that institute up in Bowhill was the gathering place for it.” – History Group Participant

The impacts of closure were discussed in passionate, and considerate terms. There was an acceptance of the need to move on from coal mining, and romanticisation of the work itself was not a feature. However, the way in which it occurred was critiqued, with it being described as “devastating”, and that it “halved the size of the community in a stroke”. One History Group Participant described the saddest part for them being the lack of memorialisation, and that “they took away every vestige in memory of that industry”. The only remaining pit wheel was salvaged by a local who had pulled it out of the river, and they emphasised that the industry, government and council had let them down in this respect.

Several participants also discussed the loss of population and livelihoods, in contrast to the period of the 60s where people moved around different coal fields and gained alternative employment Another History Group Participant had particularly strong impressions from this period of pit closures:

> “And (name redacted) and I always speak about that because I mean it always had the impact, the pit closing down, more or less on adults, but unfortunately the children, I mean for a lot of them they were just taken away from streets, taken away from the school and then taken away to Yorkshire, Nottingham and everything. But bairns in those days were just expected to go with the flow. And we always say that it was horrible when you were between the years, say eight and say 10, you used to go into your classroom and think, oh, where's so-and-so? Because there were empty seats and the amount of removals vans that were here, there and everywhere.” – History Group Participant

9.3 Interactions and tensions with local development and the wider economy

As the workshops progressed towards discussing MWT and energy systems, a wider conversation relating to local governance, development and the economy was had in both groups. The Cardenden Development Forum was the focal point with many insights on their experiences revolving around factors such as trust, resources, capacity and partnerships. Participants felt that increasingly over time, stewardship and management of the town was left to the community themselves, with the local authority and governments role diminishing.

> “So I would say in terms a local level, a local voice in the village, we've got the fight tooth and nail to get stuff done.” – Community Development Group Participant

The emphasis on trust between the Development Forum and the local community and businesses was made in both focus group events. The interactions and tensions with development, planning and land use both private and public was a major discussion point, where frustration was expressed at the lack of participation by local people, as well as the ever reducing role of the council in stewarding the local area. This section will focus on these tensions.

9.3.1 Taking on services and local partnerships

Participants were eager to celebrate the work done by community organisations to provide for the area. A Community Action Plan was developed with support from the Coalfields Regeneration Trust in 2013, around which the Cardenden Development Forum was

established in order to take the plan forward. The Development Forum has stepped in to take up activities that other groups have previously managed, and their management of the community shop allows the group to fund smaller projects around the village. Participants stressed the need to work collaboratively with other private and public organisations in Cardenden.

> “But again, the group have been collaborating with the businesses and have built-up better relationships I would like to say, that have been able to help out with materials and resources and stuff like that. So, we've seen a huge improvement in the paths and some of the some of the open spaces. I get the impression businesses trust the people in Cardenden.” – Community Development Group Participant

Older participants spoke to the past, whereas one History Group Participant put it, councils “done things, right across the board”, but that the lack of funding for local authorities has been devastating. In one example, a participant discussed how the community set up a playpark committee, raising over £300,000 towards the redevelopment of parks. Despite having no choice but to pick up services where the council had retreated, participants felt that this situation increased resilience and empowered people in the community.

> “So if we want these things, we've had no choice in the matter to do it. And then, I think from that, then the children, the people who are growing up in the village, are then seeing that actually what can be done just by putting a little bit of effort in. And actually, then we get a say in what happens, it's not the council who are deciding.” – Community Development Group Participant

This feeling of insufficient local government was exemplified in a discussion about the recent sale of local woods to a quarry company, where the loss of valued community green space was put as much at the council’s fault as the developers.

> “Exactly. We forget it's not the quarry company's fault. It’s the council they should be strong enough and willing enough to say no you're not getting that.” – History Group Participant

9.3.2 Building trust

Throughout, participants expressed a feeling that the empowering nature of community development - of communities taking on place-based management activities - also built trust within the town. Members of the community discussed the changes they had seen in the decade or so since the establishment of the development forum, where people from within the village have been at the heart of local action in supporting the community and the local

environment. They also spoke to the role of the local schools, where young people are exposed to the work done by the community, demonstrating what's possible and further nurturing a sense of belonging.

> "If it's done through the development forum, the environmental group, it seems to belong to the people. If the council was just coming in and doing this, sometimes you wouldn't want what the council would do anyway, but people then have the sense of belonging, they take ownership." – Community Development Group Participant

The community led actions in Cardenden were made extremely visible through the various community networks, and participants were keen to stress the impact of this on young people in the town. Community projects garnered more "respect" from young people, meaning that young people had not been involved in vandalism on any of the community led developments. Beyond gaining respect from the community, participants emphasised the importance of developing trust with local businesses, the council and other organisation such as the local housing association and wind farm benefit funds.

The Community Development Forum ran a survey in the town to inform their second action plan, having come to the end of the first. The top priority was the regeneration of brownfield sites, with a particular focus on the old high school Auchterderran which has lain in ruin for many years. There is a well understood link between the impact of derelict land and brownfield sites on wellbeing, beyond the environmental aspects, and thus it is no surprise to see it as such a high priority issue. Participants were critical of the council, and in the case of the school site, focussed on the transfer of ownership, suggesting it could be gifted rather than through an asset transfer which they were sceptical of.

> "You want your village to look nice and if you drive through just now you say come to Auctherderran and then you come to the derelict old house, derelict pub which was an icon in the village and it's a shame because it is a lovely area, but you've got these things that are no fault of the community." – Community Development Participant

9.3.3 (Lack of) participation in local developments

A key critique and tension expressed by participants was the lack of meaningful engagement and participation in planned developments, both from the private and public sector. There were mixed views on the local authority, with some citing a productive working relationship, cultivated over years with sympathy for the difficult position councils increasingly find themselves in. Others were more critical of the willingness of the council and other organisations to truly engage or act upon community informed processes. One participant

from the community development group event shared their experiences from being on the community council, where the local authority would consult with them, however they couldn't remember a single time of disagreement were the council didn't go ahead with their original plan. Another participant from the history group shared the following:

> "From my experience, with Fife council absolutely, definitely not… cut and dry before we even have a meeting. I mean I know a lot of it is a Scottish government thing, and I'm definitely not getting at the community council cos they do a fabulous job, but a lot of the things are already cut and dry before there's even meetings." – History Group Participant

As the participants discussed, one of the results of experiences of poor engagement is an apathetic and disillusioned population. This is where non-meaningful engagement can be extremely damaging, creating situations where attempts to bring in sceptical populations in practice creates further, embedded distrust where people feel used. One participant expressed the view that because of the complexities of the planning system, there was little to no chance of communities ever overturning decisions. They felt that it was only when situations became dire, and communities responded by "about rioting" that changes can occur, sighting one example where community discontent and action resulted in a £120 million safety development to solve gas flaring at the local chemical processing plant. The community demanded a meeting, challenging the organisation on their minimal contributions in community benefit over the years and sought to gain a greater share of their profits, this "changed the dynamics" and the safety reforms were made. However, they cited the exceptional circumstances of this case, where visible health impacts raised the stakes and urgency, believing that it shouldn't have to only be in such conditions that communities are heard.

> "I feel there's apathy in the area because they probably think it's a foregone conclusion. I'm in the community council, in every single consultation, my husband and I go along but very few people from the community go and that's not a criticism, it's just an observation, and I think it's as X says, they just think what's the point. And to be fair, a lot of the ones most recent ones for example, was about forestry and land Scotland felling the woods. They're going to go ahead with that... it's a tick box." – History Group participant

One participant in the community development group raised the engagement process example relating to a new waste energy recovery facility just outside the town on the site of a former open cast mining site. They understood and "appreciated" the project from an environmental and energy perspective, but they felt the town, and the community council

were never given a voice. As described below, they felt that what could be deemed a co-production approach would have been more suitable, rather than telling the communities what is already decided.

> “Actually you are probably doing it the wrong way around. You are actually asking, what about this site? What do you think? Rather than going well, this is happening. What do you think?” – Community Development Group Participant

A further layer to the insufficient engagement process was expressed by participants, where companies fail to understand the local area and show little interest in taking in knowledge to co-produce elements of development. In situations where communities ae involved in meetings, participants felt it had so little bearing on plans, with one participating stating that the only solution was the involvement of “honest government”. The lack of faith from the community in any meaningful engagement process, and for the public institutions to protect or support the community.

> “There's also a problem that a lot of these companies I think are quite ignorant of the setup in this area. At the last consultation the company that want to build battery storage units had an event in the Kinglassie area, when in actual fact Cardenden is closer to where they're going to build. So when we said to them, why aren't you coming to Cardenden. It's an ignorance of what the lay of the land was.” – History Group Participant

A Participant in the history group stated, “the community has been bought off for pennies”, when discussing previous engagement processes that have resulted in small community benefit packages. In another case, discussed by community development participants described cases were the developer continuously changed the plans without properly informing the community council, leading them to feel “duped”, resulting in them feeling like “they had no clue what they had actually agreed to”. In the same case, they also described a public meeting relating to the development, where not a single elected counsellor attended the meeting, and how it added to the feeling of apathy in the community.

9.3.4 The wider economy

In the community development group, the wider economic system was also under scrutiny. Participants bemoaned the singular focus on short term profits that drives all activity in the area. At no point in the discussion did participants discuss their priorities in profit terms, but did occasionally qualify their statements by saying things like, as long as someone can fund it, or if the figures add up. This conversation can be summarised by the quote below from the community development group workshop.

> There's one thing that would determine how these things move forward and that's money and how much is going to cost and whether that whoever's going to run in it will make a profit because if their no going to make a profit, they'll no touch it. – Community Development Group Participant

Conversations in the workshops flowed into wider discussions around the economy, and the experience of decline in Cardenden and the surrounding area since the 1980s. Jobs and employment was the central focus, and when asked what top priorities for the local area would be, jobs were unanimously the leading choice with one participant from the history group stating, “Well, from my point of view, again, Fife desperately needs to invest in jobs. We've got to invest in people”. A strong dissatisfaction with the economic policies of successive governments across the last few decades was expressed, with the damaging impacts felt by younger generations highlighted.

> “There is no jobs being created no matter what government is in this country. I feel strongly about because I've seen so much youngsters with so much good, so much potential. What are we doing? We've still got the highest drug (death) count in Britain. And they throw money at it, no you've got to change the system. Really change the system. If these youngsters have got the ability we used to have good training schools, Fife engineering group, the dockyard, the Coal Board had great training schools. They could have kept the training schools going, but no, they sacrificed everything.” – History Group Participant

Participants expressed frustration with the wider economic landscape and that it impeded the creation of a sustainable community that worked for younger generations and would encourage them to stay in the area. The significant levels of deprivation were also highlighted where people facing economic challenges have to leave the area on sparse public transport routes in order to find employment.

> “But if you're wanting to make a difference, the challenge in this community is that they've got a high level of deprivation across the four A, B, C, D villages (Cardenden), which means that they've got to leave the area if they want to work… there's nothing in Cardenden itself. I mean X is away to university, what's her chance of employing herself in this area”. – History Group Participant

Several participants felt that over time the town had become less connected as public transport services were cut and scaled back. They felt that as wealth and people were drained from the town, life was being made harder through reduced services, which only resulted in more people leaving who had the ability to.

> “I've been here 20 years exactly and when I first came there was four buses that went to Kirkcaldy an hour, two to Dunfermline, one to Ballingary and one to Glenrothes. You now have two to Kirkcaldy, none to Baillingary, one to Dunfermline and one to Glenrothes…and our trains now go dot to dot they don't go around the circle anymore. The circle doesn't exist. So actually there's quite a lot of things that, we have tried to fight with. But actually, up against the big cats, we just are banging heads. We were never consulted on that. – Community Development Group Participant

9.4 Reflections on the energy system

After establishing a detailed understanding of place, community, and tensions present in local development as well as wider economic perspectives, the workshops progressed to focus more specifically on the energy system.

The prominent thread running through discussions on the energy system was a feeling of distrust and scepticism, particularly relating to the ways in which the energy transition to renewable alternatives is unfolding. No critiques expressed by participants mentioned climate change, the need to transition, or a positive defence of fossil fuels. In fact, multiple participants expressed a desire, mostly from a pragmatic sense, to engage and “move forwards” into systems of the future. Criticisms were however directed at how the transition is unfolding and could nearly all be traced or linked to scepticism expressed in the previous sections of this chapter, relating to systems of planning, governance, profiteering and a general distrust of both private companies and government. This discussion began with the strong perspective from a history group participant, as shown below, before the granularity of energy critiques were explored.

9.4.1 Critiques of energy development

Participants presented a range of critiques of renewable technologies, including solar power, wind turbines and battery storage. An understanding of the intermittency of renewables was present throughout, with participants critical of “paying turbines to shut off” and the lack of integration of battery storage with household solar power; “why are they so scared to tell us about those things?”. Solar on rooftops was critiqued as being sold on false promises of its impact, as well as the maintenance risks associated with electrical cars. The ever increasing wind farm placement across local landscapes that hold value based upon their natural exploits was also discussed, alongside a sceptical view on the true recyclability of their components.

Throughout these wide ranging perspectives was a feeling that the public are never told the full truth, and that dishonesty from different groups managing the transition created opposition. One participant in the history group event stated that they had no negativity towards new heating solutions, but they wanted absolute honesty from government bodies, and felt that too often public funds are handed out to schemes that “become a disaster”. Another participant expressed the following:

> “See, the thing is these companies that are coming along, I think they're predominantly overseas companies that are finance and all the rest of it.. The government can say what they want, those companies don't care…They’ve had discussions with people that own the land where they can get it cheapest, where they can get the best prices. We are never party to that to say, okay, I see your logic now what you're doing now is going to cost X. We don't see the other outline ideas that they're coming up with. That's the dishonesty part that I don't like.” – History Group Participant

Participants at the community development group felt that energy developments were given preferential treatment by planners and developers and that in the past the community had little say over developments that have affected them. A planned battery storage project was discussed, where a large area of land outside the town will be used for a substation, cabling, and an inverter alongside the batteries, impacting local farms whose land will be dug up. A heated discussion followed where participants expressed disappointment with the impact the plant will have on the area as well as the distribution of benefits.

> “But what people don't understand is that private industries are now taking over where they're going to be taking or buying, should we say power at a cheap rate and then selling back and making a massive profit, is that going to be shared out? It will not be shared amongst the community. That's what I'm saying is we are feeling the impact of that, because that would be in our community but they’re not sharing it.” – Community Development Group Participant

The inclusion of locals in this battery storage development was also criticised with one participant from the community development group describing it as a “tick box exercise”. A feeling of dishonesty on the part of the developers relating to the actual socioeconomic outcomes of projects was expressed, and one participant felt that community ownership of some kind should have been available to provide fairer participation and benefit locally. They explained how no one had treated them with “intelligence”, demonstrating how many homes energy needs would be supported by the battery development.

> “We've got no voice in that. What will happen is that there'll be an arrangement, oh we'll give you X amount of money, but they won't actually allow you to come and say, why did the community not get an actual option to buy into it? Because they wouldn't then make a bigger profit… The community should have been allowed to invest in it at the outset, but we're not because it's a tick box exercise. We've been told that's happening, how wonderful it'll be. And they're not actually saying the impact upon the community and the amount of money that that's going to make over the actual lifetime, life span of the project.” – Community Development Group Participant

The current energy system and collection of energy industries were compared by participants to those of the past, with direct reference to the coal industry. In particular the costs and benefits were under scrutiny, one participant raised the increasing cost of the standing charge and that they did not see the benefit of it in the energy services they are exposed to. As mentioned previously, there was a real sense of detachment from the modern energy industries and communities themselves, in stark contrast to the history of the mining industry.

> “If you talk about the coal industry. The coal industry was a heart in the villages of Scotland, the majority of them, I think. But nowadays the energy system is, if you want to say overseas, unseen, it's just names, therefore it's now talking instead of being jobs in the past for our moms and dads and granddads now it's how much it costs, it’s getting too expensive.”– History Group Participant

A further concern expressed in the history group event was the encroachment of energy infrastructures into green space. This worry was raised again later with respect to imagined MWT development, however from lived experience participants are already dismayed at the land use in the local area and their lack of input on these processes.

> “…The green space, because obviously the mines shut down in this area and the land was reclaimed and some of it now has got housing on it. But what I've seen over the last year is that all the plans for energy, we've got a whole fields of solar farms going in from Auchtertool to here. We've got one going on the way to Kinglassie. We've got these battery storages that are going to go in green space. They're not going in the brownfield at Westfield, they're going in the green space. We seem to be losing a green space to promote new energy sources.” – History Group Participant

9.4.2 Local engagement with energy

During the workshops, participants discussed past and ongoing engagements with the energy system in Cardenden. Various partner organisations, led by the Community

Development Forum and the Ore Valley Housing Association are in the process of investigating what a low carbon heating system for Cardenden would involve. Participants explained that a feasibility study was already underway to explore a heat network utilising waste heat and that initial insights were promising. However, they foresaw the main challenges in the actual delivery of the project tied to the economic, planning and capacity dimensions.

> “The Cardenden community development forum have just funded, applied for a grant for £15,000 to fund a feasibility study on using the waste heat. There's a state of the art recycling facility, and to use the sort of steam that's coming from that, they are apparently producing too much steam and they will be fined by SEPA. So, the idea is that that steam will be channelled in to houses for social housing. So, I can’t remember who the grant was to, but it's a feasibility, and apparently it's feasible but now we need to cost it because it might be, although it's feasible that the cost to put the infrastructure and whatnot, it's too much.” – History Group Participant

Although minewater is under consideration as future energy resource, the idea of a heat network in the town focuses on tapping into the already existing waste heat facility and the implementation of the heat network. Perspectives on minewater are explored in the following section, however, participants from the community development group had perspectives relating to heat network infrastructure more generally, having explored it as part of their feasibility investigations. Several of the participants were aware of the challenges associated with a heat network in the village. They discussed the challenges of the piping to transport the heat from source to demand, with several highlighting this as the single biggest difficulty, mentioning previous experiences of fibre broadband instillation which had disrupted the town for much longer than had been promised.

> ““For me, it is practicality and the infrastructure and getting it from A to B, getting it to the actual customer. Look at the amount work that would need to get done to get the pipework in. How long has it taking that company to run a cable up past your bit up the hill, it's taken forever and a day just to do that one stretch because they're having to dig in amongst all the utilities, you couldn't have just expect it to be non-open cut. That's new pipe work has gone into the ground. So, you're digging up roads, you're digging up footpaths, you're digging up people's property to get that pipe work to the actual customer themselves. So, it's a huge, huge undertaking.” – Community Development Group Participant

The group also had experience constructing a new scout hall. They installed underfloor heating, an air source heat pump, and had been involved in the installation of heat pumps in

a housing estate through a developer. They mentioned pressures relating to gas boiler instillation legislation, demonstrating the effect of government policy in pushing forward transitions. However, by all accounts the new technology had been well received, people were open to the changing of heating systems, with support and education around its use identified as critical. Perhaps demonstrating the role of community organisations in the heat transition.

> “But taking the scout hall as an example, just as a building you're able to start a blank sheet and design all your kind of heating systems around it, it’s got solar panels as. Whereas when you've got existing properties, again try to retrofit systems into them. It could be a bit difficult, but it can be done.” – Community Development Group Participant

One participant who had particular concerns over the loss of green space to energy infrastructures was more receptive to heat network and minewater technologies that would be mostly confined to the subsurface, remaining somewhat unseen.

> “I have a big fear in 40 years time, not have any space left because the green space will have been taken over from new technology. So in some respects, if we're saying they're going to be underground pipes, pipes and hot water or steam or whatever, that's more palatable than things that we have to accept, there'll be battery storage, there'll be wind farms, there'll be solar panels. They're all taking up green space.” – Community Development Group Participant

9.5 Imaginaries of MWT, the repurposing of former mines for energy

After exploring the wider energy system, the workshop progressed to discuss the repurposing of former mines to develop MWT systems. At the community development group event one of the participants who works for Ore Valley Housing Association and is involved in the town’s heat network feasibility alongside community partners, explained that minewater energy is under consideration for Cardenden as a future and supplementary source. The described various factors impeding its immediate usage, such as technical understanding of the resource potential, the coal authorities regulation and planning regime and the lack of expertise available.

> “… And at the same time, even though we might feel that a sense of ownership to use the mine water energy in Cardenden it might not actually be up to us because it depends on the Coal Authority who are analysing the potential that each mine shaft

has. And depending on the distribution network, if they tap it in one place, for example, if they decide to tap it in, Lochgelly we might not be able to access it from Cardenden if it's part of the same, the same tunnels. So it's not everything is up to us. And the Scottish Coal Authority as well as Fife council would have a say in that as they look at the bigger picture." – Community Development Group Participant

9.5.1 A vision for a local minewater system

Clearly the community participants present had some more exposure to minewater than many other communities would, to varying degrees as some had heard nothing until the workshop. There was a positivity towards minewater in the broadest sense, with important and detailed caveats that mostly revolved around trust, honesty and fair benefit to the town. As one participant in the community development group put it, comparing the year round sustained energy provided by minewater to existing renewable infrastructure, "I mean that was the great thing about mine water that as long as that water's there, that heat is there. Whereas solar panels are no generating much at the moment." (it was a rather cloudy run of days leading up to the workshop). Another participant from the community development group was in shock at the potential of resource in the area, and therefore the amount of pits in the area, saying "I'm surprised Cardenden still exists".

Similar perspectives were shared at the community development group, were imaginaries of a minewater future were framed alongside a critique of the energy system. A participant from this group was enthusiastic about the idea of reusing older infrastructure:

> But the energy system at the moment is failing everybody. I mean because obviously at the moment we're paying really high prices for our energy. We're probably paying the most energy per person in the world, for energy. So the energy price cap needs to come down for me. Anything that does that would be beneficial, the idea of using something that's been abandoned makes sense to me. But the fact is how feasible is it? That's why I was interested when you see about the Glasgow project, I said before, I don't think you should reinvent the wheel. If something works then you roll out a scale and then everybody gets the benefit of it. But the fact is we've at the moment our energy system's failing because we've got these huge energy companies that are making massive profits on the back of the individual foreign companies. – Community Development Group Participant

Participants were keen to stress that they are open-minded and future orientated, but grounded and realistic about the ways in which technology change affects life. One of the first questions was about reliability, and that they would need reassurances that it works to at

least a similar standard as their current heating systems. One participant summarised the practical and forward thinking approach that the community development group embodied.

> “I mean I've heard the saying, if you want things to remain as they are, you have to accept change. And I think we have to embrace new technologies and whatnot. I don't know whether it sometimes goes above the likes of the planning and what not goes above their heads and they don't understand it. But no, we've got to embrace new technologies. It is feasible to do and to afford, yeah, go ahead with it.” – Community Development Group Participant

Those participants with a technical background, including a pair of former miners, were encouraged by the storage possibilities offered by MWT technologies. One mentioned their knowledge of the size of local mining shafts, and that “there had to be energy there”. Further, they presented a whole systems perspective which also touched upon community wealth building ideas such as the extraction of value away from their place.

> “We're producing all these kilowatts, wind power up in the mountains, out to the sea. We producing all that and what are we doing? We're giving that away to some bugger that's charging us twice as much to get it back and that's where the mistakes were made and paying somebody to switch the damn thing off and we're paying for someone to switch off. Then we should be storing the power and mine water thing, right? If you've got that mine water done there, if you've got spare capacity, fine heat the water as well. And then you've got a thermal system in there.” – History Group Participant

9.5.2 Concerns around safety and land use for minewater

Despite the broad participant support for MWT from a socio-technical perspective, others did express concerns around safety, and land use. Some participants were concerned that MWT would entail more local areas being closed off due to new infrastructure, others were concerned about the safety dimensions involved when accessing the mines, as exemplified by the participant below.

> “I think one of the questions I would ask though I was wondering because you've got thousands of mines all over the place. But if you wanted to build any place near Bowhill, they've built houses all over the top of it. There'd have to be quite some investigation going on to see where it would be possible to do that level of building.” – History Group Participant

Other participants were concerned about the environmental and health impacts, as the intense red stained minewater is well known in former mining areas. Whether there would be a smell or potential for leakage of contaminated water into their homes was also of concern, although it is well established that any MWT system would treat any minewater brought to the surface and it is generally odourless. Another participant raised the impacts that piping would have on the village footpaths and roads. This was already understood by some participants, as discussed in the previous section relating to heat network feasibility, but for others the existing state of the ground infrastructure in Cardenden was already in a bad state as a result of many other works over the years, and that they would expect guarantees of rebuilding to a high quality for any disruption caused.

> “It would be my biggest thing is yeah, if you were coming into Cardenden putting this new system in saying, we'll give you brand new state-of-the-art foot paths that don't puddle and the roads we’re going to sort that as well. Carry on. That sounds great to me. But actually if you're going to make the village worse than what we've got, then.” – Community Development Group Participant

As mentioned, land use was a concern for some participants as they envisioned MWT development. This issue was discussed in the previous section on energy system tensions, and thus it is likely these past interactions with development that contributed to this concern around future developments such as MWT. Again, distrust of corporate developers was at the heart of this fear, as green space has been lost to the local people, and as explained by the history group participant below,

> “So yeah, again, you're going to be taking away the green space, and forest land Scotland they love their trees, but they've sold up a whole woods in Cowdenbeath to a quarry, they've sold off part of the local forest. So these corporate bodies don't care, it's money.” – History Group Participant

Another participant from the community development group was convinced that MWT and heat networks where the most appropriate heating solution for towns like Cardenden, despite acknowledgement of the resource under their feet. They wanted to see retrofit and the condition of people’s homes prioritised before any exploration of heating solutions like minewater when weighing up the limited resources available.

> “For me I think the technology is great but the main point of this exercise is to keep people warm. To heat their houses, if you've got a housing stock, that's ancient, that's not well insulated, it doesn't breathe properly, the heating systems aren't great. To me the money would be better spent setting a better standard for the insulation in

people's houses and then looking at the air source heat pumps for example" – Community Development Participant

9.5.3 Justice dimensions of MWT development

Beyond the socio-technical aspects of development, management and integration with place-based priorities, we discussed moral and ethical issues with respect to the loss of miners and the legacy of deindustrialisation on towns like Cardenden. Using the prism of restorative justice, these questions were explored through theoretical and practical dimensions. Across Scotland's coalfields, mining disasters resulted in loss of life and in some cases, men were never recovered from pits, making them the final resting place of these workers.

> "What a lot of people forget, not so much this way, but you go to Dysart, go to Seafield, the Francis, the er, the lower Dysart coal there is just cinders and it burnt away for years and years. And the minute you opened that up, woof up it went and that's what happened at the Michael. But if you look, at disasters, I'll be careful here, if you look at disasters, our last one was 1931, without talking in vain, move on." – History Group Participant

Whilst this participant felt confident saying "move on", others described the historical context and detail as critical. In the case of the Fife disasters of the 20th century, including the Michael colliery mentioned, people were recovered. Participants mentioned places like Ayrshire and Lanarkshire where recovery was not possible. In these cases, participants were sympathetic to the idea that other communities would feel differently and that it would be down to those communities, as one participant put it "you would hope it would go to the community to see what they thought". Another reinforced this perspective:

> "The only place I think you'll have a problem with that romantic idea, the reality is there's some pits where people were never recovered from pit accidents and maybe they would think differently, they are graves and personally I would have a difficulty with that." – History Group Participant

Expanding on the discourse around deindustrialisation and the closure of the coal mining industry, questions of restorative justice were discussed, referring to items in policy and academic work that has been analysed in previous chapters. The Scottish Government makes explicit, that the way in which the end of coal mining affected and "scarred" communities can never happen again, whilst the miner's strike pardon act recently came into effect. Scholarship has explored ideas of restorative justice relating to the democratically informed righting of previous wrongs, and how a socially just and fair energy system would

address this dimension. There were unanimous answers from the history group that no obligation was due based upon past harms, and that all that mattered was a fairer future where the community is a meaningful partner.

> “No, none what so ever. If you're talking about bringing cheaper power, that's what the project has got to be about. No inflated prices for power, cheaper power. We've got to forget about our heart and say okay we go ahead. But honesty, morality, fair judgement has got to be done on the whole community”. – History Group Participant

Others in the History group were quick to dismiss any romantic notions associated with the mining past. Describing how although they cherish the unity and vitality of the community during this period, people were equally eager for future generations to avoid life down in a pit. As one participant put it “(Parents said) no way are you going down a pit. They wanted their kids educated to work elsewhere”. Others were practically orientated accepting the past cannot be changed, and with the passing of time, the end of mining is becoming less and less relevant to newcomers and younger generations, as spoken by the participant:

> “I think we’re too many generations down. You cannae right what happened with Thatcher. We're sitting here of a generation but the younger ones, the grandchildren in particular are not interested (in the history).” – History Group Participant

9.5.4 Ownership, participation and benefits of a minewater future

Following an exploration of the initial thoughts and concerns relating to MWT development, the focus groups progressed to a final discussion on what a fair and appropriate future minewater system would be for the people of Cardenden and for society more widely. Immediately, several participants in the history group event spoke to the critical issue at the heart of this thesis; tensions between the need for energy systems of the future to work in the interest of community and people, and the current economic system actively impeding this realisation. One participant it the history group event made an almost dismissive comment about the desire for a MWT to be owned and work for the benefit of people, yet this future was simply not possible. Another participant from the community development group was also disparaging when asked about ownership, revealing the lack of trust felt by communities in public institutions, saying that if the local authority were the owners of a MWT system, “it wouldn’t work, it wouldn’t happen”. The history group participant went on to discuss a previous experience with the major industrial development of recent decades in the local area, and how promises of its benefits were never realised.

> “On that, ideally you'd be wanting something that would be owned by the people but the reality is we're not going to have that because we're not a situation where we're going to be able to invest billions to produce that. I'm thinking about, go back to when Mossmorran was getting built and people were promised it would produce hundreds and hundreds of jobs and that never came to fruition because every construction job they brought people in, it's the same thing we're building the Queensbury crossing. The vast majority of the workforce weren't locals, they were brought in from all over the world actually.” – History Group Participant

Participants were very much open to a minewater future that benefitted their lives. One participant from the community development group event stated they were happy for mines to be repurposed “as long it could benefit the whole community”. They wouldn’t like to see the mines exploited for profit to benefit only a portion of people in the village and that benefit would need to be shared fairly. Participants did not feel MWT deserved any different kind of treatment based on the historical experience of deindustrialisation, and as one community development group participant put it “I think the communities have got the right to be involved no matter what the project which we should be consulted in”. Another participant from the same workshop presented a pragmatic supportive view of their minewater future in Cardenden:

> “I think the people in Cardenden a personal opinion, we'd back a scheme, but the investment would need to be there and the infrastructure we need to be put back in a better state than it is at the moment in terms of foot paths roads, stuff like that. But if it’s something that's going be a benefit to people in Cardenden then aye, and if it's going save money, definitely. But the practical sense of getting the source from A to B, that's the big challenge at the end of the day.” – Community Development Group Participant

A participant from the community development group meeting had a similar perspective, centred around meaningful partnership and dialogue between developers and the community. They wanted the community to be brought into discussions at an early stage, to discuss the best way in which the project would work for local people and place, and emphasised that any minewater future would need to happen differently to other recent energy developments to gain community support:

> I think it's about having a conversation, about a proper conversation. Not just, this is happening, what do you think? Rather actually this is our proposal, what's your feelings? This is how it affects you. Every project will have an effect at some point and at least get some real feedback rather than saying, fine, we're building this, it's

> going to happen cheery-bye. Because that's what's happening for so many projects. – Community Development Project

Going into more detail about integrating MWT into a sustainable future for Cardenden, participants in the history group session expressed particular importance on jobs, skills and training, tied into long-term planning. One participant from the history group felt that "bankers" and "conglomerates" could decide energy related decisions and that the government would "tick along there with them". Instead, they wanted "direction" and for professionals to give community respect, honesty and credit based on their contributions to the countries industrial past and in their ability to understand the nuts and bolts of projects. Another participant from this group felt strongly that any MWT development must invest locally and provide long-term employment and training to local people, echoing many community wealth building and place-based development approaches.

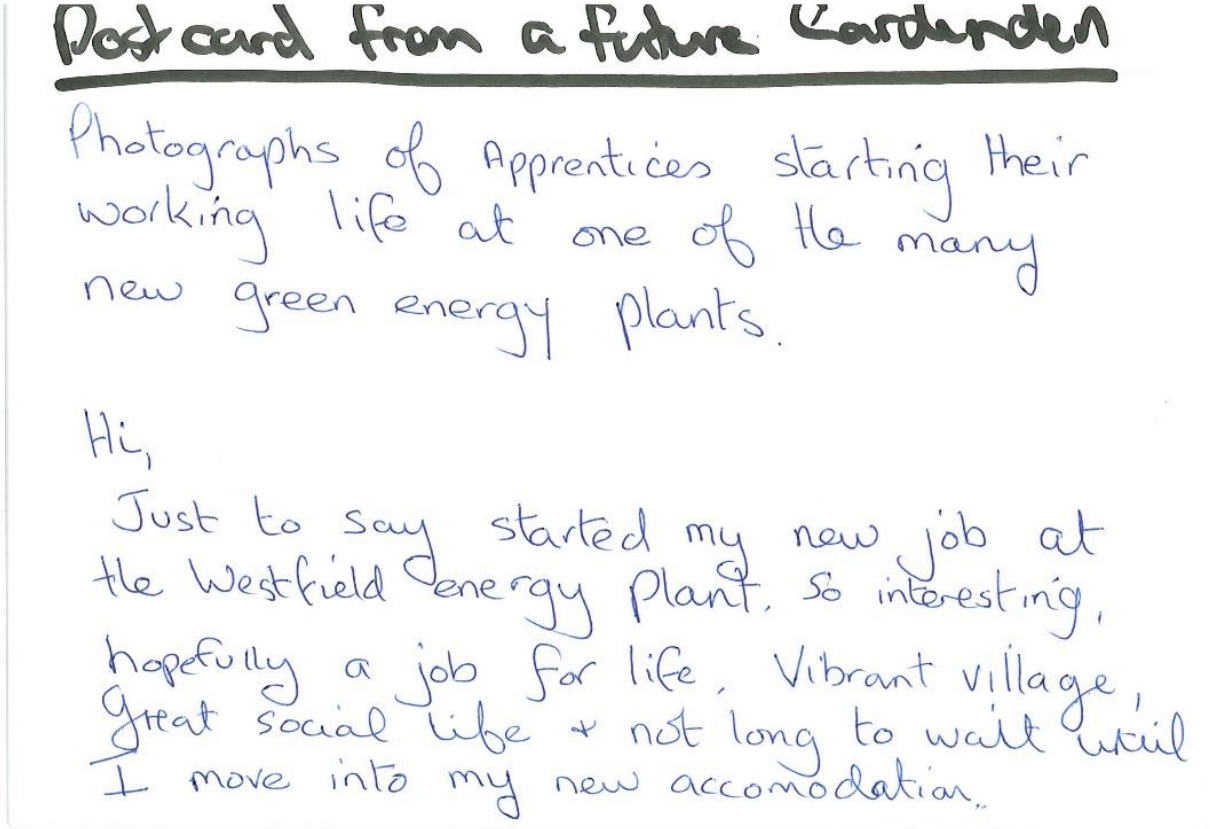
> "But if you're investing locally and you're wanting to reduce unemployment, you need to think about the kind of skills that you are looking for because this isn't going to happen overnight. You should be future proofing your training programmes to produce the individuals that you're need from that. But I think that there has to be some kind of agreement that X amount of or percentage of whatever of the staff should be local." – History Group Participant

9.6 A post card from a future Cardenden

At the end of each workshop, participants were asked to take part in an activity, where they imagined a Cardenden 20 years in the future. They would then write a postcard to a dear friend from the village who had left in the course of those years, describing the town and the changes that had taken place. Participants were given a choice to write from different perspectives, which could be based upon what they wished to happen, or a realist perspective of what they expected to happen. The exercise was introduced as an alternative method of data collection which may have been more accessible to participants less able to engage in discussion. It also asked them to summarise their feelings and positions based upon the conversations and topics explored during the workshop prior, and engage with imaginaries, eliciting insight into what enabled and disabled particularly desirable futures. A select few of the postcards are highlighted here, and the full range is shown in the appendix.

In summary, participants demonstrated a range of imaginaries, some optimistic in their outlook others less so. Green energy and minewater featured in contested terms overall, and nearly all futures interlinked various priorities relating to a sustainable place, community, wider economy, natural environment and energy system. All envisioned a sense of change,

with old places of importance or difficulty gone, and new infrastructures and employment industries. All postcards can be viewed in Appendix B.

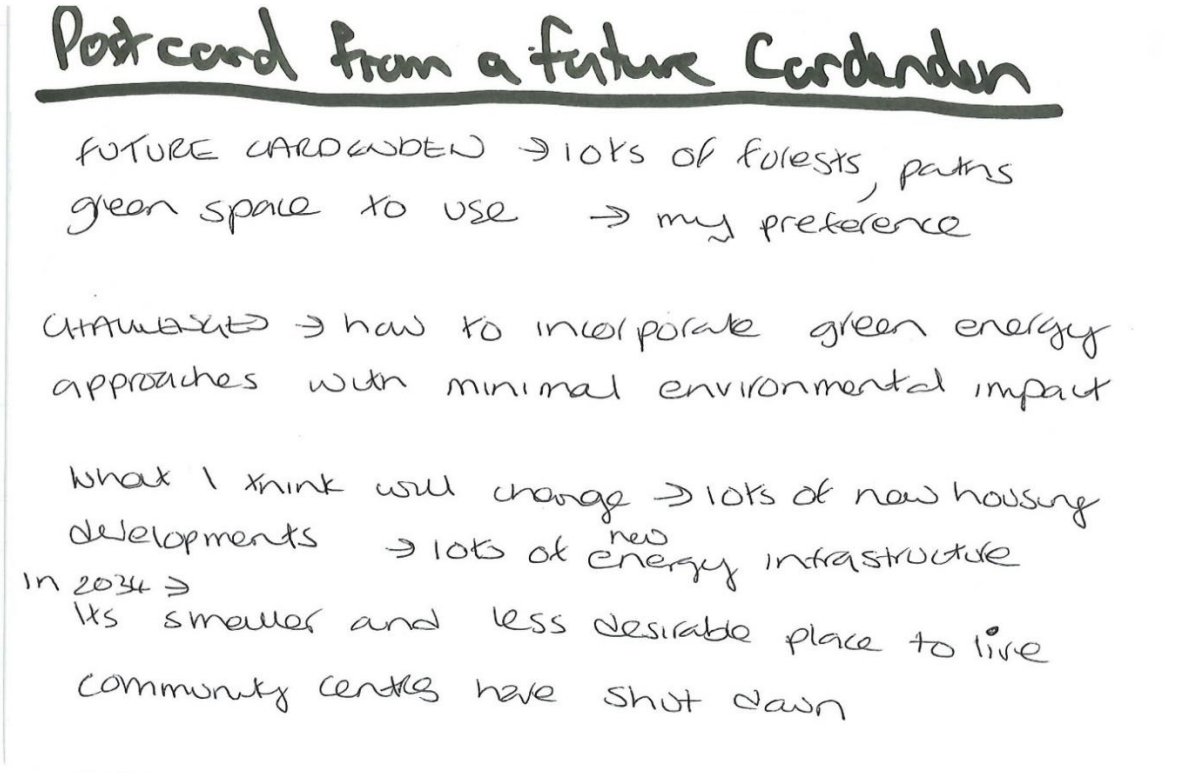


Postcard from a future Cardenden

Photographs of Apprentices starting their working life at one of the many new green energy plants.

Hi,

Just to say started my new job at the Westfield energy plant. So interesting, hopefully a job for life. Vibrant village, great social life + not long to wait until I move into my new accomodation.



Postcard from a future Cardenden

FUTURE CARDENDEN → lots of forests, paths green space to use → my preference

CHALLENGES → how to incorporate green energy approaches with minimal environmental impact

What I think will change → lots of new housing developments → lots of new energy infrastructure

In 2034 →
Its smaller and less desirable place to live
Community centres have shut down

9.7 Chapter summary

This chapter presented and analysed findings from the second phase of the data collection, a case study of the former mining town of Cardenden in Fife. It consisted of two workshops, with 19 participants in total, one group revolved around a local history society and their friends, and the other more active citizens engaged in community development activities in the village.

As discussed in the introduction to the chapter, the analytical framework was deployed in a nuanced and different way to that of the sectoral interviews, with respect to the different positionality of the participants as community members of place, rather than sectoral professionals. Many different imaginaries and insights were demonstrated as important factors to MWT development from a place-based perspective.

First, participants highlighted the importance of place, community and identity, both historically and presently in understandings of how energy economies and local developments can work for people and place. A critical perspective was expressed against both private developers and public institutions, and a lack of meaningful engagement between communities and others resulted in a sense of distrust and apathy. Energy infrastructures were at the heart of these tensions, where communities generally felt on the outside, unheard and paying the material and mental cost of an energy system which does not work in their interest. Participants were open minded to all future developments, including minewater energy, as long as honesty, participation and fairness guided any process of development. They were sceptical of economic structures and the financial factors that would enable this fairer energy future, and demonstrated that profit driven approaches were absolutely hegemonic in their ability to disarm any alternative imaginary. Participants did not feel the repurposing of mines required particularly sensitive attention other than in cases where bodies had not been recovered from pits. What did matter was that a MWT industry developing in Cardenden would work with communities to co-develop an energy future that created a sustainable place, local economy, community and environment.

Chapter 10 - Discussion: Findings and Contributions of the Research to the Wider Literature

In this chapter I will present further analysis on the research findings, reflecting upon the insights using the analytical framework and the literature review introduced earlier in this thesis. The main purpose of this chapter is to situate the research findings within the relevant literature and discuss the key contributions to scholarly knowledge.

I demonstrate the contributions to each strand of literature within the sections that follow, with a focus on socio-technical imaginaries and transitions (STI) in section 10.2, political economy and development literatures (PE) in 10.3, energy justice literatures (EJ) in 10.4, and broader social science understandings of geothermal and minewater energy technologies in 10.5. The contributions this thesis makes are covered in detail throughout this chapter. They are first visualised in Figure 29 and summarised in Table 4.

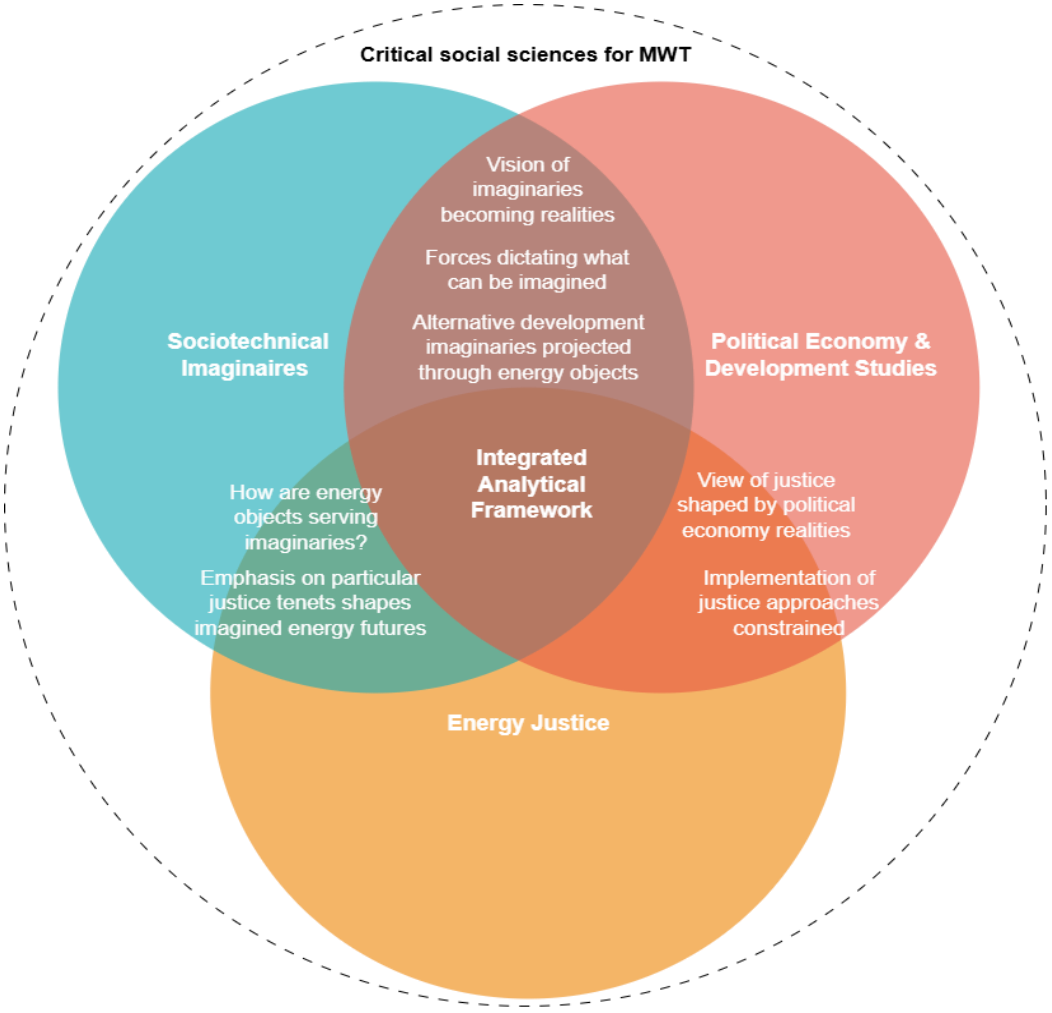


Figure 26 Overview of major areas of literature contributions

Literature contributions	Theoretical	Empirical
Integrated analytical framework (section 10.2)	- Bridging of major energy transition literatures to understand the process of energy future making at different scales, geographies and backgrounds	- Gathers empirical understanding of how future making, political economy structures and fairness of process interact in the development of a new energy industry
Sociotechnical imaginaries (section 10.3)	- This thesis develops a synthesised understanding of the dynamic production of socio-technical imaginaries through focus on an object (i.e. MWT industry) at scales, geographies and backgrounds within Scotland - This thesis develops understanding of how processes of reimagining are an important dynamic in the transition from fossil fuel infrastructures and histories	- Across various participant groups, different energy imaginaries were projected for MWT, exhibiting various economic and social futures. Notable distinction amongst professional participants and community members leaning towards techno-optimistic visions and place-based sceptical orientations respectively - Findings suggested that professional participants across sectors were supportive of repurposing imaginaries, viewing MWT as a positive story of reclaiming an energy past and moving beyond the challenges of deindustrialisation. Community members on the other hand were less taken by such narratives, and were more focused on what input they might have and what benefits it could provide local place and in everyday life
Political economy of energy transitions (section 10.4)	- This thesis contributes to the development of a political economy of emerging energy transition industries, through the tensions present between counter-hegemonic ideas, such as eco-welfare states and place-based, with the hegemonic ideas of neoliberalism and green growth, as they are	- Contributes empirical knowledge on the political economy of energy transitions in Scotland through a study of a MWT industry. It explores how hegemonic neoliberal ideas reproduced through the state, markets, legal and economic systems distort and dictate political economy

	entrenched through political economy structures and manifest in the case of MWT	- Demonstrates how counter-hegemonic ideas are imagined in the context of MWT in Scotland, but deemed unfeasible due to hegemony of neoliberal energy governance
Energy justice (section 10.5)	- This thesis highlights that energy justice perspectives are embedded in both individual and collective imaginaries. Found at various scales and cultures in the context of MWT, these perspectives are both counter to and constrained by hegemonic political economy forces - This thesis explores restorative justice dimensions in the context of deindustrialised communities and new energy futures, finding that conceptualisations vary at different scales and cultures through shared meaning and values	- Various insights with respect to energy justice perspectives of imaginaries and political economy of energy transitions in Scotland, through the prism of MWT. Suggesting energy justice approaches are counter-hegemonic and currently sidelined by existing political economy - In the context of repurposing former coal mines in Scotland, justice language is rarely used, however professionals and communities prioritise inclusive, fair processes and strive for trustful partnerships, however, are sceptical of opposing parties willingness to engage fairly
Critical social sciences for MWT (section 10.6)	- This thesis contributes to the understudied literature of geothermal energy and minewater technologies in society. It explores the relationality of the different groups involved in envisioning its development and the usefulness of studying power, politics, inequality, plural knowledges and imaginaries	- This thesis suggests that the repurposing of former mines requires careful consideration of the unique historical and cultural characteristics of former mining communities. However, their desire to be empowered through participation most strongly relates to material conditions of the present and the pressures of incumbent political economy structures

Table 4 Summary table of thesis contributions across literatures

10.1 Addressing the research questions

The research was guided by an overarching research question and a set of sub-questions that provided structure to the study. The research questions are directly addressed in this section, based upon the findings of this research through the sectoral level interviews and case study analysis of a former mining community presented in Chapters 8 & 9 respectively. The three subordinate questions are addressed first before the overarching research question is addresses.

10.1.1 What are the perceived opportunities and challenges facing Scotland's minewater thermal energy industry?

Opportunities exist within Scotland's energy economy that MWT technologies could benefit from, ranging from expertise to suitable spatial and resource characteristics as highlighted by interview responses across section 8.2. Existing expertise already within Scotland could be used for a MWT industry, with a strong skill base across drilling, geology and piping infrastructure deployment. Proximity between heat demand sources and mining infrastructure is present in many locations were MWT potential is high, particularly communities where affordable solutions are needed and other low carbon alternatives such as heat pumps are less viable. There exist many brownfield sites ripe for regeneration, utilising them as sites for energy centres, and MWT infrastructures alongside other sources such as solar generation. Thus, a huge potential for visible local renewable and environmental improvements is present.

Mining communities themselves are open to MWT development, as demonstrated in Gateshead, the heat network in MEL and in the workshops covered in Chapter 9, given the process is centred around local inclusion and benefit. Further, former mining communities such as those found in Cardenden and Gateshead express a strong community identity and solidarity, important foundations for energy developments that work with local people. Community groups can already be found coordinating local services and energy infrastructures and can possibly extend this into MWT developments.

Structural and socioeconomic barriers affecting MWT are also varied and significant as discussed in section 8.1 on political economy challenges and through 8.2 on MWT imaginaries. Fragmented and unclear legislation is slow and can burden the development process for MWT, with multiple regulators managing disjointed licensing, permit and environmental reviews. The high upfront costs associated with MWT and heat networks is a significant challenge, with drilling costs and piping infrastructure necessitating a high risk investment profile. Despite the co-location of demand and generation, the uncertainties tied

to critical anchor connections and the seasonal demand of residential housing creating a picture of many moving parts that must align for projects to be viable. Further challenges exist from a socioeconomic level are prevalent, where apathy, health and social issues, a distrust of developers, alienating bureaucratic language and processes along with fears of accident tied to mining pasts are all challenges found at the community level.

Historical disappointment and experiences with energy industries where projects proceed with limited community input has produced a culture of scepticism and distrust within communities, as found within the community case study in sections 9.3 and 9.4. Whether it is national, local authorities or private developers, the planning system has created a widely held perception that outcomes are pre-decided before and regardless of community involvement, which discourages trust and undermines meaningful co-design of energy initiatives.

10.1.2 What are the collective alternative energy imaginaries as both a process and outcome for minewater thermal energy futures?

In the face of opportunities and challenges in the energy economy landscape that shape MWT development pathways, as well as the structures and norms of neoliberal energy governance, alternative imaginaries were presented by experts from a range of backgrounds, throughout the interviews and community case study data. Considering counter-hegemonic ideas from post-growth development literature discussed in Chapter 3, alternative imaginaries for MWT displayed characteristics of eco-welfare states, community wealth building, and place-based approaches. Significant public, local and community involvement underpinned nearly all imaginaries presented, with several propositions presented for the delivery model. In the interviewee data in sections 8.3 & 8.4, forms of shared ownership where most prominent with the local authority a primary owner, state ownership also being touted in order to secure local decision making and public benefit respectively. Some visions included private firms as being part owners, others as purely providing technical expertise.

Community involved ownership was presented in mixed terms by both the sectoral interviewees and the community case study, due to the technical complexities and scale of investment required, however the benefits of local community governance were deemed critical, with some visions suggesting the state intervene to facilitate greater community ownership. An emphasis within all imaginaries were on locally driven, community rooted co-production approaches that explored community context and identity. Community, council, and commercial hybrid models were envisaged, where the council and community retain

minimum fifty percent governance, sharing risks and investment returns and ensuring local benefit.

A place-based, phased infrastructure roll out was an important aspect of envisioned project delivery as discussed in sections 8.4 on delivery approaches. Starting with smaller schemes that are robust and successful before scaling, but with future demand and generation opportunities scouted from the start. Changing public procurement regimes to prioritise community and local authority led energy projects, and mandating connection to them would significantly derisk projects through demand assurances. Additionally, MWT systems should be considered as part of integrated diverse energy systems, integrating with solar, wind, storage and other heat pumps for system level optimisations. Just transition and regenerative visions were present in which MWT is framed as both an ecological and social benefit, reviving former coalfield communities through investments in local infrastructures and social opportunity.

10.1.3 What forces are enabling and/or disabling the imagining and implementation of alternative economic development minewater thermal energy futures?

Alternative imaginaries are both enabled and disabled by particular forces that relate to development models and political economy as highlighted by interview responses in sections 8.1 and 8.2, in addition to workshop perspectives in sections 9.3, 9.4 & 9.5. Enabling forces revolve around engaging with public and community bodies. First, as lessons from existing heat network projects demonstrate, such as the MEL project in section 8.4.1, local authorities have a huge role to play. By taking a leadership role on delivering local heat networks, and in particular the funding of full-time roles to develop heat network and MWT opportunities, local authorities can take strategic long-term planning decisions and coordinate across sectors, as was discussed in section 8.3.2. Further, local community networks are a force that can be utilised to connect local businesses, citizens and public institutions to develop an open collaborate culture that can enable alternative visions of economic development.

Related to the first point, MWT imaginaries are enabled by a public funding regime, as supported by data throughout chapter 8. Whether supported through public investment banks which prioritise heat projects and MWT that deliver public benefit or through direct state investment in projects. As piping infrastructure is one of the most expensive obstacles, suggestions included piping funding programmes, where profits could pay back state loans

over time. “Spend-to-save” approaches across public are necessary to enable MWT imaginaries, entering into revenue generating energy projects.

Disabling forces were discussed in sections 8.1 and 8.2, including market incumbency and inertia, were entrenched fossil fuel systems resist transition. State level constraints exist in Scotland, as the Scottish government has limited fiscal autonomy in relation to its borrowing and tax powers, and is not able to issue currency. At the UK level, the ideology of the monetary system is also a disabling force, where the household budget myth is applied to national economies. Despite the critical role of local authorities, the reality is that they have been hollowed out and have weak capacity. This stifles democratic development of energy developments and the ability of institutional support at the local level.

10.1.4 What drives and shapes the formation and implementation of minewater thermal energy industry imaginaries for a just transition in Scotland?

Turning attention to the overarching research question, answers to the three subordinated questions are integrated in order to understand what drives and shapes both the formation and implementation of minewater thermal energy industry imaginaries, for a just transition in Scotland.

Underlying many of the alternative imaginaries, are co-production values, starting MWT and energy projects with a recognition of place, identity and community context. This was most prevalent in the workshop data, however the sectoral interviewee data also broadly supported these ideas, as was discussed in section 8.4.4 & 8.4.5 for example. Further, trust and partnership building is a key facilitating factor, involving communities from the start on issues from brownfield regeneration, planning, infrastructure and governance shapes the legitimacy of energy initiatives.

The foremost driver found across the data collection, particularly from the interviewee data is that of strategic public investment and infrastructure planning. Emphasis was placed on the role of state energy companies, public investment banks to derisk infrastructure challenges such as heat network piping, and work towards long-term returns on investment that will enable scaling of MWT. This would involve local authorities serving as an operational anchor for local heat networks and MWT systems, transforming their role from the present. Providing councils with the capacity, tools and finance to directly lead in partnership with communities and private expertise. Thus, councils can set up joint ventures, own energy systems and manage risk sharing with partners. Embedding community governance and ownership was another prominent driver. This could be through democratic share offers tied

to place, governance rights were essential in making sure local communities are not sidelined.

A whole-systems, staged approach drives the implementation of MWT and heat network alternative imaginaries, beginning with single anchor projects. Demonstrating their success and then expanding in phases to utilise heat demand sources under public ownership and financing.

Positioning MWT as a driver of social good and far beyond being a technical solution has the potential to drive implementation and shape imaginaries. Emphasising reducing fuel bills, creating jobs, enabling community cohesion and stopping local wealth leaving the area. Reinvestment can support public services, young people and local facilities central to the just transition principles.

However, as demonstrated throughout the findings a hegemonic market-led political economy dominates and frustrate the emergence of alternative imaginaries. Alternative realities are often difficult to imagine in the first place, and even when they are, a path to realising them is often dismissed apathetically or unimagined. A wider transformation of the ability to imagine alternatives is therefore a critical way of enabling just minewater futures.

10.2 Contribution of an integrated analytical framework: the bridging of sociotechnical transitions, political economy, and energy justice literatures

The integrated analytical framework itself, developed in this thesis is a novel contribution to scholarly knowledge in several ways.

> Contribution 1: Developing and demonstrating the application of a novel analytical framework to explore sociotechnical imaginaries using a phased approach that traverses scales and social class backgrounds

First, the integration of sociotechnical imaginaries, neo-Gramscian political economy understanding and energy justice is a new and insightful way in which to explore the development of sociotechnical industries such as MWT and the wider energy transition, as illustrated in Figure 18 An integrated analytical framework illustrating the dynamics of energy imaginaries interplaying with political economy forces, hegemonic and counter-hegemonic ideas, . The extensive literature review conducted in this thesis that led to the creation of the analytical framework demonstrates a rigorous approach to addressing research gaps within respective bodies of literature. It demonstrates that these literatures can complement each other, whilst together in the framework becoming more than the sum of their parts.

It demonstrates empirical contributions through the use of the framework to analyse the development of a MWT industry in Scotland today, eliciting a novel theoretical approach in which to collect data for this emerging industry. As a result, the framework contributes empirically and methodologically by showing that data analysed this way creates clear and coherent findings pertinent to the literature strands drawn from.

The analytical framework developed here can be employed by other researchers to examine the development and application process of sociotechnical imaginaries and their relationship with political economy across a range of contexts that stretch beyond energy systems and a western neoliberal economic paradigm. The methodology this thesis develops demonstrates how the analytical framework can be successfully mobilised, presenting avenues for further use with an emphasis on the diversity of individual and collective imaginaries from different backgrounds, adding breadth and depth to methodologies used in sociotechnical imaginaries and transitions research.

> Contribution 2: The analytical framework addresses sociotechnical imaginaries research critique, which identifies a lack of accounting of power structures and hegemonic forces by utilising a neo-Gramscian political economy framework that highlights the interplay between imaginaries, hegemonic power structures and ideologies that shape the process of future making

The inherently political nature of energy futures is accepted across scholarship (Longhurst and Chilvers 2019c), and yet forthright engagement with political economy knowledge is lacking within the transitions literature. Critical engagement with the process of making collective and individual sociotechnical imaginaries is a necessary step in advancing understandings of how and why particular imaginaries gain power and prominence or are marginalised, co-opted and defeated (Kuchler and Stigson 2024b).

Jasanoff and Kim's 'Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power' (2019) invites scholars to further investigate interactions between 'structures of normativity and power' and the development of sociotechnical systems. It highlights how imagining affects the 'salient political challenges of modernity', such as democracy, public ethics, institutional accountability, and the expert/lay divide.

Socio-technical transitions and imaginaries perspectives have not sufficiently analysed or critiqued the incumbent regimes that dominate and resist change from a political and power perspective. Furthermore, the ways in which a political economy interacts and distorts transitions is not well studied across levels, and how global structures and local dimensions impact one another. The bridging of political economy perspectives in the context of the energy transition and emerging industry of MWT in this thesis, bring to light the importance

of addressing this ‘difficult political economy’ (Newell 2019), to better understand the reality of transitions.

In the context of energy transitions, and the development of a yet to exist industry in MWT, this thesis integrates perspectives from political economy to account for the affect in which dominant and incumbent forces impact and determine the kinds of futures imagined and whether they are deemed achievable or not. Hegemonic forces influence collective imaginaries through their distortion of cultural understandings and finds that it is not so much radically alternative futures that collectives cannot imagine, but the ways in which they could ever come to pass. Even critical imaginations can be influenced by hegemonic forces (Laclau and Mouffe 2014), by recognising this, a more complete and complex picture emerges that does not obscure taken-for granted constructs (Stirling et al. 2023).

Market, institutional, systemic and ideological incumbencies are highlighted for their role in shaping energy futures. Therefore, a key contribution of this thesis is the bridging of political economy literature with sociotechnical imaginaries literature. Empirically, the thesis demonstrates how imaginaries relating to MWT and Scotland’s energy economy are constrained by neoliberal hegemonic forces, in which alternative approaches are envisioned in unreachable ways. As was put by P14, “it is easier to imagine the end of carbon production than not just the end of capitalism, but even just an alteration to the workings of capitalism”.

In the empirical findings of this thesis, a strong trend in the energy futures discussed leaned towards a more democratic state led energy governance regime. Imaginaries of a democratic state emerged together with a pessimistic perspective on the likelihood of achieving and the actualisation of democratic governance not only of the transition, but in society more broadly. This thesis brings to light, through the application of the analytical framework and the methodological approach to data collection, that it is the market, profit driven structures and ideologies that directly contest the possibilities of a more democratic energy future, and the ability of the state to work in the interests of such alternative futures.

The development of an emerging MWT industry was characterised through alternative development imaginaries, democratic, place-based and well-being focused on their nature. However, dominant market-led realities contorted the ability of participants across class and background to believe in its actualisation. That is to say, the perceived legitimacy of an imaginary, and the appetite to develop imagined futures, lies very much in how likely it is considered to be possible. Often, this manifested in unawareness, or a simple acceptance of market-led dominance, without ever analysing or critiquing it in such terms. Thus, this thesis presents an informed understanding of the energy political economy, where market-led

approaches dominate, and frustrate alternative imaginaries and visions of democratic institutions such as the state implementing them.

This section highlighted contributions of the analytical framework theoretically, empirically and methodologically. In the following sub-sections, distinct contributions to the individual literatures are discussed, beginning with sociotechnical imaginaries.

10.3 Sociotechnical imaginaries literature

The contributions to sociotechnical imaginaries and transitions literature are at the centre of this thesis, and manifest at different theoretical, empirical and methodological scales.

> Contribution 3: This thesis develops a synthesised understanding of the production of socio-technical imaginaries for a developing energy industry (MWT) at various scales, geographies, collectives and cultures, pointing to plural imaginaries process

Jasanoff and Kim (2009) introduced sociotechnical imaginaries as being “collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects” (p. 120), and in time since, has become a mainstream theoretical approach to energy transitions.

This thesis develops the socio-technical imaginaries approach and understanding in several important ways, building upon shortcomings, critiques and suggested improvements in the scholarly literature. First, it builds upon literature (Stirling et al. 2023; Escobar 2020; Hendriks et al. 2025) that emphasises the plurality of imaginaries, and their emergence, contrary to dominant nationalist led imaginaries. For example, the assumptions about the ‘lock in’ of historical legacies and singular perspective of ‘harmed’ coal communities was demonstrated to be false. Rather, communities were pragmatic in their visions of the future, and expressed a desire to not be defined by the past, or dominant techno-centric imaginaries of deindustrialisation. While legacies of deindustrialisation are important (Johnstone and Hielscher 2017), there is a need to refocus on the importance of a pragmatic agency that is future facing, meets basic services without dwelling so strongly on addressing past injustices.

It expands upon existing literature which focuses on the projection of energy futures towards a material object (Magnani and Cittati 2022), in this case MWT. Whilst national industries and ideas such as community energy have been used a lens in which to project sociotechnical imaginaries, technical objects have not been studied this way in much breadth or depth. Particularly those that repurpose former infrastructure, and MWT has

never been studied this way before, demonstrating both theoretical and empirical advancements.

Across various participant groups, different MWT imaginaries were projected, ranging from forms of state-led resource nationalism or localism, primarily amongst politicians and policy actors, a technocratic transition tool from participants of engineering or developer backgrounds, and as part of a communitarian and place-based vehicle for reimagining former coal field areas amongst community development and advocacy professionals, as well as with communities. Community members viewed MWT as another way in which the energy system is done to them and could have negative impacts on characteristics of place such as green space, homes and pathways.

> Contribution 4: This thesis examines imaginaries related to the repurposing of former fossil-fuel infrastructure as part of energy transitions.

Research exploring repurposing of former fossil fuel technologies is largely from an engineering perspective, and sociotechnical imaginaries is an underutilised lens. This thesis aimed to uncover the different energy and societal futures imagined, exploring values, priorities, materialities and critical perspectives through the vehicle of the technical object of MWT. By channelling the creation of energy imaginaries through MWT, dynamic linkages emerged, which demonstrate the ways in which new forms of society are imagined and how this technology can meet these needs. Thus, MWT became a lens in which futures orientated themselves, and both impediments and pathways towards the fulfilment of these aspirational futures emerged.

A deeper level of novelty was present in this process due to the nature of repurposing former coal mines for greener energy futures, which provided a necessary connection between imaginaries about the past, the path to the present and how these past imaginaries affected the creation of futures. Findings suggested that professional participants across sectors were supportive of repurposing imaginaries, viewing MWT as a positive story of reclaiming an energy past and moving beyond the challenges of deindustrialisation. Community members on the other hand were less taken by such narratives, and were more focused on what input they might have and what benefits it could provide the village and in everyday life.

In their paper, reviewing 69 articles exploring the socio-technical imaginaries of energy system, Kuchler and Stigson (2024b) call for a focus on how collective imaginaries are understood by going beyond place and scale to include diverse perspectives such as class, gender, or race. Further, the understudied interactions between imaginaries and the ‘lived experience of everyday people’ (J. M. Smith and Tidwell 2016) is largely unaddressed. The stark gap between technologically driven imaginaries of powerful actors and local life of

citizens draws out the contestation and power balances inherent in energy futures (Pink 2022). Tidwell and Tidwell (2018) centre “the underlying messiness and variation found within the individual perspectives within local communities”.

This thesis directly contributes to these knowledge gaps through its focus on the development of socio-technical imaginaries across social backgrounds through class, cultures and identities. In the research, participants were from a range of professional backgrounds, in the private, public and third sector. Citizens, and community perspectives were also a significant and highly important aspect of the research. This enabled contributions to better understand the interplay between narratives at the global, national and local levels, and where moral, material and scientific goals from across society emerge and develop.

10.4 Political economy of energy transitions

This thesis has made several novel contributions to literature developing understanding of the political economy of energy transitions.

> Contribution 5: This thesis contributes to the development of a political economy of emerging energy transition industries, through the tensions present between counter-hegemonic ideas such as eco-welfare states and place-based, with the hegemonic ideas of neoliberalism and green growth, as they are entrenched through political economy structures and manifest in the case of MWT

As identified through undertaking the literature review for this thesis, it was clear that the application and bridging of political economy and energy transitions research was limited (Meadowcroft 2009) (Lawhon and Murphy 2012) (Newell and Phillips 2016) (Power et al. 2016). Where politics and power play a limited role in energy transition studies, political economy engagement with the sociotechnical transitions field is emergent, and alternative development approaches lack direct association with existing political economy systems and sociotechnical understandings for energy transitions. This thesis has provided a detailed, empirically grounded study, which threads together these literatures and advances our understanding of political economy dimensions affecting alternative development approaches in the energy transition.

The emergence of alternative energy economies, that draw from democratically driven post-growth, ecological and well-being approaches, as well as place-based governance, are demonstrated to be in tension with hegemonic political economy forces.

These approaches, from their individual and collective ideation, through pathways to their actualisation and implementation are demonstrated to be in direct contestation with the incumbent landscape of power, and the particular ways in which forms of capitalist, neoliberal profit driven order will attempt to co-opt, transform and defeat them in the context of energy transition.

Across energy transition studies, managerial and technocratic scenario approaches are ubiquitous, where the majority fail to adequately account for the powerful forces of capital, which work to co-opt democratic institutions including the state, and thus sideline democratic and place-based alternatives. This thesis builds upon emergent energy transitions - political economy scholarship that highlights the incompatibility of the 'natural forces' of the market and cycles of technological innovation with sustainability transition goals, and reemphasises the non-neutral and critical role of the state (Johnstone and Newell 2018b) (Scoones et al. 2015b) (Newell and Simms 2021).

Examining the landscape for MWT development, two strands of study emerged for which this interjection of a political economy analysis was required. The first emerges from looking at the contemporary economic, political and social dimensions which dictate the development and deployment of MWT. Where despite overwhelming scientific consensus of the need radically transform energy and heating systems away from fossil fuels, as well as the need to address inequalities and disparities between communities, and utilise opportunities for economic development tied to green energy, all of which have popular support; action taken by political leadership and institutions has been limited and in some cases appears oppositional, committed to maintaining things as they are for as long as possible.

The second strand is a product of a deeper understanding of the historical account, closure of the national coal mining industry and the wider transformations observed in not only British society over that period, but across advanced economies under the phenomenon of deindustrialisation. As discussed in the literature review, the period of economic transformation beginning with deindustrialisation is often marked as a juncture, and the beginning of a turn towards neoliberalism and financialisation, which is understood as the primary set of ideologies guiding capitalist societies today, particularly those in the West. The important point being, that far beyond being a simple economic evolution, this turn was inherently political in the set of interests it set out to promote, and the ones in which it eroded. Thus, MWT developments are situated in the legacy of deindustrialisation and neoliberalism in significant ways, whether it be the transition from national objective led energy economies to private profit orientated sectors.

10.5 Energy justice literature

This thesis contributes to energy justice literature, particularly the role of restorative justice as a distinct element, as well as the ways in which energy justice visions emerge in a plural and context specific nature.

> Contribution 6: This thesis highlights that energy justice perspectives are embedded in both individual and collective imaginaries at various scales and cultures in the context of MWT and are both counter to - and constrained - by hegemonic political economy forces

Energy justice literature has evolved and grown as a major strand of energy social science research, however critical perspectives call for renewed focus on its practical use across scales, politicisation and relation to a pluriversality of ethical understandings (Wood 2023) (Healy and Barry 2017) (Pellegrini-Masini et al. 2020). Energy justice presents an alternative approach to the value, use, production of energy from a whole systems perspective, placing it firmly at odds with the current energy governance paradigm. Yet, as the literature has suggested, and this thesis reinforces, energy justice literature would be enriched by political economy analysis, where engaging with the very forces that counter energy justice would enable greater proliferation in both imaginaries and in practice. By doing so, energy justice approaches are more connected to the realities of power, and which can aid in their implementation and in the critique of current unjust energy governance.

Throughout the empirical findings from this research, participants used language and suggested approaches which embodied energy justice approaches, though the scales and priorities in focus varied greatly from the social background of participants. Despite presenting energy justice visions, such as fairer processes of engagement and decision-making, distribution of costs and benefits, and recognition of communities of place, no participant presented this vision without a grounding in political and economic structures that does and would frustrate the emergence of an alternative just energy system. Community participants in particular expressed understanding that it was irrational to expect fairness, inclusion, trust and respect from the current energy governance system.

The embeddedness of neoliberal market approaches in the energy sector and wider governance frameworks was identified by participants as critical in their view as to why the state or private energy companies would never permit genuine energy justice style approaches. The embeddedness of capitalist forms of energy production are at the centre of global, geopolitical issues as well as the everyday matters of social life, which threads right through any alternative energy economy such as that of energy justice (Frigo 2017). By

articulating this matter within its framework, the energy justice approach can move closer to a fuller picture of the world as it is. Emphasising where imaginaries may be in support of justice principles but are at odds with the prevailing political economy orthodoxy. Thus enabling more effective and accessible strategies for its ideation and implementation, by better reflecting the conditions of the present as they are.

> Contribution 7: This thesis explores restorative justice dimensions in the context of deindustrialised communities and new energy futures, finding that conceptualisations vary at different scales and cultures through shared meaning and values

The various ways in which relationships between land, everyday life and energy infrastructures manifest represent a struggle over meaning and value, and restorative energy justice discourses are one way in which this struggle is addressed (Tornel 2023). Approaches that attempt to define what fair and just transitions are before they take place require critical engagement, and this thesis confirms that professional and national scale perspectives of just energy futures differ from citizen and local visions, particularly in the context of a community with a widely acknowledged unjust economic past.

Restorative justice perspectives manifested in several ways within the data collected for this thesis. Professionals working across public, and third sector organisations overwhelmingly expressed support for restorative justice perspectives for former coalfield communities, with private sector support less significant. The previous transition and wider experience of deindustrialisation was central to professionals' perspective on the ways in which the energy transition should unfold. The social and economic legacy of closure and the deprivation that former mining communities face was cited as justification by many as restorative justice was discussed in a broader sense relating to sustainability and well-being transitions. However, for some, the fact that MWT repurposes the former mining infrastructure itself added further significance to the need to engage with restorative justice perspectives. Despite the support expressed for a restorative approach, participants generally did not emphasise it ahead of other concepts of fairness and justice or procedure and benefit in the present. Demonstrating that without fairness and inclusion of process through meaningful participation and distribution of benefits, restorative justice is not as important and can be viewed as an additional layer on top of these fundamentals.

In contrast, participants from former coalfield communities themselves did not present or place emphasis on ideas of restorative justice or to engage with the present on such terms. Whilst the past history of coal was important and aspects where thought of positively, communities presented a nuanced picture that generally acknowledged the harms of the industry, accepting its eventual end. However, there was little distinction made between

wider concerns with the political and economic system and the particular way in which deindustrialisation was done to these communities.

Participants did not express a desire to be defined by past injustices, and instead pivoted discussions of restorative justice towards a fair and honest energy future, in which they were given respect and meaningful involvement, not as a result of past injustices, instead tied to a universalist position of place-based, democratic participation. Whether these principles of participation and fairness were passed down as a result of previous injustices was hinted at and could be an area of further study.

The findings demonstrate represent new steps for restorative energy justice empirically based research, suggesting that perspectives vary greatly across social backgrounds and scales, emphasising pluriversality. As such, restorative justice approaches should not involve any kind of preconceived outcome, even when self- perceived as a supportive and positive one. The findings also suggest that struggles over land use and energy infrastructure should remain future facing, rather than defined by historical factors, as long as meaningful partnership is present to create lasting trust and place-based energy futures.

10.6 Critical social sciences for MWT literature

Forms of geothermal energy, and MWT specifically, are understudied from a social science perspective, where analytical diversity is lacking and descriptive perspectives are commonly found (Spijkerboer et al. 2022; Vargas-Payera et al. 2020; Manzella et al. 2019). Its imaginaries and assemblages, role within society, meaning to different groups, issues of acceptability and concerns are areas in which this thesis contributes to new scholarly and empirical knowledge.

> Contribution 8: This thesis contributes to the understudied literature of geothermal energy and minewater technologies in society. It explores the relational nature of the different groups involved in envisioning its development, with a particular focus on the role of the state in creating an appropriate funding, planning and development landscape

In this thesis, MWT technologies were explored, which through the repurposing of former mining infrastructure, offer a variety of energy usage scenarios from direct geothermal systems to integrated thermal systems. In the Scottish and UK contexts, the thesis suggests that minewater technologies encounter similar but distinct economic and social challenges to geothermal and subsurface energy technologies. The analytical framework utilised in this thesis allows for a sociotechnical systems understanding of MWT, through imaginaries and complimented by literature from political economy of energy transitions.

The relationality of a MWT sector was brough to the fore, where technical expertise from industry, local authorities, alongside community development orientated groups, prioritise and envision different aspects of what a MWT could look like. Yet across sectors, a greater role for the state to coordinate, invest and plan for a MWT industry in Scotland was highlighted as the most critical step, in opposition to 'natural' market development pathways.

The thesis builds upon knowledge from heat network studies, where technical orientated challenges relate to the co-location of anchor heat demand sources with minewater resources, and the legislation planning regime that effectively enables demand to generation connections. Economic dimensions such as the risk associated with uncertainties inherent in tapping into the heat in mines are also critical, as well as price agreements to incentivise connections. The state and public institutions must be more actively involved in minewater regimes as a result.

The research finds that the repurposing of former mines requires careful consideration of – and sensitivity to - the unique historical and cultural characteristics of former mining communities. However, their desire to be empowered through participation most strongly relates to material conditions of the present and the pressures of incumbent political economy structures.

Finally, this thesis has created a methodological and analytical approach to the study of minewater technologies which can be replicated and built upon for further examination of the social and economic dimensions.

10.7 Chapter Summary

This chapter has situated and discussed the key findings from the previous chapters within the context of the wider literature, as summarised in Table X at the beginning of the chapter, and directly addressed the research questions. Throughout, I have articulated the major contributions of the thesis to knowledge across interlinked literatures, in particular the sociotechnical imaginaries, political economy, energy justice and critical social science for MWT literatures.

Theoretical contributions have been made primarily through the interlinking of the different literature strands into the analytical framework which addresses the research gaps in respective literatures. Empirical and methodological contributions were also made through the type of data collected and the methodology used to explore the analytical framework. This thesis has created novel and rigorous understandings of the sociotechnical imaginaries for a MWT that repurposes former fossil fuel infrastructure, it has advanced understand on the hegemonic forces of political economy which dictate this emergent industry and

imaginaries, and has demonstrated where energy justice perspectives are important in this case, as well as providing valuations on the fairness and justness of the current energy economy. The integration of these understandings presents a new, in-depth picture of energy transitions through the case of MWT.

In the following conclusion chapter, key policy, scholarly and practical findings of the thesis are summarised, and their fulfilment of the research questions is underlined. Key strengths and weaknesses of the research approach are examined, with a focus on the analytical framework and methodological choices. Finally, suggestions for future research are presented, which would enable further knowledge to emerge that directly builds on the insights and experiences of this research.

Chapter 11 - Conclusions

> "Let us not submit to the vile doctrine of the nineteenth century that every enterprise must justify itself in pounds, shilling and pence of cash income… Anything we can actually do, we can afford" – John Maynard Keynes in a 1942 BBC address

This final chapter provides a summary of this thesis, presenting key findings which answer the research questions that guided this thesis. I then explore the practical and policy implications of the research. I consider strengths and limitations of the approach, suggest future research opportunities on this topic and conclude with final remarks on the significance of the thesis.

11.1 Summary of the thesis and key findings

This thesis set out to explore the conditions around the development of a minewater thermal energy industry in Scotland. It was motivated by increasing attention towards MWT in academic, policy and industry spaces as part of an energy transition which addresses environmental, climate and social challenges. Despite its technical challenges, MWT is a potential sustainable energy resource. Stored within former coal mines and providing an opportunity to help address both climate, environmental and security of supply concerns within the energy transition. However, the ability for an MWT industry to meet social challenges and empower communities is far from certainty and is interconnected with the issues present in the wider energy economy.

The aim of the study was to understand how an imagined MWT industry would develop with respect to a just transition and alternative economic paradigms which address social needs, while also understanding how these alternative ideas run counter to and are contorted by a neoliberal political economy which drives energy governance. The literature review revealed an understanding of the wider energy economy in which MWT could be studied further. In the past, the energy economy has served nation building projects under a social democracy paradigm in the aftermath of WW2. The former coal industry is a particular and evocative example of this. Since the transition to a neoliberal paradigm and that of a globalised energy market, institutions of the state have been captured, in which the bottom line of economic growth and shareholder returns dominates and distorts all development processes away from any sense of ecological wellbeing and public good.

Emerging from the literature review, an analytical framework was developed in which knowledge from sociotechnical imaginaries, political economy, and energy justice literatures, were integrated in order to study MWT research gaps with significance, rigor and depth. The

analytical framework was used in a methodology in a reflexive methodology, in which critical realist and interpretivist approaches to knowledge were used alongside acknowledgement of research positionality. Qualitative methods were used, including semi-structured interviews and workshops informed by an ethnographic and case study approach.

In this thesis, it is the socio-technical object of MWT under study. Individual and collective imaginaries about this object exist, some tied to outcomes of net zero, social justice/fairness, others economic development and regional empowerment and state entrepreneurialism. The first phase of the data collection explored sectoral professionals relevant to MWT. The findings demonstrate that different groups attach different meanings, values and imaginaries to energy infrastructure, this is the same for the repurposing of former mines. Sector professionals see it as a technological tool to transition the heating system when it makes financial sense to do so.

Community members and advocates see both opportunity and risk, where it may bring a fairer distribution of wealth to the local area, or as another development which ignores their voice and needs, altering the characteristics of place and being forced upon them. Once potential heat networks or minewater geothermal opportunities are mapped out, before any commitment is made, funding wealth is sought or further developments are, the community and citizens must participate with their own perspectives. The findings suggest that this should be guided by principles of co-development, sensitivity and respect, building trust between communities and developers as well as enabling a better understanding of communities, developing locally appropriate ideas and mitigation strategies. Ideally this simultaneously top-down and bottom-up process will produce most appropriate and effective choices for initial heat network development and delivery.

The second phase of the data collection explored the insights from an in depth-case study of a former mining town, utilising focus group workshops. These findings, which build upon the first phase of findings suggest that former mining communities may be as cohesive, strong and capable as any other community in Scotland, and despite their unique history of challenges associated with deindustrialisation are not looking for special treatment. They want to be respected and empowered by the local resources and developments in their area, not forgotten or perceived as a tick box exercise to be overcome by a range of public and private bodies. They are motivated by living well locally, with a healthy local economy, affordable services, and employment opportunities, tied in with respect for cultural dimensions such as local uses of land and greenspace, as well as restoration of former community sites which are now brownfield in many cases. The energy economy should use the insights of the communities dynamically to define and refine its goals and development.

Any alternative vision of the energy economy will require strategic decisions being taken by public institutions to reshape markets, economic and legal systems and institutions to serve society. It will require a combination of national government and local authorities in partnership with communities and industry expertise. Fundamentally, the objectives of the strategic decision making must be with medium and long-term goals of public and environmental wellbeing, shifting the regimes and landscapes towards different aims. Decisions around the delivery model arrangements (finance & governance) need to be made with a nationally coordinated but locally adapted approach. It will involve working with technical expertise and understanding operations across the project lifetime. This may involve procuring a private sector partner, or making a strategic decision to invest and recruit expertise at the national level and deliver through the public sector. Local authorities should be empowered to take action that promotes wealth building for local places as long-term anchor institutions. The reduced and short-term profitability of these schemes, the level of strategic planning, infrastructure and potential disruption to people's lives requires coordinated public involvement.

In answer to the overarching question which has guided this research, this thesis suggests the process of imagining and implementing alternative MWT futures is shaped by various hegemonic political economy forces found in multiple energy regimes and landscapes. It suggests an integrated approach to studying emerging industries, as taken here, is an effective and promising avenue of research. It has demonstrated the potential of alternative approaches which are place-based, involve a state working strategically for public benefit and empower communities, and the role of hegemonic and counter hegemonic ideas in shaping the imaginaries and implementation of alternative energy governance. There are practical and policy implications which arise from this, and these are worth directly addressing in this conclusion chapter.

11.2 Practical and policy implications

Beyond the theoretical contributions discussed in the Chapter 10, this thesis also has implications for practice and policy that are highlighted here. Policy implications are relevant to those involved in establishing a national strategy and framework to guide and direct the conditions in which a MWT industry would develop, practitioners can operate within frameworks by adopting best practice across economic and social dimensions.

11.2.1 Emphasise the plurality of energy futures

As discussed in the findings and discussion chapters, this thesis emphasised the multiple dimensionalities and temporalities that shape energy imaginaries. There is a risk with current

just transition policy approaches, and with restorative justice perspectives that result in homogenisation and othering of communities. Particularly commonly defined, disadvantaged communities such as former coal communities. Instead, an emphasis on exploring the place-based context of imaginaries, and justice should be present in policy perspectives, routed in dialogue and deliberation between groups. Recognising this plurality, multiplicity of imaginaries, agency and place-based realities will inform better policy design for places and avoid patronising and alienation. In the context of Scotland's just transition policy programme, heat policy and community wealth approaches, this finding is an important insight for policy developments.

11.2.2 Support place-based shared ownership and governance models for MWT

The findings have implications for different types of practitioners. For technical experts, whether private or public developers, made up of professionals from backgrounds such as engineering, legal and finance, rooting the project in place should be the first priority. This includes the mapping of heat demand opportunities, such as anchor loads and housing types, the planning of piping infrastructure, as well as the ownership and governance models. Joint venture and shared ownership models led by community-council partnerships should be pursued in MWT projects; it enables risk sharing and provides varied expertise, inclusive governance and local oversight, reflecting the preferences expressed for democratic involvement. Meaningful partnership building should be adopted as a practitioner aim, whether with local public institutions, businesses, infrastructure companies and citizens themselves. As the findings suggested, in doing so projects can benefit from having a greater and more visible impact locally, increasing the wealth kept in areas, navigating any issues more effectively and reducing the risk level in projects through trust, shared finance and governance tied to place and increasing local accountability.

Investing in honest and open partnerships with local communities must be a first step taken at the earliest possible stage, utilising existing community bodies and networks before any serious plans have been made in order to ensure the unique considerations and experiences of a former mining community are at the heart of development. This may include elements such as the use of greenspace or brownfield land, the phasing of installations in different parts of the place, interactions with travel infrastructure, addressing mining history concerns, but perhaps most importantly, democratic involvement and fairly negotiated distribution of the benefits of MWT resources.

For communities, considering how MWT would fit in or best operate within *their* place would be the best starting point. This may take the form of community-led energy place plans in a formal sense, utilising any existing organisations such as a development trust or community council to anchor plans. Part of this may entail working with local people to better understand and develop a fuller picture of the feeling towards mining histories, particularly for former mining communities that have a history of disaster and accident. It would also involve partnership building with the local authority and organisations to ensure that the community voice is present throughout levels of governance. The research findings suggest that this would create more inclusive, beneficial and lasting energy projects for communities.

Policy could support these critical areas of ownership and governance through legislating for a minimal percentage of all projects to be council owned as well as offered to a community board of various local groups; governance rights being equal here are critical, so even in cases where public and community funds aren't able to match investment equally, governance rights should be retained on an equal basis at minimum. Policy could also support these models by stipulating that any public investment or support is only provided to place-based and shared ownership models, incentivising them further. Thus, local legitimacy is more likely and benefits are shared more equitably.

11.2.3 Anchor-led, phased deployment of MWT

Anchor-led, phased deployment should also be the strategy taken by MWT developers. Utilising non-domestic buildings, like schools, health centres or community halls as starting points for pilot projects, or in some cases new build housing opportunities, should be used. This way, technical viability is demonstrated and momentum can be built towards further network expansion, an incremental approach such as this can optimise cost efficiency and also build trust and appetite for connections to a MWT heat network. This approach could be embedded within the LHEES policy and other council strategies. Further, policy changes could alter public procurement towards mandatory connections of public buildings and to the kinds of place-based shared ownership models described in the previous section; providing long-term assurances for area based planning. Ultimately this promotes manageable early wins for MWT and encourages scalability.

11.2.4 Derisk investment

Connected to the first two areas of recommendation is the need to derisk financial investment in order to increase deployment of MWT heat networks. Establishing public investment tools, going significantly beyond the existing heat network funds, and offering a range of options such as low-interest loans or funding for infrastructures such as pipes which

could represent a sound state investment over long periods. The mandatory connection of public buildings discussed in the previous section would also aid in the derisking of investment, providing a guarantee of future connections and revenues. In this way funding models are aligned with long-term strategic goals of energy transition and place-based development.

11.2.5 Building community & local capacity

Building local and community capacity allows for projects to be more successful through their grounding of projects in the local social and economic contexts, and the ability for local actors to engage and ensure local benefit. Funding for dedicated full-time roles within councils and communities that are solely responsible for the development of large scale heat network projects such as MWT would enable strategic coordination for long-term area planning and partnership building. Improvements to policy regulations for co-production, improving upon the practice principles currently used, ensuring genuine engagement and building trust across project lifespans; early communication and community inclusion could be mandated into planning regulations. The creation of national level support teams that local actors can utilise to build skills, capacity and expertise, thus enabling local projects to adopt best practice and leverage successful approaches, tailoring them to local contexts. Building community and local capacity will focus resources and time towards development, building trust and long-term chance of success.

11.2.6 Embed MWT in just transition & co-benefit strategies

By targeting and prioritising areas of deprivation, multiple socioeconomic challenges can be addressed together. Post-industrial communities are littered with brownfield sites, and regeneration schemes would not only contribute to energy transitions and economic development but improve mental wellbeing and social cohesion. Holistic measures should be implemented to assessment criteria within planning and policy objectives. Going beyond emission reductions, or GDP growth, regulation could be introduced to include social dimensions that assess wellbeing, health, job creation and wealth retention. A more just and equitable energy system is then contributed to by MWT development.

11.2.7 Streamline regulation & licensing

Subsurface heat governance should be revised through streamlining of regulation and license regimes. A legal framework for MWT access and use, as well as shared-thermal licences would significantly improve project timescales and early-stage costs to development. Any new MWT licensing regime must integrate into frameworks such as the

Heat Network (Scotland) Act. Ultimately regulatory clarity enables quicker investment and progression in developing an MWT industry.

11.3 Strengths and limitations of this study

Having discussed the recommendations and implications of the research, this section looks inwards to reflect on the ways in which the study is limited and could be improved. The strengths and limitations of this study can be summarised under two major headings which are dissected in this section. First being the analytical choices, where the selections from literature shaped the development of the analytical framework, the methodology and the knowledge contributions. Second, is the practical research strategy, in which the material conditions, context and planning determined the outputs of this thesis.

11.3.1 Analytical choices

The sociotechnical imaginaries theoretical lens utilised in this thesis was I believe an effective way in which to understand the envisioned MWT industry that is yet to exist in Scotland. By the nature of its pre-development stage in Scotland, MWT pathways of development are imagined and understood in relation to the systemic landscape and world around it.

Building upon the sociotechnical imaginaries understanding developed primarily by its originators Jasanoff and Kim (2019), the framework aimed to act upon critical observations for an improved understanding of how politics and power influence the imaginaries process, turning to the political economy literature. In doing so, alternative economic development approaches were explored to frame what MWT development could entail, and a political economy understanding of incumbent structures allowed for interaction between the imaginaries process and that of alternatives. This approach emerged from insights generated via the literature, but also in response to the observed empirical data, where participants consistently highlighted the centrality of incumbent political economy structures and ideologies as discussed in sections 8.1 of the findings chapters.

The analytical framework does however have limitations, including the difficulty associated with analysing imaginaries as they scale from an individual to the collective (Kuchler and Stigson 2024b). People are rarely sure where their ideas come from, which is a challenge across qualitative research. Where imaginaries originate, the myriads of influences and positionalities that inform them, can be hard to uncover beyond the choice of language used by participants, a possible area of future work to complement the findings of this thesis. As a result, this thesis acknowledges that the full picture was never going to be entirely

deciphered. Great care was taken in the data collection process and the analysis to ensure that emerging imaginaries and energy futures were understood in a balanced way, cognisant of the unknown influences but also of the background and experiences of participants.

A further limitation of the approach taken by this thesis, is the ability to understand accurately the role of political economy structures throughout scales, affecting both global and national issues, right down to individual energy developments. Attempts to address this were made by integrating multi-scalar, political geography and spatial political economy approaches that recognise overlapping layers of governance and markets, account for structural global influences and embed local dynamics (Park 2005; R. Williamson 2015; Prys-Hansen et al. 2024).

Further, despite the fact that people may not use the language or terminology to describe phenomena tied to political economy language, it does not mean the concept doesn't affect them and it cannot be studied, for example, people may not identify with the language class, but the material and cultural conditions of their role in society can still be studied. The rest of this section will discuss the strengths and limitations of the research strategy.

11.3.2 Research strategy

This research strived for a multiplicity of participants across scales, social class and expertise to contribute to the data collection. Whilst the networking, connections and capacity required to involve professionals who are paid to work on the topics relevant to this PhD proved successful, working with community and citizens to participate in the study in an appropriate manner proved more challenging. During the early stages of research, an understanding was reached through various insights that rightly or wrongly, former mining communities could be sceptical, apathetic or hostile to my elitist researcher connotations as an outsider, particularly if the process was deemed to be extractive and 'done to them'. The aim was to engage with the communities as sensitively and considerately as possible taking insight from ethnographic methods, including a commitment to co-production, participatory and reciprocal approaches. This meant that a slower and more thoughtful process of engaging communities was required.

As this research was conducted as part of a three-year funded programme of study, time and capacity constraints were major limitations. For the case study, having had no prior connections to rely on in any former mining community, the process of gaining traction and support within these communities was done from the bottom up, where attempts to utilise existing organisations were made in order to tap into their networks and to not impose on an area without having some grounding in the local community. With more time and capacity

available, ultimately a greater number of voices could have been included in the research, giving a broader and deeper account of community expertise. This could have included multiple case studies primarily within Scotland but also beyond to enable a further layer of social impact comparisons. In-depth interviews could also have been taken with a wider array of community participants.

The data collected from the interviews and the case study in this thesis cannot be determined as to be representative of all knowledge relating to MWT development in Scotland, and the wider energy economy. However, it does present novel findings that are not presently found in the existing literature, suggesting there is much knowledge to be accrued, building upon the analytical and empirical perspectives in this thesis.

11.4 Future research opportunities

Firstly, this research could be highly complimented by further comparative research which involved the study of a different former coal mining community. A different community may produce different findings related to a just energy transition for MWT, therefore exploring a different community, or preferably several case study communities would increase breadth and depth of the research findings for this topic of study.

Further, future research could be guided by further development of the analytical framework deployed in this thesis, namely utilising insights from the political economy and sociotechnical imaginaries and transitions. The approach helps address difficulties associated with energy transitions, as noted in the literature review chapters with respect to injustice, insufficient democratic governance, and ecological limitations. Future research that utilises the analytical framework may uncover insight which articulates more effective development practices and policies across scales, which can be disseminated to communities, practitioners and policymakers.

The framework could also be applied to provide insight on the imaginaries of different socio-technical systems beyond MWT and other energy systems, and their relation to political economy structures, such as water or transport systems. This would be most pertinent in systems where alternative pathways are widely envisioned, but their actualisation remains constrained. Research focussed on water systems for example could explore individual and collective imaginaries around water systems as a universal service or right, in contrast to the privatised commodity seen in many western economies, and the political economy structures shape and define this process of stasis or transition.

An important area of examination could be a further exploration of the dynamic between repurposing infrastructures and the potential to develop and realise visions of a new reality. Whether it is made easier or harder, and whether infrastructures not related to the coal industry would have a different imaginaries dynamic.

Further interdisciplinary research that builds upon the work of this thesis, with a focus on MWT in Scotland, is required from a socioeconomic perspective. Scotland provides a useful context for the exploration of MWT in several ways. Scotland's coal mining history across regions of the central belt means that the resource is available in a concentrated area of land, which also entails a wide range of community expertise to draw upon in how it can be best developed for economic wellbeing. Further, the Scottish Government has utilised and actively supported alternative economic development agendas such as community wealth building and just transition as well as other aspects of community empowerment such as land reform and ownership. The knowledge on this topic would be enriched from further study with a broader range of experts and communities across Scotland. As this research focussed on the critical role played by incumbent economic structures and ideologies, greater engagement with experts at different scales could bring further insights on how an MWT industry in Scotland traverses such challenges. Bringing community and sectoral experts together into the same room, in the form of participatory workshops for example, may bring further insight as to the appropriate MWT development pathway.

A further area of further exploration is the social meaning and grassroot perspectives on MWT found in Scotland's former coalfield communities. Whilst this thesis explored this theme through imaginaries, justice and political economy perspectives, it was limited in breadth due to the time constraints and the need to collect other data. A study from an anthropological, ethnographic perspective to better understand how former coalmining communities relate to the industrial past and face the energy transition future would be beneficial in advancing a plural understanding of what MWT and Scotland's energy economy should consider.

Finally, if MWT projects begin to develop in Scotland, more statistical data opportunities will emerge, which can enable greater quantitative analysis on the economic structures and impacts of MWT in Scotland.

11.5 Concluding remarks

If I am able to leave the reader with any final thoughts, it would be to emphasise and reposition the findings of this thesis in relation to a bigger picture of the economy.

Continuous growth orientated paradigms are evidently incompatible with planetary and environmental health, as well as that of human and non-human species, as commodity driven consumption patterns devour resources in socially damaging and polluting ways, as well as concentrating power to serve the interests of fewer and fewer individuals. As a result of this 40 year-long paradigm shift, the financial class influence the energy industry through the lens of extractivism, where real value is channelled in whatever way that maximises profit, hence the reluctance from the private sector to significantly invest in riskier projects with lower financial returns without socialisation from the state.

Communities and citizens increasingly view energy systems with scepticism and distrust, and as being done to them, as new developments exploiting energy resources do nothing to lower costs or improve livelihoods. Technocratic managers in the state attempt to manage these tensions, but as with social democratic arrangements of the past, are defeated by the interests of capital and power accumulation. This profoundly undemocratic situation is a major issue facing the energy transition or indeed transformation to a system which serves social and environmental wellbeing. Whilst bottom-up organisation and resistance to capital exploitation is critical, in this modern world, the state and its levers, with international coordination remain the key battleground capable of reversing the neoliberal project towards more just energy futures. The state can and must tackle the democratic deficit and power imbalance in governance structures, the management of wealth, the use of resources and control of the monetary system. Thus, a bold new vision of the energy economy is necessary, in which the wellbeing of the planet's natural world and the public is prioritised over the interests of international capital, and its goal to move beyond place, state, and democratic accountability.

The energy economy we find ourselves in, where contestation and discontent is rife and transitions to ecological sustainability are insufficiently progressing, is not a natural state of human organisation, but is the result of power, politics and decisions across time. The insights from this thesis demonstrate that just as the energy economy, as it exists, has been constructed and made, alternative visions of a different energy economy are tangible, widespread and just as possible to realise with the right steps taken.

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Appendix A: Participant Consent Form & Information Sheet

Consent Form

Name of department: Hunter Centre for Entrepreneurship

Title of the study: Minewater Geothermal Energy: Just and place-based development frameworks for community wealth

- I confirm that I have read and understood the Participant Information Sheet for the above project and the researcher has answered any queries to my satisfaction.
- I confirm that I have read and understood the Privacy Notice for Participants in Research Projects and understand how my personal information will be used and what will happen to it (i.e. how it will be stored and for how long).
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences.
- I understand that I can request the withdrawal from the study of some personal information and that whenever possible researchers will comply with my request. This includes the following personal data:
    - audio recordings of interviews that identify me;
    - my personal information from transcripts.
- I understand that anonymised data (i.e. data that do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the research will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project.
- I consent to being audio recorded as part of the project
- I consent to the interview taking place:
    - At home (or in your garden)
    - In a public space
    - Online
    - Other (please specify):

(PRINT NAME)	
Signature of Participant:	Date:

Participant Information Sheet

Name of department: Hunter Centre for Entrepreneurship, Innovation and Strategy, University of Strathclyde, Glasgow
Title of the study: Repurposing Scotland's former Coal Mines: Visions of development and Just Approaches

Introduction
My name is Finlay Bain Kerr and I am a researcher from the University of Strathclyde.

Email: Finlay.bain-kerr@strath.ac.uk

Phone: 07500382866

You have been invited to participate in a research project about the development of minewater geothermal technologies in the former coalfields.

Before participation can go ahead, I need to be sure you understand why I am doing the research and what it would involve if you agreed to take part. Please read the following information carefully and feel free to ask any questions of myself or my supervisor (full contact details below).

What is the purpose of this research?
We (the research team) are interested in your experience and perspectives of how this technology should be deployed in the context of local social and economic factors, historic and in the present day. Not enough is known about how former mining communities view repurposing of ex-mines for renewable energy and what role they can play. With agendas for a just transition and community wealth building as well as the legacies of deindustrialisation, energy resources such as Minewater Geothermal require novel management approaches, particularly around governance and business models that bring together stakeholders and communities.

Do you have to take part?
Your decision to take part in the research is voluntary and you have a right to withdraw from the research without detriment.

What will you do in the project?
We will simply ask you to participate in an informal and friendly interview or focus group. This is a bit like a semi-structured conversation, which will cover a variety of topics about and around repurposing ex-mines for energy and how it might fit into future visions of the local community and area. The interviews last approximately one hour and can be conducted by Zoom, Skype (or another application), by phone or in your office, at your home or in a café or in a quiet place that we will arrange. If you give your permission, we will make an audio recording of the interview, to help me remember what you have said.

Please let me know if there are any other arrangements I can make for the interview which will make you feel more comfortable and secure.

Why have you been invited to take part?
We are contacting individuals we believe will have valuable insights into the deployment of Minewater Energy systems from a community and stakeholder perspective.

What information is being collected in the project?
This research seeks to collect qualitative data about your perspectives of the deployment of Minewater energy schemes and how stakeholders and communities can integrate appropriate local context and strategies to achieve community wealth and a just energy system. It is not our intention to collect data which identifies you personally and if (inadvertently) it is this will be disregarded by the researcher and deleted from any written record of the interview.

Who will have access to the information?
If you choose to participate, the data we gather will be accessible only to the research team and transcription services who will not disclose this data to any other individual or party.

Also, whatever you say in the interview may be used in reports and academic papers that are written for the project, but your contribution will be attributed under a pseudonym. If you do not want information provided in the interview to be included in the project or academic papers, please state this clearly in the interview. We will then not include it. You are free to express any opinion with no risk to yourself and all information will be anonymised.

Where will the information be stored and how long will it be kept for?
Original audio files will be transferred from the audio recorder and secured on encrypted hard drives under pseudonyms in accordance with the University's data management and record-keeping policy. Electronic files will be stored in a secure folder, while paper copies/documents related to the research will be held in a locked cabinet on campus for a period of five years. The data will be retained by the investigators for a period of 5 years from completion of the project, after which it will be securely archived (non-sensitive personal data) or destroyed (sensitive personal data) in line with the Data Protection Act 1998.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 2018.

What happens next?
If you are happy to be involved in the project, you will be asked to sign a consent form to confirm this.

If you wish, we can provide you with feedback upon completion of the research.

While we will seek to write reports or articles which may be based on some of the information provided here you will not be identified in these documents.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

Researcher contact details:
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This research was granted ethical approval by the University of Strathclyde Ethics Committee. If you have any questions/concerns, during or after the research, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the University Ethics Committee

Research & Knowledge Exchange Services

University of Strathclyde

Graham Hills Building

50 George Street

Glasgow

G1 1QE

Telephone: 0141 548 3707

Email: ethics@strath.ac.uk

Privacy Notice for Participants in Research Projects

Introduction
This privacy notice relates to individuals participating in research projects led by the University of Strathclyde. It explains how the University of Strathclyde will use your personal information and your rights under data protection legislation. It is important that you read this notice prior to providing your information. Please note that this standard information should be considered alongside information provided by the researcher for each project, which is usually in the form of a Participant Information Sheet (PIS). The PIS will include further details about how personal information is processed in the particular project, including: what data is being processed; how it is being stored; how long it will be retained for, and any other recipients of the personal information. It is usually given to participants before they decide whether or not they want to participate in the research.
Data controller and the data protection officer
The University of Strathclyde is the data controller under data protection legislation. This means that the University is responsible for how your personal data is used and for responding to any requests from you in relation to your personal data. Any enquiries regarding data protection should be made to the University's Data Protection Officer at dataprotection@strath.ac.uk.
Legal basis for processing your personal information
If you are participating in a research project, we may collect your personal information. The type of information that we collect will vary depending on the project. Our basis for collecting this information is outlined below:

Type of information	**Basis for processing**
Personal information and associated research data collected for the purposes of conducting research.	It is necessary for the performance of a task carried out in the public interest.
Certain types of personal information such as information about an individual's race, ethnic origin, politics, religion, trade union membership, genetics, biometrics (where used for ID purposes), health, sex life, or sexual orientation are defined as 'Special Category' data under the legislation.	It is necessary for the performance of a task carried out in the public interest and It is necessary for scientific or historical research purposes in accordance with the relevant legislation (Data Protection Act 2018, Schedule 1, Part 1, Para 4).
Criminal conviction / offence data	It is necessary for the performance of a task carried out in the public interest and is

	processed in accordance with Article 10 of the General Data Protection Regulation and the Data Protection Act 2018, Schedule 1, Part 1, Para 4.

Details of transfers to third countries and safeguards

For some projects, personal information may be transferred outside the UK. This will normally only be done when research is taking place in locations outside the UK. If this happens, the University will ensure that appropriate safeguards are in place. You will be fully informed about any transferring of data outside the UK and associated safeguards, usually in the Participant Information Sheet.

Sharing data

If data will be shared with other individuals or organisations, you will be advised of this in the PIS.

Retention of consent forms

If you participate in a research project, you may be asked to sign a participant consent form. Consent forms will typically be retained by the University for at least as long as the identifiable research data are retained. In most cases they will be retained for longer, the exact time frame will be determined by the need for access to this information in the unfortunate case of an unanticipated problem or a complaint. 5 years after the research is completed will be suitable for many projects, but beyond 20 years will be considered for any longitudinal or 'high risk' studies involving children, adults without capacity or a contentious research outcome.

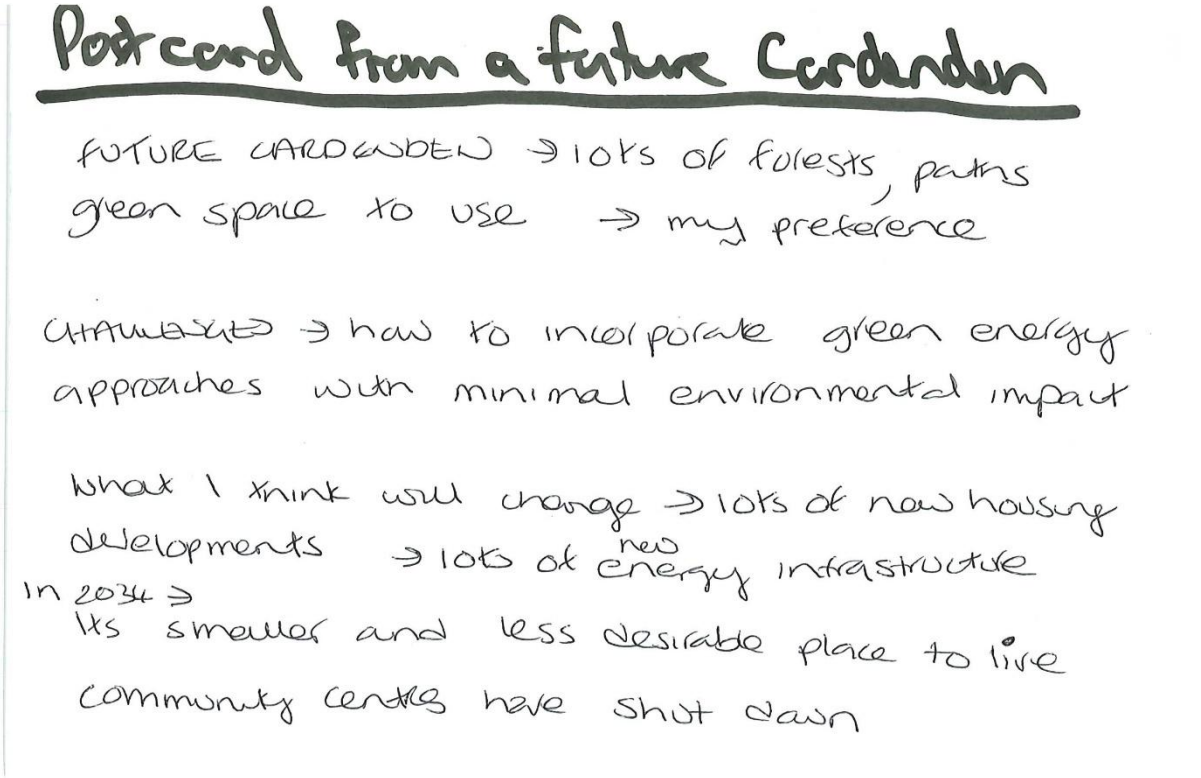
Data subject rights

You have the right to: be informed about the collection and use of your personal data; request access to the personal data we hold about you; request to have personal data rectified if it is inaccurate or incomplete; object to your data being processed; request to restrict the processing of your personal information; and rights related to automated decision-making and profiling. To exercise these rights please contact dataprotection@strath.ac.uk.
Please note, many of these rights **do not** apply when the data is being used for research purposes. However, we will always try to comply where it does not prevent or seriously impair the achievement of the research purpose.

Right to complain to supervisory authority

If you have any concerns/issues with the way the University has processed your personal data, you can contact the Data Protection Officer at dataprotection@strath.ac.uk. You also have the right to lodge a complaint against the University regarding data protection issues with the Information Commissioner's Office (https://ico.org.uk/concerns/).

Appendix B: Postcards from Cardenden case study across both workshops



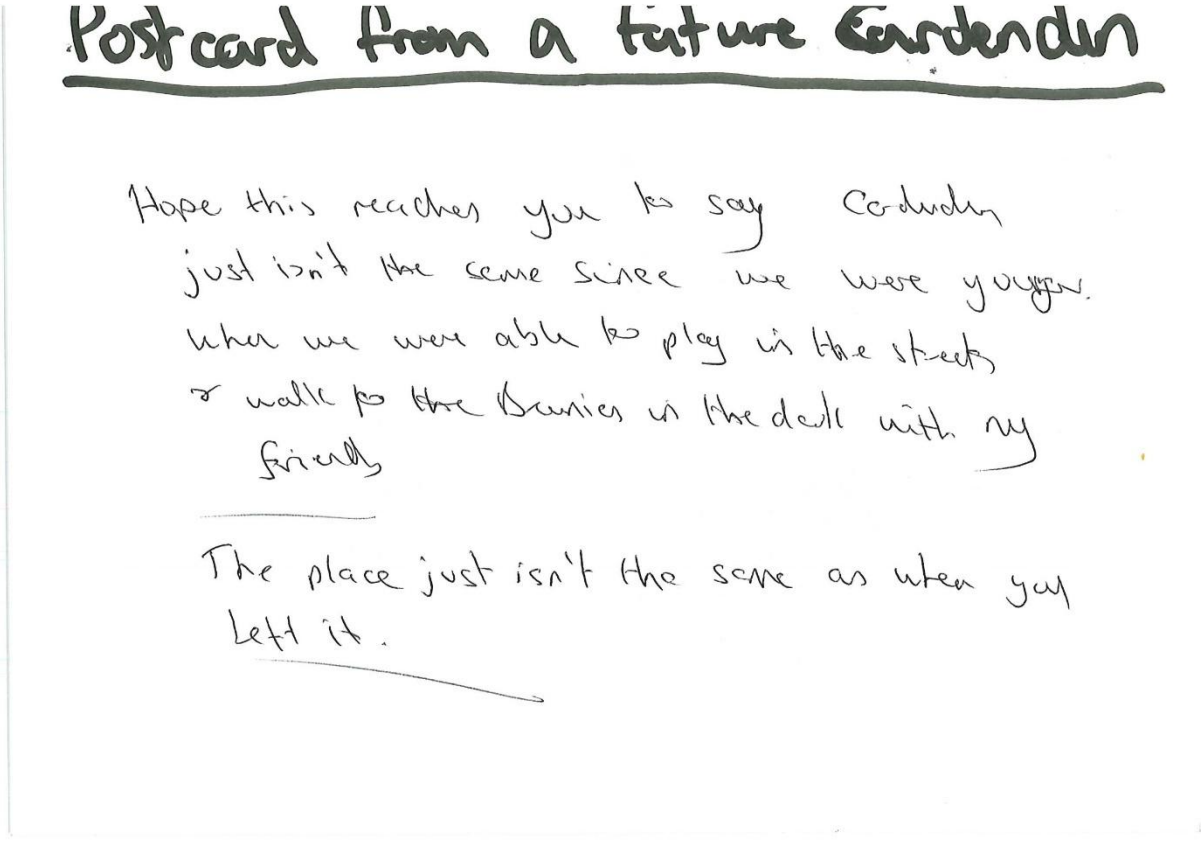
Postcard from a future Cardenden

FUTURE CARDENDEN → lots of forests, paths green space to use → my preference

CHALLENGES → how to incorporate green energy approaches with minimal environmental impact

What I think will change → lots of new housing developments → lots of new energy infrastructure

In 2034 →
Its smaller and less desirable place to live
Community centres have shut down



Postcard from a future Cardenden

Hope this reaches you to say Cardenden just isn't the same since we were younger. When we were able to play in the streets or walk to the Dunies in the dark with my friends

The place just isn't the same as when you left it.

Postcard from a future Cardenden

What we need is homely, a nice place to

Postcard from a future Cardenden

You'll hardly recognise the place all the old landmarks are going or gone. The old Goth demolished. Auchterderran Church and the chapel closed. The institute where we have had many a great day in the wee clubs we attended, closed because the council wouldn't maintain it.

We still have some groups working hard to look after the community, fireworks and football tournaments are still happening thank goodness.

Still I love this wee village and the memories I have.

Postcard from a future Carderden

Photographs of Apprentices starting their working life at one of the many new green energy plants.

Hi,

Just to say started my new job at the Westfield energy Plant. So interesting, hopefully a job for life. Vibrant village, Great social life + not long to wait until I move into my new accomodation.

Post Card from a future Carderden

1. To Economically refurbish old buildings in to liveable buildings / but retain ~~facade~~ facade.

2. Young trainin for actual jobs.

3. ~~Jobs~~ Economical, challenges to bring to, furintion a Future for all.

Postcard from a future Cardenden

Dear whoever

Somebody blow the dump up. This place of Cardenden is a shut hole. Maybe I'll move to Australia to be near you.

Postcard from a future Cardenden

Hello Dear Friend

You would see many changes in the Village some good + some bad but I would say the community spirit remains as strong now as it did when you lived here! Hopefully that spirit which has continued ~~of~~ through the years will thrive for many years to come!

Margaret x

Postcard from a future Curderden

When the miners were here they had recreational facilities that did not require cars for very few miners had cars so most things had to be on the doorstep eg. Picture shows 2 recreational facilities to suit everyone. Boxing, weight training, reading rooms etc and no food banks. things have really changed.

Postcard from a future Curderden

- Place got bigger with more housing filling up the green spaces.
- Westgield hole still not landscaped.
- The old Auchterderran School Building which was demolished years ago has only just been developed into housing.

Postcard from a future Cardenden

MORE HOUSES, SHOPS SAME.
STAY WHERE YOU ARE.

Postcard from a future Cardenden

Postcard from a future Cordender

The village is now a large town, and the people have their energy switched to allow electricity during daylight hours. I wish they had undertaken the mine water heat system because costs would have been ~~about~~ reduced.

Postcard from a future Cordender

- We now lovely insulated houses cheap to heat using minewater
- Working better than air source but has been very expensive to install but should be a good investment as running costs are low.

Postcard from a future Carbernden

- Lovely housing development at Auchterderran School site.
- Playparks at all areas.

Postcard from a future Carbernden

- Improved public transport.
- Lovely new footpaths.
- Lidl at Auchterderran Site.