A Pathway to our Renewable Future

June 2023

CASE

CENTRE FOR ADVANCED SUSTAINABLE ENERGY

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In this new world we have a simple but imminent choice: learn from our innovative history and lead, or lag and fall behind.

1 GW
of offshore wind planned for Northern Ireland

140 GW
of offshore wind planned for our closest neighbours

Executive summary

Ambition, Action, Progress

Three simple words define our energy challenge. Rapid change is happening around us, reshaping how we support both people and the planet. In this new world we have a simple but imminent choice: learn from our innovative history and lead, or lag and fall behind.

We cannot continue to wait while **others invest, at pace, to secure the jobs and green industries of the future. Northern Ireland was once a global powerhouse** built on a unique combination of renewables, agriculture and manufacturing. It is time to confine procrastination to the past. **The drive to net zero gives us the opportunity to repurpose our strengths** and demonstrate how we can deliver a more sustainable, more prosperous, more inclusive future for the generations to come.

We have become too reliant on external sources for our energy, and too complacent on our successes to date. Yes, we exceeded our targets for renewable electricity, but electricity is currently only 14% of our total energy demand. Renewables can deliver so much more for the economy, yet our strategy appears limited to delivering only half of our future energy needs.

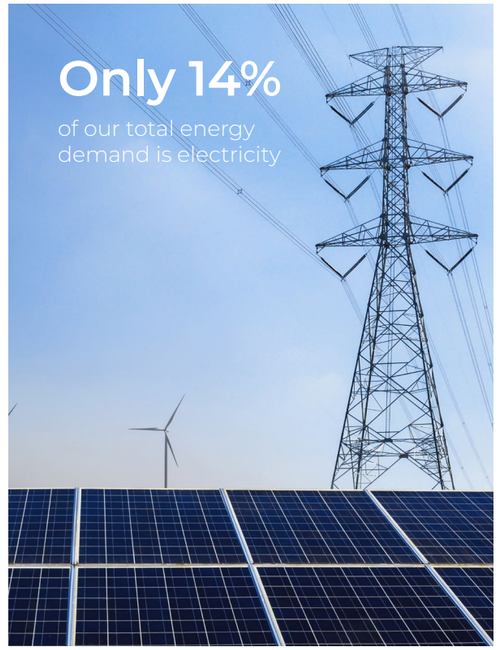
We must think bigger.

While Northern Ireland plans for 1 GW of offshore wind, our closest neighbours are confidently planning more than 140 GW. **We can leverage our neighbours' energy ambition to multiply our own** tenfold, allowing us to achieve not only our carbon targets but to also increase societal and environmental wealth.

If we fail to move quickly the opportunity will be lost. The pandemic has showed that **bold, ambitious, and pragmatic decisions can be made with speed**. That experience proved that we can rapidly overcome political conditions, economic constraints, governance issues, and a culture of risk avoidance and siloed thinking when faced with a national emergency.

Connected policy across boundaries in national and local government departments is essential. Creating policy in isolation results in missed opportunities to holistically address a larger scale problem.

Joined up policy succeeds.



If we think differently and more ambitiously we can deliver the actions needed to make tangible progress on our energy challenge. The key components are:

- **A whole-of-government approach is essential** if we are to deliver a renewable future. We need to identify cross-departmental opportunities to maximise the benefit for Northern Ireland's people and the environment. Only together can government work proactively to deliver a mission for the decarbonisation of energy and wider society, and to assign clear ownership for all aspects of the journey.
- **Governance, planning, and regulation must be streamlined, connected, adequately resourced, agile, and transparent.** Timidity and risk aversion cannot be allowed to continue to paralyze progress. Weighting decisions on theoretical, short-term risks ignores the devastating long-term consequences of inaction. Frameworks which remove barriers to accelerate investment rapidly and deployment of low-carbon energy infrastructure is the only chance of achieving our 2050 targets.
- **Devolving significant elements of carbon budgets and energy targets to councils** will create a greater sense of ownership, responsibility, and capability, leading to opportunities for local growth and prosperity.
- **Ensuring that energy infrastructure is prioritised** will allow businesses and communities to generate and use energy in ways which maximise efficiency.
- **Enabling the Utility Regulator to seek to maximise benefits to the consumer** will offer more opportunity to ensure the optimum outcomes for inclusive growth and carbon emission reductions than a focus on protecting price and quality of service.
- **Attracting capital investment is vital.** Large, direct subsidies are mostly unaffordable, but strategically creating opportunities for low-risk, fair returns will stimulate investment.

Establishing an attractive investment environment will be helped by a combination of factors including:

- rapid planning and permitting consents;
- a high certainty of contracted long-term returns;
- a ready local supply of skills and services;
- and carefully designed incentive or
- support schemes to enable early investment and scale-up.

We urgently need a **new financial institution specifically to support energy and decarbonisation in Northern Ireland**. An institution with a mandate to facilitate targeted investments for enterprises engaged in commercial projects which advance the delivery of net zero energy.

This institution could draw capital from the £billions of Northern Ireland's assets which are currently invested (many of which are outside the region) by utilising financial instruments – such as sustainability bonds, and performance-linked loans – which are designed specifically for Northern Ireland to support a wide range of sectors and projects.

This paper sets out to demonstrate that Northern Ireland has the potential to be an international leader. By building on our regional innovation DNA, with its inherent strengths in manufacturing, renewables, agriculture, education, and community development, we can achieve inclusive and green growth.

Northern Ireland can only succeed by recognising the need to create an environment where we do many things differently, where investments return value to people and nature, and where perverse fiscal or environmental outcomes are mitigated. Success will result in an economy which is better, stronger, and more biodiverse.

Through this paper we have identified four drivers to power a virtuous circle of green growth:

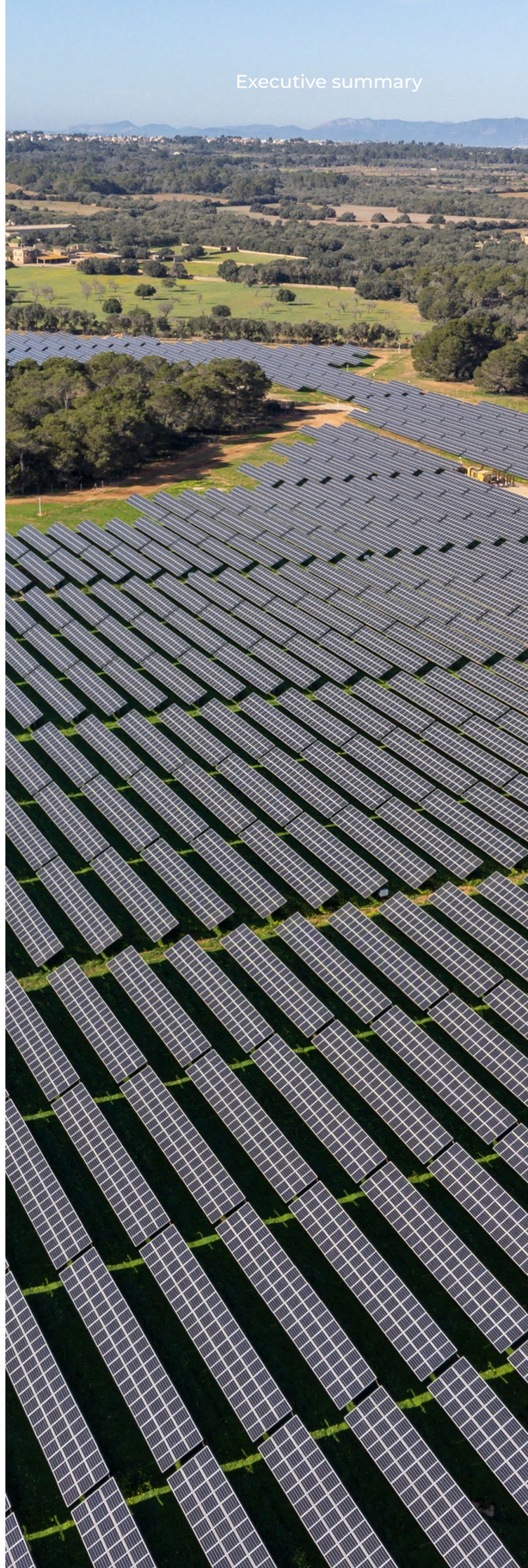
Investment in critical infrastructure is essential with broader financing instruments designed to deliver key metrics of carbon savings and social good.

Governance and planning which recognises the need for timely action, transparency, and providing confidence to investors.

Inclusive growth which accelerates the just transition and where all sections of society can benefit from the combined success.

Innovation and skills which create and support longer-term growth over multiple areas and assures a continuous pipeline of talent.

In turn, these four drivers create a pathway to our renewable future and lead to a set of 10 recommendations which are outlined in the next section.



Our 10 recommendations

01

Immediate adoption of a mission-based, whole-of-government approach by the Northern Ireland Executive, supported by evidence and data, to evolve the economy by building on our regional strengths and leveraging the renewables ambitions of our neighbours to amplify our own.

This is critical if we are to achieve net zero targets and deliver green growth. Alternatively, Northern Ireland must accept the reality of more radical changes, particularly to key sectors of the current economy, and a greater reliance on energy imports to sustain the region.

02

Develop a financial ecosystem focused on the capital and development infrastructure needed to support regional government backed projects dedicated to the Northern Ireland mission across all energy vectors.

Projects must be supported by terms and conditions which incentivise both the quantity and quality of carbon savings realised through changes to the effective carbon emissions or carbon inventory of the region. This is likely to take the form of a regional development, mutual or investment bank and by utilising financial instruments, including performance-linked loans, carbon contracts, and sustainability bonds.

03

Develop critical infrastructure to allow for increased renewable energy generation, flexibility, and energy storage at a scale which will deliver the overall mission.

Northern Ireland government must work with industry, regulators, and other stakeholders to deliver enhanced interconnection and large-scale non-fossil energy storage. The planning and permitting system must evolve to assure the timely delivery of projects necessary to achieve the mission in a fair and transparent manner.

04

Establish Energy Islands to match energy and material streams across industry sectors, agriculture, and local communities allowing them to be more effective in lowering energy costs and accelerating mutual decarbonisation.

A major local project has shown the potential to link an agricultural cooperative with the manufacturing sector to form the first *Zero Carbon Cooperative*. This concept can be expanded and used alongside other renewables as the basis for over 10 TWh of renewable natural gas, enough to decarbonise the entire gas grid.

To maximise the wider opportunity, we need to establish exemplar **Energy Islands** which cluster energy consumers and producers within a geographical boundary allowing a balancing of production and demand.

This islanding approach, on a town or district scale, can optimise gas and electricity grid reinforcement and will enable public-private partnerships to maximise their energy portfolio through the production of e-fuels, district heating schemes, and so much more.

05

Grant the Utility Regulator the remit to deliver the highest benefit to the regional consumer and encourage investment.

Decision making must weigh the benefit of projects against the cost of inaction using carbon pricing and other criteria such as the Envision rating system[1]. At current trajectories the cost to the regional economy will be >£2bn per annum if carbon is priced at £180/tonne. Projects can be measured against such metrics.

Confidence in governance and regulation needs an innovative form of institutional stakeholder engagement to manage trade-offs, unintended consequences, secure buy-in, and participation from multiple parts of society, and encourage constant recursive learning so mistakes are identified and rectified quickly, and targets are adjusted.

The Just Transition Commission and Northern Ireland Climate Commissioner roles need to inform timely action and evidence the impact of actions.

06 Support councils to work proactively and collaboratively to identify and expedite projects which maximise carbon savings within their regions to the benefit of communities and business.

Carbon data and the emissions savings of projects developed within councils need to be transparent and linked to the regional carbon budget allowing them to draw resources through the financial ecosystem and be supported by the regulator and other expertise.

07 Leverage existing investments to create a virtuous innovation ecosystem and provide the key skills needed to deliver the mission.

We need to assure investments relating to energy and decarbonisation not only address economic value but also social value. We cannot squander the opportunity to maximise the existing pipeline of projects aligned with the mission. Housing associations, schools, and hospitals can all benefit from and contribute to balancing of energy alongside business, and amplify success.

08 Encourage business groups, HE/FE, and InvestNI to work together to identify and support opportunities.

A more coordinated, agile, and appropriately funded approach needs to be adopted which seeks to aggregate capabilities and skills, particularly amongst the micro-businesses which make up 89% of the sector. Our analysis has shown that many Northern Ireland businesses lack the critical mass to compete effectively in larger UK programmes and that a more proactive approach is needed.

At present, too much of our activity is responsive rather than seeking to create new opportunity. The success of larger Northern Ireland businesses to the UK Net Zero Hydrogen Fund have shown that innovation exists and is competitive. We need to amplify it.

09 Establish a mechanism to coordinate and standardise baseline carbon calculations and validate performance.

Our unique circumstances as a small, regional, mainly rural economy, with a large agri-food sector presents significant opportunities to leverage networks, build evidence, and support new businesses and services.

The soil nutrient health scheme can serve as the basis for a Regional Carbon Inventory and help to establish a market for atmospheric CO_2 removal by drawing on the financial ecosystem to create investment ready projects and incentivise new business opportunities. Biochar is just one example where we have shown co-benefits such as energy production and decarbonising the concrete and precast industry.

10 Act now.

Many of the above can begin immediately. Some will take longer than others and more detail is required. The expertise exists to provide the evidence and assurance. Perfection cannot be the enemy of the good.

Introduction

Between October 2021 and February 2022 several regional and national government strategies, consultations and white papers were published covering areas of green growth[2], net zero[3], energy[4] and levelling up[5]. All these documents and more contain statements and concepts which serve as the ingredients for an overarching vision for a decarbonised Northern Ireland, recognising the need for a fundamental transformation that will lead to better outcomes for people and the planet.

Soon after these publications, Russia invaded and occupied parts of Ukraine, beginning a war that continues to this day and which has changed the global energy landscape. The impacts of this have been widely felt by individuals and communities and spurred the UK, Republic of Ireland, and other governments around the world to work at ensuring that the systems needed to maintain a quality of life, such as energy and food production, are more resilient.

The need for resilience parallels the need for decarbonisation and, on the 6 June 2022, the Climate Change Act (Northern Ireland) 2022 received Royal Assent[6]. While this Act compels government departments to ensure that the net emissions account is at least 100% lower than the baseline, it also provides specific provisions for agricultural methane emissions by limiting the requirement to 46%. These conflicting targets suggest the necessity for negative emissions technology or carbon offsetting to compensate.

Within the Act is the requirement for sectoral plans which fall under the remit of the Department for the Economy (DfE); the Department of Agriculture, Environment and Rural Affairs (DAERA); and the Department for Infrastructure (DfI) to support inclusive growth, creating secure green jobs as well as facilitating the underpinning of investment, training, and infrastructure. These plans must also help tackle inequality by ensuring that affected workers and communities which remain dependent on the existing high carbon economy are supported, so that a 'just transition' is realised[7].

There will be many complex and interdepartmental challenges arising from the combination of higher renewable electricity targets and increased electrical power consumption in areas such as heating and transport.

While energy efficiency savings will allow for reductions in consumption, the transition from imported fossil energy to more regionally generated renewable sources requires new and large-scale energy infrastructure. The scale at which this is needed will clearly depend on the technologies used, but significant investment in the grid is inevitable.

Responding to this need, in April 2023, Northern Ireland Electricity Networks set out its plans to invest almost £3bn over the period of 2023 to 2032 to support Northern Ireland's climate change commitments[8]. The sectoral plans for DfI must align this need for infrastructure with their own proposals and policies for planning, construction, public, and private transport.

Similarly, as the technology seeks to access both onshore and offshore assets, synergies or conflicts can result with agriculture and fisheries, and – again – sectoral plans must recognise the overlap and opportunities by co-designing proposals and policies with DAERA for the marine and terrestrial environments.

Further proposals committed to farm-based carbon audits for assessing performance improvements and savings can also benefit through cross-cutting policy. There are clearly opportunities in manufacturing, agriculture, renewable energy generation and use, financial technologies, data and AI, as well as other associated services and co-benefits.

In his letter of March 2022 to the then DAERA Minister Edwin Poots MLA, Lord Deben, Chairman of the Climate Change Committee (CCC), commended the ambition of the Climate Bill which had set an emissions target well beyond their recommendation and further highlighted that the priority is now to deliver the statutory goal[9].

This ambition and the resulting challenges were also evident in the CCC's advice report[10] to Northern Ireland of March 2023, in which the authors suggested a 'Stretch Ambition' pathway. This pathway sought to deliver a lower 93% reduction but recognised that the suggestions were 'radical actions' which, even if realised, would lead to a gap in the legislated target.

The aggregated challenges are clearly interconnected and significant and the risk for failure is high, particularly given the existing regional and wider political environment. It is also clear that neither climate or energy targets can be made by considering policy and investment within government silos.

While the Climate Change Act (Northern Ireland) 2022 has created an impetus and a legal obligation for cross-departmental working, there is a lot to do, and the clock is ticking. At the same time, it is not only cross-department collaboration that is needed but mobilising existing and new forms of partnership between government, communities, and businesses.

The discussion above leads to the implication that if the Climate Change Act limits our attention to only removing fossil fuels from the current system, it misses the opportunity for investment in the transition to a new economy. A new approach is required which will support an evolution in the regional economy, allowing industries and communities to pivot and gain from the resulting opportunities while also improving our natural ecosystem.

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Questions which must be addressed include:

- What evolution is required in our regional innovation DNA to make this vision a reality?
- Which of the core elements which have shaped innovation in the region over time can be utilised going forward and how this can be realised?

These questions form the core of this paper. But before we look to the future, it is useful to consider our past.

Energy islands

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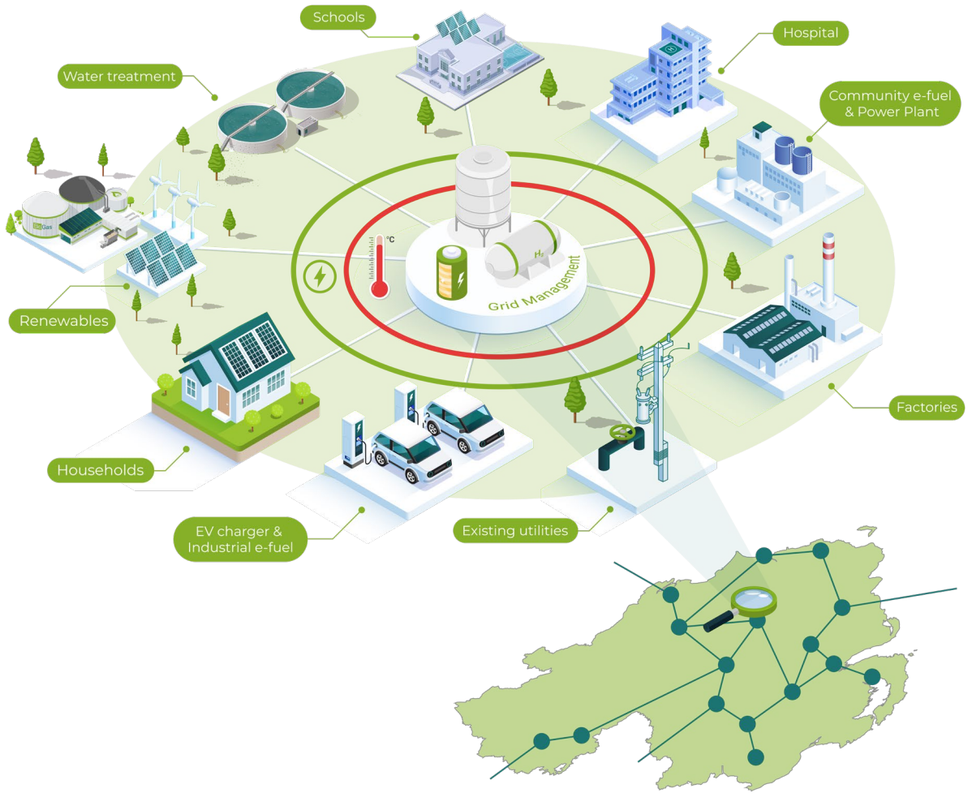


Building on our innovation DNA

The innovation DNA of Northern Ireland is seen in the many historic industrial buildings and ruins scattered across the province demonstrating a past golden age where renewables, agriculture, and manufacturing combined to deliver growth and regional prosperity. This was exemplified during the 18th and 19th centuries where an abundant regional supply of waterpower, a skilled labour force, and lack of major fossil fuel deposits, powered a more sustainable industrial revolution.

Linen flax growers, in conjunction with local manufacturing expertise in textiles, accelerated economic growth with exports of linen from Ireland growing from 520,000 yds in 1705 to 42,781,000 yds by 1795[11]. This growth became the catalyst for other sectors in its supply chain including shipbuilding, rope works and other heavy industries with each enabling the other.

The unique colocation of an industry powered from renewables, agriculture, local skills and the port of Belfast resulted in the city becoming the largest manufacturer of linen in the world gaining the nickname of "Linenopolis"[12]. By 1888 when Belfast was granted city status it had become the third most important port of the British Isles and, within three years, was home to a population exceeding that of Dublin[13].

Waterpower supplied from Northern Ireland's fast flowing spate rivers had a cost advantage estimated as one third that of a similarly-sized steam-powered engine. Availing of this renewable resource was enabled by our history of innovation.

The first water-powered bleach green, a method used for processing linen mechanically, was installed in 1705 at the Lowtown works in Cullybackey and was powered by the River Maine. Similarly, the "beetling engine" (a mechanical device invented by Hamilton Maxwell and described in 1855 as first deployed at Ballydrain, Co. Down in 1725) worked six times faster using a tenth of the power of manual labour, reducing costs and simultaneously increasing the quality of the final linen produced[14].

Growth in this renewable resource necessitated the development of early energy storage schemes. One of these located in Upperlands, Maghera comprised five dams with a total area of 10.64 hectares. The stored water taken from the Knockoneil River then used to power the William Clark and Sons Ltd linen factory, a company established in 1736 and still in operation today[15, 16].

The first electrified railway operated between Portrush and Bushmills in 1883 using 67.1 kW of electrical energy from the River Bush. A second similar railway was powered by the Camlough River running between Newry and Bessbrook transporting coal, flax and people between Newry Port and the Bessbrook Spinning Company[25].

Further innovation occurred in the design of the "Vortex" hydroelectric turbine at Queen's University Belfast in 1862[17] which was the forerunner of the modern Francis turbine subsequently installed across the world. Similarly, this regional innovation culture inspired Harry Ferguson to design the "Ferguson System", an innovative three-point hitching system for tractors which is still in use today.

While many of these industries were adversely affected by international economic developments, including the dominance of cheap fossil fuels, first coal and then oil, which they were powerless to control, industrial manufacturing remained important to the region throughout the 20th century and by 1951, 215,000 people were employed in the sector[18].

These industries have continued to evolve and currently advanced manufacturing and engineering account for 11% of employment and over 15% of GVA within Northern Ireland. Similarly, agri-food is the largest manufacturing industry, and agriculture remains more important in Northern Ireland compared with other regions with its share of total GVA at 1.6% which is over three times that of the UK average and almost twice that of the Republic of Ireland's[19].

11%

of employment in Northern Ireland is within advanced manufacturing and engineering

15%

of GVA in Northern Ireland is within advanced manufacturing and engineering

Overall, this history shows that Northern Ireland has a heritage of innovation in manufacturing, agriculture, and renewables. The historical evidence suggests that this forgotten nexus which enabled a golden period of industrial innovation, and the development of a flourishing united civil society during the 18th and 19th centuries could be re-ignited to mitigate many of our current challenges and provide Northern Ireland with a pathway for growth.

Our heritage of innovation could be re-ignited to navigate many of our current challenges and provide Northern Ireland with a pathway for growth.

Field of linen flax

Building on the evidence

A portion of the evidence base for this paper is outlined at the end of this report. From this, is it clear that while considerable thought and effort has been made in identifying strategies for the decarbonisation of existing systems, less thought has been made in terms of the opportunity to decarbonise and transition to an inclusive, green, climate-resilient economy within Northern Ireland.

Addressing this suggests that strong leadership and a more joined-up approach is needed between government departments, commercial enterprise, the wider educational sector, and communities. It is also clear that a successful strategy and policy can only be achieved with the involvement and ownership of the strategy across social, political, and commercial spaces. A transition of the type needed requires mass behavioural change as well as buy in and consent.

> **A more joined-up approach is needed between government departments, commercial enterprise, the wider educational sector, and communities.**

Current progress in both energy and wider decarbonisation (and climate adaptation) has been much slower than required to meet legislated targets. While an early leader, Northern Ireland is now being outpaced by other areas of the UK, Europe, and elsewhere. This suggests an urgent need to focus on building upon regional and unique strengths to create investment in infrastructure and other enablers for decarbonisation.

This also indicates consideration of regional renewable, geological, education, and skills resources and a longer-term view of the opportunities that can result from their development. It further implies that regional supply chains should be more connected and thus enabled to support the energy transition leading to a new growth model.

While many sectors in Northern Ireland are already investing in renewable energy and the greening of their supply chains, they are also trying to remain competitive internationally. Price shocks due to energy costs (exogenous such as the war in Ukraine or endogenous in terms of profiteering), or changes in policy such as red diesel replacement, have impacted the viability of businesses with commensurate impacts on the economy. During periods of transition, a suitable response requires early identification of policy impacts, an effective communication strategy and support where necessary.

Incentivisation will be necessary for some, but not all, projects which could have positive impacts in terms of increasing renewable energy supply. For projects where incentivisation occurs, a greater level of transparency is required to ensure accountability to the taxpayer, with the burden for managing the risk being included in the project costing.

Analysis of the literature and published reports suggests that projects should be evaluated on their net benefit to the regional carbon balance and, where necessary, supported accordingly. Where projects can proceed without intervention, the government should support action by removing barriers in areas such as obtaining a grid connection and particularly to expediate planning approvals.

The scale of the investment required is significant and financial instruments will be needed to provide the resources to deliver renewable energy infrastructure for the wider just transition. Returns on that investment will be required; however, simple economic metrics such as GVA will be increasingly insufficient in themselves.

Together this indicates that projects which support decarbonisation of energy and other sectors will need to cover the quantity (physical value and permanence) and quality (e.g. construction products vs nature) of the carbon reduction as well as cost. Performance-based terms and conditions against these metrics may allow for greater flexibility in relation to funding and measuring the success of projects.

Analysis also suggests that, within Northern Ireland, a focus on larger energy users will miss the opportunity for communities and smaller businesses to collaborate and aggregate resources for enhanced benefit. Systems which therefore facilitate action by communities in areas such as renewable energy generation and sequestration should be supported. This should happen across Northern Ireland's 11 local councils allowing them to benefit from investments made to offset emissions within their boroughs or districts. This would encourage the uptake of low carbon solutions, alongside the identification and sharing of best practice.

In many councils and districts the agri-tech sector will play a significant role in the charge to net zero energy and wider society. This sector already contributes significantly to the GVA of Northern Ireland and is key to rural communities. Business models and farming practices which accelerate carbon sequestration through an evolution of farming need to be supported, including education and financial support.

More specifically the analysis of the evidence suggests that combinations of carbon farming, improved agricultural practice, and increased access to renewables would allow for new agri-energy and agri-biotech clusters. These could, in turn, develop complementary agri-based sectors that would not only produce low carbon foods but also provide energy solutions for other hard-to-abate sectors.

Case study

The Bann Road Solar Farm powers almost 20,000 farms and will offset almost a million tonnes of CO_2 during its lifetime. This solar farm is not just photovoltaic panels occupying land as it is designed to allow renewable energy and agriculture to co-exist.

Farming is an integral industry throughout Northern Ireland. This investment saw the project being planned so the land could still be used for agriculture. The panels were elevated to 0.8 meters above ground, allowing livestock to graze and conventional farming to continue.

It is important that renewable energy does not consume and take over the Northern Irish countryside; having the two industries co-habiting is a challenge which the Bann Road Solar Farm shows can be overcome.

Several research works have shown that there is considerable potential to utilise regional resources in more innovative ways by employing systems level thinking approaches. Significant and untapped resources are available, but care should be taken to prevent unintended consequences.

Clustering and aggregation of community and industry energy and material flows can lead to positive economic and environmental impacts, and innovation can lead to new industries in areas spanning circular economy, renewable fuels, data and energy services.

Northern Ireland needs a step change in thinking if it is to realise a green 10x economy.

Overall, while the resources and technology exist, Northern Ireland needs a step change in thinking if it is to realise a green 10X economy. A step-change in thinking requires several things.

- We need **ambition** in our ability to add value to a quantum of renewable electricity matched not to our needs but our potential.
- We need **ambition** in the way we design policy and govern, and the way we design financial instruments which are meaningful and attractive.
- **Action** is essential from regional and local government, businesses and communities to support the delivery of energy vectors needed for growth.
- The Utility Regulator must ensure that projects can be **actioned** which work for the **benefit** of society and consumers.
- We need to deliver **progress** quickly so we can maintain a global leadership role, increase opportunities for the next generation, and retain talent.
- We must remember that **progress** can only be accepted by society if it is **inclusive** and just.

Investment in critical infrastructure is essential as it will unleash the financing instruments needed to deliver our ambition. But financing alone is not enough; it must be accompanied by transparent and stable **governance and planning** which can enable and support action. We also need **innovation and skills** to assure a continuous pipeline of ideas and talent.

Together, these can set us on a pathway to our renewable future and give us a sustainable and long-lasting competitive advantage.

Case study

NIE Networks' flagship innovation project, FLEX, creates local markets where customers can offer demand or generation response services to help manage congestion on the electricity network. This allows network reinforcement to be deferred or — in some instances — avoided, saving customers money.

Furthermore, whilst the role of electricity in a net zero future is clear, uncertainty remains with regard to the exact blend of low carbon technologies that will emerge and at what pace. FLEX allows network congestion to be managed in the short term to allow for greater certainty to materialise before making decisions regarding network reinforcement solutions which can be costly and disruptive, by nature.

Following the outcome of the first FLEX trial, NIE Networks was able to make a "FLEX First" commitment, testing the flexibility market first before committing to conventional network reinforcement. Adopting a "FLEX First" approach is expected to save Northern Ireland customers circa £25m in the period to 2030.

Building a competitive advantage

There are many different models which can be used to analyse competitive advantage at different scales, but a common feature is that successful regions build on their regional strengths, including infrastructure, education, people, and natural resources.

While there are many natural resources strengths in Northern Ireland, availing of their inherent opportunity will require significant investment in new energy infrastructure, including the upgrading of existing assets. The design of such assets also needs to remain mindful of the ambitions of our neighbours. For example, the Scottish Government has a stated ambition to deploy 20 GW of onshore wind and increase offshore wind capacity to 11 GW by 2030[20].

Similarly, while the Republic of Ireland has approved plans to accelerate the delivery of 5 GW of offshore wind by this same date[21], its 2050 ambitions – like Scotland's and the UK's – are significantly higher.

Within Northern Ireland, the ambition for wind energy is, therefore, more than an order of magnitude less than the combined ambition of its closest neighbours. While this does not prevent Northern Ireland from developing additional regional renewables capacity to meet its own needs, it does suggest that exports of cheaper renewables will also occur within the proximity of Northern Ireland and hence industries which can valorise that energy could grow.

Despite this, it is clear that some sectors of the economy will need to change[22]; however, the extent to which this must happen will depend on the path taken.

At the same time our size and connectivity are both regional advantages. Within Northern Ireland, clusters of related industrial activity with strong interlinkages in geographical proximity can support close working relationships and assist in innovation and technical interchange to sustain growth. This is clearly seen in areas such as agri-food and advanced manufacturing as well the aviation and construction sectors.

Innovation, in turn, requires an increase in skills training and the establishment of environments conducive for creative design thinking. Linkages across the education sector will identify new growth opportunities and will help to assure a pipeline of talent and an appropriately skilled workforce across all levels and economic sectors to support and maintain growth.

However, despite offering benefits, there is also a risk. History has shown that Northern Ireland's focus on linen – and subsequently textiles – and their supply chains was an advantage while the sector was growing but made it difficult to respond to the impacts of abundant fossil fuels, polymers, and cheaper labour, condemning the sector to a slow decline.

If we want to build competitive advantage, we need to identify an area which is likely to grow and leverages place-based resources so that competition is more difficult.

It stands to reason that, if we want to build competitive advantage, we need to identify an area which is likely to grow and leverages place-based resources so that competition is more difficult.

Supporting industry clusters to develop and transform so they can take advantage of the opportunities in green growth is essential and some progress is being made through InvestNI and regional city deal plans. However, more is needed to enable and support nascent clusters in areas such as hydrogen, biorefinery systems, energy storage, heat pumps, geothermal, smart systems, e-fuels, housing insulation, and energy efficiency; all of which are required for the energy transition.

Initiatives which also assist industrial clusters to adopt circular economy and industrial symbiosis strategies will provide them with a competitive edge within the rapidly growing green economy. New businesses and service industries can then emerge to facilitate and support the trade of energy and carbon between clusters building value not only for the businesses but also the wider community.

Understanding the changing regional, national, and global demand preferences and direction of travel also impact on the longer-term competitiveness of a region. There is clearly substantial scope for growth within Northern Ireland to produce low carbon products and services as well as energy – particularly where these can amplify the value of other established areas.

As highlighted elsewhere in this document, the ability for the future energy sector to support the expected demand in low-carbon products – particularly those which can be derived from agriculture, forestry, the marine environment, and other regional assets – would be greatly enhanced by having access to significantly larger quantities of low-cost renewable power than are currently being explored.

Connecting all of this is the need for a clear focus. While several government departments have outlined their strategy, there is an opportunity to create an overall mission for growth, which extends beyond the current policy thinking.

The interconnected food and energy system and global economic factors (including, importantly, financing the energy transition) will constitute the market and policy contexts of the future. Internal and external competition is necessary to drive innovation, and – notwithstanding the sovereignty and trading complexities arising from the Windsor Framework – there is a significant opportunity for Northern Ireland in terms of economic opportunities within the timeframe of both the 80% renewable electricity target by 2030 and net zero commitment by 2050.

There is, however, a significant danger which is summarised by the saying that perfection is the enemy of the good. This recognises that decision making and resulting action is made more difficult when many powerful stakeholders have an interest in maintaining the status quo. Their inertia can result in a decision paralysis that is enabled by complexity of regulation, planning, and legal challenge.

When operating under a specific timeframe, the longer the delay, the more costly and more severe the action needed when it comes. After all, you fix the roof when it's sunny, not when it's lashing with rain. For some, they hope that the general direction of sociocultural evolution will, in and of itself, reverse society's perceived naivety – particularly when the interventions required are increasingly difficult and result in trade-offs.

For others, significant early action is required to set the direction of travel. The scale and delay in meeting the challenge makes policymaking increasingly difficult. However, for moral, ethical, social, and economic reasons, decisions do need to be made to increase economic efficiency and growth with the resulting wealth distributed more equally within society.

Ultimately, there are also enormous economic opportunities to be gained, and multiple co-benefits to be achieved as our economies and societies transform to address locally the global challenges of the climate and ecological crisis.

When operating under a specific timeframe, the longer the delay, the more costly and more severe the action needed when it comes.

A pathway to financing the energy transformation

So far, this paper has outlined a multi-faceted joined-up strategy for using a range of technologies, skills, and comparative advantages to build new energy and related infrastructure within Northern Ireland.

That, in turn, offers numerous investment opportunities in multiple upscaling projects and has been already recognised internationally. For example, the current United States presidential administration has indicated its appetite for US companies to invest in Northern Ireland as a priority – including in green tech sectors – with a figure of up to $6bn highlighted.

However, it is important that the benefits, the assets, and the value generated from investments are largely retained for local communities. A significant degree of local control and autonomy, in relation to the governance of these resources, is highly desirable. To that end, as well as seeking to attract external investment, Northern Ireland, like other areas of the UK such as Bristol and parts of Wales, should seek to grow its own supportive financial ecosystem to generate investment for the numerous activities and projects required.

The following are worthy of further consideration and trial in a Northern Ireland context:

Just Transition Bonds

There is a growing demand from both individual and institutional investors for financial instruments that contribute to climate action. Recognising this the UK government is estimated to have already raised £16bn from the issuing of green or sustainability bonds. Such bonds are commonplace in the housing association sector in the UK and have been utilised to raise debt with use-of-proceeds including programmes of retrofitting to deliver energy efficient homes.

Building on this it has been suggested that the Northern Ireland Housing Executive (NIHE) could issue a just transition specific bond (with appropriate social guardrails, potentially harnessing the UK's Social Value Framework) to provide capital investment for a retrofitting programme that would have an economy-wide multiplier effect[23].

While such a just transition bond label has not been developed, the International Capital Market Association (ICMA) does have a just transition working group on fixed income suggesting that progress is being made. Operationally NIHE would directly issue the bond at a relatively low, fixed income rate of repayment and have well defined use of proceeds to provide assurance for investors from a financial and social perspective[24].

In its current form, the NIHE proposal suggests a partnership be developed with the UK infrastructure bank, applying its guarantee book to the bond raise, but also to provide technical assistance. However, given that retrofitting is only one of many areas requiring investment in a comprehensive energy strategy for Northern Ireland, the Northern Ireland Executive may wish to develop its own distinct **Just Transition or Sustainability Bond Framework for Northern Ireland**.

Under such a framework, certain actors – both public and private – would be licensed to issue Northern Ireland government approved just transition or sustainability bonds (the exact branding would need attention but market appeal should be a primary consideration) in accordance with specified conditions and clauses (that may vary in type with product design responding to different forms of market and investor appetite).

The specifics and design of each product could be agreed by a combination of local and outside experts, with input from appropriate bodies such as the UK infrastructure bank, Financing the Just Transition Alliance (FTJA) and their partner financial institutions, experts in corporate finance and law, and a dialogue with the Prudential Regulatory and Financial Conduct Authorities.

The Northern Ireland government should consider creating a panel or agency to design and administer such bonds for a range of actors. A scheme that is backed and to an extent coordinated by the Northern Ireland Executive, and/or the UK government is likely to have enhanced market credibility in relation to investor risk, but could also operate in a more focused, directed fashion.

A Northern Mutual Bank

The proposal for the establishment of a Northern Mutual Bank rests on the idea that Northern Ireland, itself, has reserves of capital, savings, and investments that are not necessarily being put to their most productive use – i.e. in ways that support the necessary transition to net zero and the targets which the Northern Ireland Climate Change Bill 2022 requires.

Under this proposal, a new financial lending institution specifically for Northern Ireland would be created with a mandate to offer targeted investments to enterprises engaged in commercial projects that would relate to the areas identified in this paper[25].

Whilst the broad proposal requires further detail and testing, the general idea is to draw slices of capital for the new mutual from some of the £1.6bn assets of the Northern Ireland credit union sector, the £7.878bn of the Northern Ireland Local Government Pension Scheme (the vast majority of which is invested outside Northern Ireland) and the Northern Ireland savings books of local banks, such as Ulster Bank (most of which are several billion each, with only portions invested in Northern Ireland, about 50% in most cases).

The precise capital base of a new institution and the legal and regulatory specifics and details would obviously require careful attention, details, and specifics. Under the Mutual proposal, a variety of stakeholders would contribute capital as members or owners of the new bank.

This capital could then be lent to local councils, public bodies, companies, co-operatives, social enterprises, farmers, SMEs, and micro businesses, allowing them to create new jobs and new enterprises that have social and environmental value to the region, and which meet social and environmental needs in accordance with identified priority investment areas. The mutual would offer needed lending across Northern Ireland but also stimulate innovation and mature emerging net zero markets in a similar way to other development banks in Wales and Scotland.

Support from government in the form of a full feasibility study and legislation to create a new government-backed and recognised institution with a developmental function would be a potential valuable component part of creating a Northern Ireland specific supportive financial ecosystem.

Northern Ireland ISAS

Estimates suggest 81% of UK pension wealth is held in heavily tax-incentivised products, including more than £500 billion in ISAs[26]. This pool of capital could be made to work more effectively by attaching a condition to ISA and pension reliefs that funds saved through these mechanisms be invested in activity intended to tackle the climate crisis and energy decarbonisation.

Many regions throughout the UK could benefit from such a move, including Northern Ireland. The National Savings and Investment (NS&I) scheme offers 100% secure savings and investment scheme backed by HM Treasury, including a green savings bond scheme. One way for Northern Ireland to take advantage of this scheme is to make a request that NS&I provide a wrapper for an account to be marked explicitly for investment within Northern Ireland, as one of their offerings.

Discussions with the UK government on adjusting tax reliefs on savings and investment products, and with the NS&I on developing Northern Ireland-specific offerings could both be usefully taken forward and made a priority.

A Test Bed for Carbon Finance

An additional form of innovation, of which Northern Ireland may be well placed to avail itself, relates to evolving carbon markets and carbon offsetting schemes. The Committee on Climate Change (CCC) has opined that the “purchase of carbon credit from the UK-by-UK businesses and organisations can usefully contribute towards sector pathways, especially land use, which are currently off track and underfunded”. Globally, the voluntary carbon-offset market is expected to grow from $2bn in 2020 to around $250bn by 2050[27].

A voluntary carbon offset involves a company, or a country, purchasing credits from projects that remove or reduce carbon output; the idea being that this mitigates the impact of their emissions in the short term as they work toward eliminating their carbon emissions.

In this wider context, a prioritised world-leading, coordinated carbon sequestration programme across Northern Ireland becomes potentially financially lucrative in its own right. Sequestration could be accompanied by the creation of a bespoke virtual Northern Ireland Carbon Bank that measures and accounts for carbon removal and reduction.

This would create a credibility to Northern Ireland carbon credits, attracting potential purchases across the UK and globally. This, in turn, could generate a potential pool of capital for financing a range of projects in the priority areas noted.

The Carbon Bank would need to be developed alongside a strategic carbon sequestration programme, which, in turn, would require initial investment. The success of such a programme would, in large part, depend on cultivating a reputation for carbon sequestration, transparent measurement and accounting. This would require a structured programme and institution building (a virtual carbon bank).

This type of scheme could be used to provide either additional investment, and/or additional financing for repayments in the just transition/sustainability bond framework. As mentioned previously, Northern Ireland, through the soil nutrient health scheme, will by default have the best data set in the world for soil carbon sequestration and above ground biomass evaluation. As such, it is the most likely region for such an approach to be successful.

A pathway for energy governance

Vital to the success of Northern Ireland's drive to a low-carbon future is the design and quality of execution of all forms and levels of governance. Currently lacking the highest level of political authority, many key decisions have yet to be made which will have an adverse impact on achieving carbon budgets. Whilst it is hoped that resolution of this political vacuum will come soon, much can be done while the Northern Ireland Assembly is in abeyance.

There are huge barriers to delivering the Northern Ireland Climate Change Act 2022. Even if major energy projects – such as wind farms or centralised Anaerobic Digestion plants – all start construction today, it will still be challenging to meet our targets. Long delivery times, queues for specialist equipment, grid connections, and availability of skilled workers will all be difficult enough to overcome, especially when other countries are competing for the same resources.

This point is illustrated by the fact that globally, as of mid-2023, only 29% of the wind turbine manufacturing capacity and 57% of the electrolyser production capacity required to achieve the IEA 2030 net zero scenario has currently been built or announced. The situation for batteries and Solar PV is at or above 100% of the manufacturing capacity required, so these may be better choices in the short term.

Despite this, there is an appetite for building new capacity. If, however, one asks any energy developer in Northern Ireland about **obstacles to progress**, a frank discussion on their major frustrations will ensue. These are well known: **planning, permitting, and grid connection**.

Unfortunately, most of the energy and decarbonisation projects we need are still speculative. They do not have signed-off plans and permits, or orders placed, even if initial concepts have been developed. If the starting gun was fired tomorrow to obtain planning and permits, then 2025 is optimistic for the simplest projects to start construction and possibly 10+ years for offshore windfarms. The inevitable and undeniable conclusion is this: **we will fail to meet our targets unless we are radical in our approach to planning and consenting**.

Consultations and reviews which are already under way may improve timelines, reduce complexity and cost for planning permission and other permits needed, especially if processes can be run in parallel and not sequentially. However, the timescale for these changes will be years and longer if recruitment and training is required to increase capacity.

These issues are not unique to Northern Ireland, but action is needed. One proposal that received much traction during the consultation for this document was the idea of having a '**Critical Energy and Decarbonisation Consenting Bill**' passed by a returned Northern Ireland Assembly. This Bill would give all necessary consents for pre-identified and strategically planned, critical national infrastructure necessary to deliver our greenhouse gas targets and ignite our green economy.

As the previous discussions indicated, a successful Northern Ireland energy transformation will require bold innovation. That, in turn, will necessitate new innovative forms of co-ordinated participatory stakeholder governance to translate an overarching strategy into a set of practical workable steps at a range of scales in different domains, sectors, and communities. Energy transformation cannot be confined to a box or silo marked 'energy' or 'environmental policy'.

For that reason, a strategic '**Net Zero Energy Strategy Setting and Co-ordinating Committee**' could usefully be created with its own distinct institutional design, comprised of multiple stakeholders. This committee and associated subgroupings would have a remit of setting and monitoring strategic priorities, identifying a pathway of sequencing, managing trade-offs and conflicts, overseeing financing and economic performance, and a range of targets and resulting localised experiences.

Ideally, such a committee structure would cover representatives from the highest officials in regional and local government, from sectors such as farming, transport, agri-tech, finance, housing, education, science, voluntary and advice sectors, environmental NGOs, community groups, and trade unions. This inclusive approach to strategy formulation and its subsequent implementation would mean Northern Ireland's transformation would be a shared, collective endeavour.

For the transformation to have legitimacy, proceed and be effective, it will require consent, participation, ownership, and behavioural change from all. It will also require a willingness to learn in multiple ways, to identify things that are not working in particular locales, that will need to be revised and amended; and to identify errors and trial new approaches and strategies, including drawing on local knowledge, experiences and initiatives, while constantly monitoring all of the above.

The committee would also need to be appropriately empowered, legally and politically, to set and revise targets and priorities that are binding for public and private actors.

A complex, multi-faceted energy strategy of the sort outlined here will also involve multiple targets, that may produce unintended and unanticipated consequences and conflicts. Such trade-offs will need to be responded to and managed.

The approach outlined is, however, consistent with the Regional Development Strategy 2035[28], particularly regarding the regional planning consideration of energy, community cohesion, supporting urban and rural renaissance, and carbon reduction with climate mitigation measures.

In this respect, energy strategy will be most effective when located in a systems solution framework for arriving at net zero, that promotes biodiversity, reduces loss, waste and pollution, while creating new jobs, innovation and investment opportunities; a wholly new circular economy[29].

Those processes and mechanisms require a systematic joined-up systems thinking approach, involving sets of specific local and sectoral applications that have to be identified, monitored, and revised as they and technologies evolve. It also requires a capacity to apply scientific and technological innovations in socially, politically, and administratively acceptable ways and to build support, consent, legitimacy, and participation from multiple stakeholders.

An inclusive institutional design involving a co-ordinating committee with the breadth of vision to cover these different areas is therefore essential. To some extent, a mindset of trial and error and a willingness to engage in bold institution building will be required. This might include a series of technical sub-committees to oversee and deliver infrastructural roll out; legislation for the creation of a mutual investment/ development bank; and – likewise – carbon sequestration programmes and related financing.

> **For the transformation to have legitimacy, proceed and be effective, it will require consent, participation, ownership and behavioural change from all**

Guidance on how to most effectively design such a new governance architecture is at hand in political science and legal literatures, which have identified forms of 'experimentalist governance' as a process of participatory and multilevel problem solving.

This literature has been developed by academics from the University of Chicago, Harvard, New York University, and Amsterdam[30, 31]. Robust examples of this governance approach operate in the United States and the European Union (EU) in domains ranging from the provision of public services, such as education and child welfare, to the regulation of food and air-traffic safety, as well as in transnational regimes regulating global trade in food and forest products and ozone depletion.

This approach is a distinct response to the rise of complex volatility and uncertainty that overwhelms the capacities of conventional hierarchical command and control governance. It involves establishing deliberately-provisional frameworks for action and then elaborating and revising them in the light of new information and recursive reviews of attempts to implement them in various contexts.

These groupings have had various degrees of success in their role to provide support in the delivery of complex projects. Lessons can be learned from previous attempts to establish regional bodies to tackle emerging issues. The need to transform waste collections rapidly to incorporate the requirement for greater levels of recycling and support for the nascent circular economy witnessed the establishment of three regional waste groupings across Northern Ireland.

In short, such innovative governance involves local units being given discretion to adapt technologies and targets to their specific contexts. A more central unit of diverse stakeholders then reviews progress and experiences across local units, to negotiate a new shared understanding of mutually beneficial technology-related tasks for each group of actors in a feedback loop[32]. The approach requires the embrace of a spirit of mutual, recursive learning and aspires to a joined-up, holistic approach while preserving degrees of local autonomy and discretion. It can be done.

This proposed broad framework and suggested institutional features provide plenty of scope and latitude to consider how a specific form of Northern Ireland experimentalist multi-stakeholder governance might be designed to construct energy transformation and a circular economy.

This would include exploring how to implement it in practical sequenced ways and what divisions of labour it would entail. Further consideration of how to apply the lessons would lay the groundwork for designing a blueprint for a new governance architecture that could strategize, oversee, and monitor the entire energy transformation.

New markets and new opportunities

Atmospheric Carbon Dioxide Removal

Creating and initially incentivising a local market is one proven way to establish commercial operations such that economic forces aid development of technologies and, over time, decrease costs through competition. We have seen this approach succeed for renewable energy generation in many jurisdictions. We propose that creating a market for sequestered carbon in Northern Ireland offers a relatively rapid route to reducing carbon emissions.

The latest prediction from the Committee on Climate Change (CCC) is that Northern Ireland will have to fund Carbon Dioxide Removal (CDR) if we are to meet our 2050 target. Even if we are successful in meeting the CCC ambition, and failing our own Climate Change Act 2022, Northern Ireland is predicted to need to capture and sequester 1.8 $MtCO_2e$ at a cost >£0.5bn per annum.

More pragmatic estimations put the CO_2 required to be sequestered several times higher and consequent cost at over £2bn per annum. These costs would have to be funded by Northern Ireland's government, perhaps through carbon taxes.

The Bryden Centre and CASE have looked at many CDR options on behalf of DfE. It is likely that a combination of techniques will be needed to achieve the CCC's predicted CDR targets. The best approaches will depend on several factors, including capital and operational costs, the availability of land, and the environmental impact.

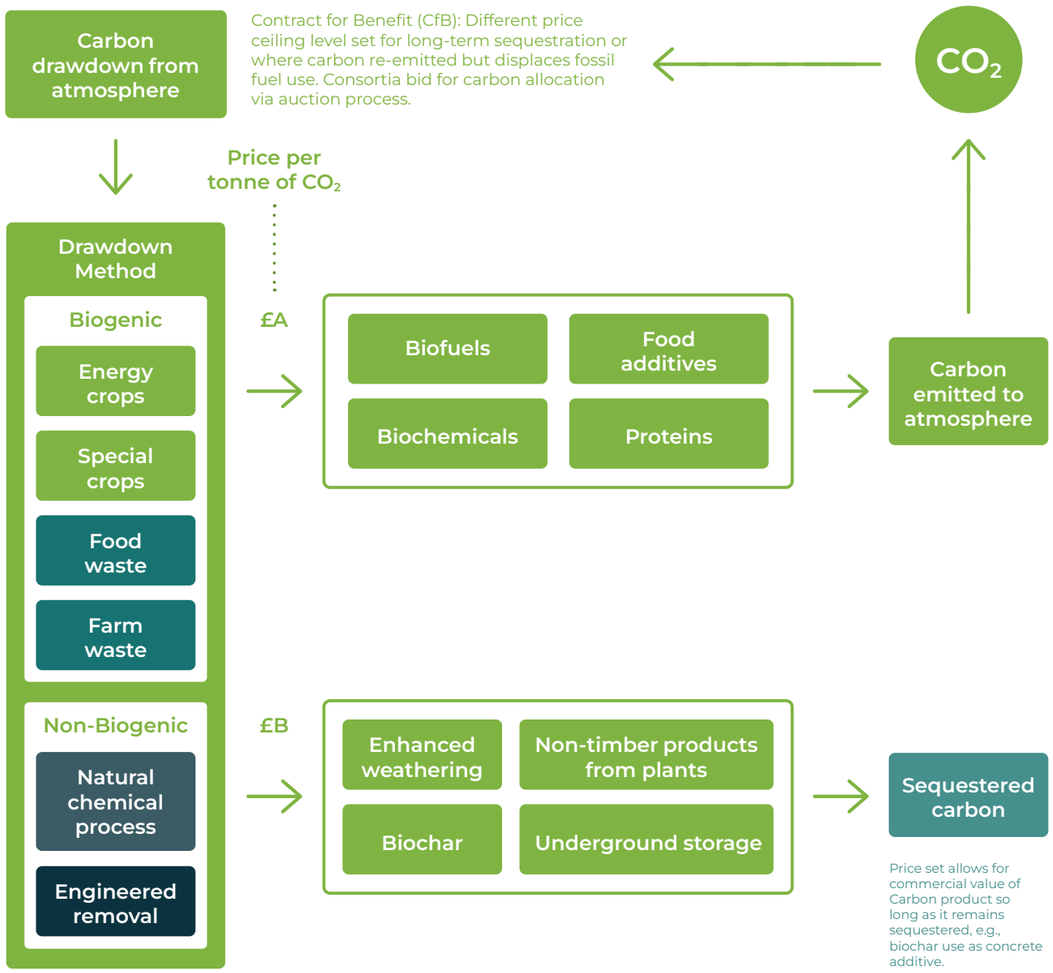
Practical techniques for atmospheric carbon dioxide removal suitable for Northern Ireland include:

- Bioenergy with carbon capture, utilisation, and storage (BECCUS) is a process where CO_2 is captured in biomass (trees, energy crops). The biomass is then combusted or processed to produce bioenergy. Residual Carbon – which can be a co-product such as biochar or emitted biogenic CO_2 – can be captured and utilised as a building block for alternative fuels and products or transported and then stored in underground reservoirs.
- Direct Air Capture (DAC): is a technology that removes carbon dioxide directly from the atmosphere. DAC is still in development but is energy intensive and expensive.
- Afforestation: Northern Ireland has potential for significant carbon sequestration through planting trees.
- Algae: many species of algae can directly convert CO_2 to a variety of biochemicals, animal feeds and fuels. Biogenic CO_2 from, for example, biofuel combustion or Anaerobic Digestion, fed to algae can sequester carbon and displace fossil fuels.
- Alternatives: other processes exist relevant to Northern Ireland including enhanced weathering of basalt, ocean fertilisation to stimulate growth of algae or biogenic CO_2 to enhance crop growth in vertical farms. These all need further research to demonstrate their effectiveness and environmental impact.

Many of these options have been explored in the Northern Ireland context considering how these could leverage other investment in decarbonisation, renewable energy or have CDR costs offset by production of carbon-based products. They all could contribute to CDR and hence reduce Northern Ireland's carbon budget deficit.

However, where CDR costs are offset by product sales then accounting for carbon could become complicated if sequestered carbon is rapidly lost back to the atmosphere or sold on beyond Northern Ireland.

Contract for Benefit



Case study

A suite of CASE funded projects has demonstrated how to maximise energy production from Anaerobic Digestion (AD) using as feedstock farm wastes and increased production of silage or energy crops.

The latest work has also shown how pyrolysis of the solid digestate waste from the AD process can recover both more bioenergy and produce a valuable biochar that effectively sequesters atmospheric CO_2. Biochar is a highly stable form of carbon.

CASE research, on behalf of DfE, has demonstrated that up to 0.4 Mt CO_2e could be sequestered by co-producing biochar from bioenergy crops, assuming the CCC's predictions of land use in Northern Ireland. This could create 700-800 new jobs in rural communities and mitigate 7% of the greenhouse gas emissions from the agriculture sector.

Biochar has a growing market locally and internationally, both as gold standard carbon offsets but also to decarbonise other industries. Substituting biochar for some aggregate in concrete production locks in the carbon long-term, helps to reduce the carbon footprint of concrete products, and initial results show it can enhance the mechanical strength of concrete.

At present, we do not know the price for CDR beyond predictions for engineered removals which are likely to be at the top end of the scale. However, there are proven routes such as bioenergy linked to biochar production or enhanced weathering which are ready for investment if a market can be established in Northern Ireland with an associated CDR certification body. A market with measured and certified quality standards gives confidence and reduces risk to traders and investors.

CASE has previously proposed a Contract for Benefit scheme which effectively is an auction for CO_2e sequestered and certified for quantity, quality and minimum lifetime by whatever method that the industry thinks offers the lowest cost. Such tools can form part of a new financial ecosystem.

Eventually, these new carbon-sequestration product streams should become economically self-sustaining once supply chains and scale-up is achieved. This will make a significant difference to the region's carbon balance and establish a robust, gold-standard market for carbon credits that does not have the credibility gap or reliability issues with many carbon offsetting schemes around the globe.

Replacement fuels

Northern Ireland has a unique mix of resources and strengths. Production of protein by farmers is one of our strong points as we produce 500% of Northern Ireland's requirements, mainly for export. Impressive though this achievement maybe, the intensity of our livestock sector causes serious waste management issues with consequent air pollution from ammonia as well as nutrient pollution of soils and water.

Work undertaken by CASE for the Department for the Economy has demonstrated how farm waste challenges can be addressed and, at the same time, make a large contribution to decarbonising the gas grid.

Our work showed that up to 82% of the current fossil gas demand in Northern Ireland could be displaced using farm wastes and excess silage depending on feedstock capture rates and system productivity. This work was subsequently used by the CCC to revise up their own estimates for biogas within Northern Ireland.

Additional work, linking AD plants to green hydrogen production shows that the residual biogenic CO_2 from the AD process can be upgraded to e-methane at similar prices to that for biomethane. Combined production should give in excess of 10 TWh of energy from non-fossil gas. This is sufficient to remove fossil gas completely from the gas grid with additional spare capacity.

Given that demand for gas is much lower in the summer (but production volumes remain approximately constant) seasonal storage is required. If realised this would also provide considerable resilience to the energy grids for extended periods when other renewable forms of energy are limited.

Recognising that fossil fuels currently power and heat much of Northern Ireland's economy[33] and the need to displace such fuels, a January 2023 report from the Bryden Centre, CASE, and Cenex[34] examined the potential for regionally alternatives for heat and transport uses. To replace fossil fuels directly with the equivalent amount of energy, it was estimated that 9.4 GW of additional wind power would need to be installed. However, if green hydrogen was the chosen energy vector, then up to 15.5 GW would be required due to efficiency losses.

Within Northern Ireland hydrogen production and consumption will grow but it has its limits. For example, in replacing heating oil which still dominates in Northern Ireland homes. A typical home, storing 1,000 litres of heating oil, would require approximately 13,500 litres of hydrogen at 350 bar for the equivalent energy storage. The space, transport, cost, and safety issues with such a large, high-pressure hydrogen tank makes it difficult to conceive of hydrogen being a viable replacement for such purposes.

Therefore, for some applications, hydrogen may be an answer but for others the higher energy density of other gaseous or liquid fuels is attractive. Using green hydrogen to enable the production of e-fuels is therefore a significant opportunity.

During and after the energy transition, there will continue to be a need for green fuels for applications that cannot be electrified other than road transport, such as heating the large proportion of Northern Ireland homes that cannot connect to green gas heating or easily convert to heat-pumps. International shipping and aviation are other examples where a green fuel will be required.

E-fuels are synthetic fuels that are produced using renewable energy sources often using captured CO_2 and hydrogen as feedstocks. They are also a promising alternative to traditional fossil fuels, especially during the transition from fossil fuels, as they can be used in existing vehicles without the need for major infrastructure changes.

Where e-fuels are produced from CO_2 captured from the atmosphere by engineered or biogenic methods such as captured from AD plants, combustion of biomethane or biomass they have the potential to reduce net greenhouse gas emissions, making them a key part of the UK's net zero emissions target.

E-fuels have several additional advantages, and the UK government is supporting their development. In 2021, the government launched the "E-Fuels Grand Challenge", which is a £100m research and development investment and complements the development of a roadmap for their commercialization in the UK.

It is important to recognise that the optimum and most efficient use of renewable power is direct use of the electricity generated for heat, transport, or power. At each step in the production of e-fuels, energy is lost. Production of green hydrogen from electrolysis loses around 40% of the initial electrical energy, mainly as heat. Production of e-methane or e-methanol incurs further loss of energy, and these additional losses continue as heavier e-fuels are produced. If these are then subsequently used in combustion engines for transport further losses occur. Depending on efficiencies 90% or more of the input energy can be lost.

Most energy loss from the production of e-fuels is in the form of heat. Traditionally, this waste heat is vented to atmosphere or water and the value is lost. However, much of it can be captured and used to supply a district heating scheme. For example, a model system where a portion of the biogenic CO_2 from a 10 MW (thermal) AD plant was converted by green hydrogen to form e-methanol the waste heat was enough for approaching 1,800 homes as well as the production of 1,480 tonnes of fuel.

When thinking in a systems-based approach where each waste stream (CO_2 and heat) has value and used in a cascade then the viability of the whole project is positively and significantly changed. In this case it is also

important to note that there are other waste streams from the AD process which can be used to create additional energy, fertiliser, and biochar all adding additional returns to the overall project.

Connected Energy Islands

Many paths could lead Northern Ireland to achieve our Climate Change Act 2022 obligations. All of them will need to displace fossil fuels and see large growth in electricity supply. Choices will need to be made while the technological options and optimum decisions still have a degree of uncertainty.

We know that we will need to increase the supply of power, either by growth in domestic supply or by leveraging the ambitions of our neighbours through increased interconnector capacity. Large-scale generation of renewable electricity will play a key role in the future of energy in Northern Ireland, but this will have to be distributed to where it can be used, necessitating major grid reinforcement or alternatively siting new industries such as green hydrogen alongside newly-constructed wind or solar farms.

An alternative approach leverages local generation capacity from wind turbines, solar and battery storage or biomethane from AD plants and matches this to local demand in an **islanding approach.**

We have already seen micro-grids prove successful for electricity distribution across the world and **islanding** builds on that concept to create a town or district-sized **island** to match demand and supply, not just for power but also for gas and heat.

Energy islands are simple in concept, creating local ownership and a degree of energy independence. They are not intended to be isolated from the gas and electricity grids as major peaks and troughs in demand will have to be managed through the grid infrastructure. However, they do minimise the need for large scale grid reinforcement and consequently potentially offer significant cost savings.

The islanding approach creates opportunities for smaller scale, local energy entrepreneurs or cooperatives. Partnership with public bodies creates demand such as public fleet charging at times of lower electricity use, such as overnight. This concept therefore builds on work by Regen which identified that, within the UK, local authorities would like to see a collaborative partnership approach to regional energy system planning[35].

Within such Islands the public estate would be an ideal early adopter of heat networks, utilising waste heat sources from local industry or existing combined heat and power units for heating leisure centres and hospitals. An energy island can also match new generation capability such as a solar farm over an existing car park with the need to introduce new electric vehicle charging infrastructure in shopping centres and other venues.

Islanding offers a rapid and inexpensive route to decarbonising the energy use of an industrial park, town, or region. Solving the removal of fossil fuels from our energy mix is the first step towards creating a sustainable and more circular economy with the goal of creating a net-zero-carbon community.

Importantly it further allows for agility and flexibility in both planning and governance allowing approaches to be tested and trialled before being rolled out more widely across the UK. Furthermore, it utilises where possible the existing energy infrastructure, allowing it to be reinforced as required and assuring that the wider network which connects and supports the islands is maintained for all energy users.

Case study

Glanbia's GB and NI plants both require 450m³ of gas per hour. In GB, they have shown that dewatering and transport of cattle slurries to a centralised gas to grid AD plant will generate between 2500 and 3000m³/hr of biomethane.

As a licence to inject to grid is available in GB, they can place the AD biomethane production where it is optimum and extract at plant using the existing grid network. This will remove over 18,000 tCO_2 per annum from production alone and reduce on farm emissions by 6%.

It also allows the production of pelletised fertiliser, rebalanced and shippable, allowing nutrients to be applied using precision agriculture or better still shipped back to arable land supporting nutrient redistribution, especially phosphate. Excess gas is available to local homes and businesses.

The same system is deliverable in Northern Ireland as long as licensing for grid injection is granted.

The evidence base

1. The latest DAERA estimates for emissions (2020) is 21 million tonnes of carbon dioxide equivalent ($MtCO_2e$) or 11 tonnes per person, representing a 24% decrease from the 1990 baseline. DAERA currently projects that emissions will reduce by 34% relative to the baseline by 2031[36]. This is significantly lower than the CCC advice reported target of 51% under the stretched ambition pathway equating to a shortfall of approximately 4.8 $MtCO_2e$ by 2031.

   Given that the reductions in the CCC report are lower than that within the Climate Change Act, more transformative and radical actions will be required to meet the current targets within the legislated timeframe.

2. NISRA data and projections to 2031 suggest an average decline in both historic and projected emissions from 1998-2031 of 0.33 $MtCO_2e$/annum or a projected decline of only 0.18 $MtCO_2e$/annum for the period of 2020-2031. If emissions continue to decline at these rates, by 2050 there would be a net shortfall of between 11.5 and 14.8 $MtCO_2e$.

3. The CCC advice report suggested that the use of direct air carbon capture, transport and storage of CO_2 could cost at least £180/tCO_2. Therefore, if such technology was used to address the predicted shortfalls, it would cost approximately £352m per annum under the CCC stretched pathway (93% reduction) or £2,670m per annum if declining at projected rate for the 2020-2031 period (47% reduction).

4. A report by the Bryden Centre[37] identified that unlike other parts of the UK, Northern Ireland does not have large industrial clusters with ready access to high-capacity, long-term geological storage.

   As such, relevant technologies, opportunities, and cost of carbon capture cannot be assumed to be consistent with a general UK picture, given the different industrial landscape and geographical spread of emissions. Overall, the use of standard carbon capture and storage is likely to significantly disadvantage regional industry if mandated.

5. The UK government is currently in the process of amending the existing duties of the Gas and Electricity Markets Authority to include specifically the net zero targets in the Climate Change Act. This will require the regulator to consider how its decisions will assist the government in meeting its net zero targets[38].

6. The Energy in Northern Ireland (2022) report[39] estimated that total final energy consumptions in 2019 was 52,476 GWh (52.4 TWh). Of this total power, heat and transport accounted for 14%, 56%, and 30% respectively.

   Of the electricity consumed, 41.3% was from renewable sources, 82.1% of which was wind. By 2022, the total electricity consumption was 7,494 GWh of which 3,825 GWh was from renewable sources, thereby increasing the proportion to 51%: 85.3% being generated by wind[40]. With around 1,270 MW of installed wind capacity this equates to an average capacity factor of 29%.

7. The SONI report on 'Tomorrow's Energy Scenarios Northern Ireland 2020'[41] presented several scenarios, amongst which was their Accelerated Ambition (AA) pathway, which anticipates a requirement to meet decarbonisation targets earlier than 2050 and has parallels to the stretched ambition pathway of the CCC.

   Within the AA scenario, it was estimated that the annual primary energy demand in Northern Ireland would drop from around 54 TWh in 2020 to 32 TWh by 2050. Of this, an estimated 17 TWh was from wind, solar, and other renewables with circa 11 TWh generated from wind alone (mostly onshore).

   More detail was presented for 2040, where SONI estimated that onshore wind capacity would need to increase to 2,762 MW, offshore to 850 MW, solar PV to 1,777 MW, biomass to 144 MW, hydro to 6 MW and marine to 200 MW.

   Assuming capacity factors within the report this equates to 15 TWh generated for renewables. Scaling this to meet the 2050 demand of 17 TWh suggests that around 3 GW of onshore wind, 1 GW offshore wind as well as 2 GW of solar would be required alongside other renewables, namely marine tidal and wave power (226 MW).

8. Importantly, the SONI report stated that new interconnector capacity was a fundamental to the efficiency of the wholesale energy market and a potential barrier to investment and success of its ambition. This was further highlighted in the recent Engineers Ireland[42] report on 'Powering Ireland: An Electrical Energy Review' which recommended prioritising the North-South Interconnector project and other outstanding grid development projects to support wider grid capacity and resilience.

9. It is also noted that the 2050 SONI energy demand mix contains approximately 14 TWh of low carbon fuels which includes biomass burned for heating, biomethane and green gas etc. Recent analysis by Neha *et al*[43], estimated that feedstock for up to 6.1 TWh of biomethane per year was available within 10 km of the existing gas infrastructure in Northern Ireland when using Anaerobic Digestion as the conversion process.

A more modest 3.5 TWh was subsequently suggested in the CCC advice report which recognised that biomethane is likely to be a cost-effective approach for Northern Ireland but one which must be done strategically to avoid perverse outcomes such as pollution. Assuming the CCC biomethane potential, this leaves an 11.5 TWh gap in the availability of low carbon fuels.

10. Hydrogen contains approximately 33.3 kWh/kg of energy but will typically require around 57 kWh/kg to produce (subject to system efficiencies) with the bulk of the difference lost as waste heat. As such the 11.5 TWh low carbon fuel gap could be met via circa 345 kt of hydrogen produced from an additional 19.9 TWh of electricity.

    While this would more than double the requirement for installed renewables, it highlights the opportunity for increased interconnector capacity which would allow Northern Ireland to serve as a hydrogen production hub within the UK, as well as supporting growth in its associated supply chain.

    Other countries are racing ahead and recently the Neom Green hydrogen company in Saudi Arabia secured financial closure on the largest green hydrogen production facility which is valued at $8.5bn. This plant will produce approximately 600 tonnes of hydrogen per day or 210 kt per annum i.e. less that the Northern Ireland demand.

11. Hydrogen is only one of several different low carbon fuels and a Bryden Centre and Cenex report identified that the marine and aviation sectors will continue to have a future demand for fuels derived from agri-wastes.

    The report further suggested that any investment in new infrastructure should be compatible with final 2050 future fuels such as Sustainable Aviation Fuels (SAF), Ammonia, and Synthetic diesel. Within the report, the UK industry fuel supply data were adjusted to estimate Northern Ireland fuel demand, which showed that the current annual potential total market for waste agri-fuels in the Northern Ireland transport sector is estimated at 15.5 TWh with a market value of around £1bn. Key transport market sectors were aviation (46%), road transport (25%) and maritime (10%).

    The opportunity for e-fuels was highlighted recently by Stena, who announced that two 'NewMax' ships will be deployed on the route between Belfast and Heysham and can operate on renewable methanol and diesel.

12. The production of hydrogen and e-fuels results in energy losses in the form of heat. Analysis suggests that approximately half of the energy used in the production of e-fuels could be suitable for district heating schemes thereby significantly improving the overall economics of the system.

13. A report by Steer[44], which analysed the opportunities for the formation of a low or net zero carbon cluster within the Mid and East Antrim Borough, found that for two modest projects focussing on the development of 35 MWth capacity of anaerobic digestion and 0.14 TWh of hydrogen demand has the potential to create at least 1,000 jobs (670 of which would be permanent jobs through operation and maintenance), £370m in GVA, and 1.6 Gt of CO_2e savings over a 30-year period.

14. Northern Ireland has been an early leader on the international stage in reaching circa 50% renewable electricity consumption by 2023 and has ambitions for 80% by 2030. However, many other countries are also setting ambitious targets for the 2030s. For example, Denmark is aiming for 100%, Ireland and Spain 70%[45].
    To support the ambition for increasing renewables, the recent NIE Networks RP7 announcement outlined the requirement for increased network and connection capacity for the customer and renewable generator respectively. This will be underpinned by a smarter, data enabled, resilient, and reliable network which can support power flow in different directions. Opportunities exist for Northern Ireland leadership through innovations in both renewable integration, smart system management, and control.

15. In contrast to the rest of the UK, Northern Ireland also has significant numbers of smaller generators. In 2020 wind turbines with a declared network capacity of less than 250 kW accounted for 35.49% of total ROCs issued in Northern Ireland, while only contributing 13% of the renewables produced[46]. The value of this has led to suggestions that the cost per tCO_2e saved for policies specifically adopted, implemented or overseen by the Executive should be reported regularly[47].

16. Concerns relating to the management of the Renewable Heat Incentive (RHI) scheme and the more recent inquiry by the Public Accounts Committee into Generating Electricity from Renewable Energy have impacted public and business confidence in renewable energy support schemes. For example, the Northern Ireland Audit Office reported on the need for a better understanding of how renewable electricity generation is publicly incentivised, due to its impacts on the economy, the environment, and the security of the future energy supply.

    Similarly, actions to tackle incentivisation leading to quick returns which negatively impact the environment, issues related to fast-tracking planning and the integrity of installed renewable assets are needed. This further recognises the need for better joined up thinking across government, as well greater awareness, and engagement of the public for the need for the rapid transition to renewable energy[48].

17. The Public Accounts Committee Report on Generating Electricity from Renewable Energy made several recommendations. These included the early identification of potential environmental, planning and other risks, with early due diligence and engagement with equivalent bodies in other UK regions to ensure that any new legislation is fit for purpose for Northern Ireland.

    More robust accreditation requirements, including options for penalties and appropriate action, as well as mandatory requirements for investors to be transparent on key information to ensure fairness to the investor, the consumer, and taxpayers[49].

18. An Ulster University study[50] investigated the socioeconomic and environmental impacts of different levels of domestic fabric retrofit in Northern Ireland. Within this it was identified that flats and terraced houses were the cheapest to retrofit to passive house standards; however, it was cheaper to rebuild a highly energy-inefficient terraced houses.

    Airtightness improvements, cavity wall insulation, loft insulation top-up, solid floor insulation and glazing improvements were all identified to yield greater potential for reductions in demand and emissions than other measures in the Northern Ireland context.

    The installation costs of houses suitable for retrofit varied between £60 and £8,000, and 74% of the houses recommended for retrofitting were off the gas grid. The high levels of energy poverty in Northern Ireland, which are mainly attributed to oil dependence for space heating and poor insulation were also noted in the Belfast Climate Commission's report on *A Net Zero Carbon Roadmap for Belfast*, which also found that building retrofit is the most cost and carbon reduction effective strategy for the city[51].

19. A more recent report investigating the decarbonisation of housing[52] identified that Northern Ireland lags behind other UK regions and the Republic of Ireland, partly because the policy landscape is fragmented.

    It was further noted that the lack of agreed targets and associated milestones permitted a lacklustre approach, particularly amongst private homeowners and the private rented sector. Similarly, the lack of incentives for green retrofitting in Northern Ireland was identified as a major barrier to the decarbonisation of the housing sector.

20. The *Pathway to Net Zero* report[53] identified a six-stage pathway for the Northern Ireland gas industry to decarbonise by 2050. Several key areas cover strategic planning with an emphasis on regulatory frameworks, research, and consumer stakeholder engagement, the establishment and proving of renewable gas connections to facilitate the connection of biomethane and green hydrogen, and then supporting the displacement of fossil gas by establishing supply and demand within the sector.

21. A study on the geothermal energy in Northern Ireland[54] identified that the sector is presently in an early development niche phase. Several recommendations were made to build confidence including a commitment to policy alignment with the energy transition. Recommended activities included the establishment of geothermal demonstrators which have since been tendered.

22. The Northern Ireland Productivity Dashboard has identified that Northern Ireland is the worst performing of the 12 regions in the UK[55]. Several reasons for this have been identified including areas such as infrastructure, skills, and policy, as well as the profile of businesses within the region.

23. The Independent Strategic Review of the Northern Ireland Agri-Food Sector[56] identified that the gross output of agriculture in 2020 was £2.2bn, with the wider food and drinks processing contributing £5.4bn.

    The agri-food sector was considered critical to rural areas, with 86% of agri-food processors being based outside the Belfast City Council area and where farmers manage more than 75% of Northern Ireland's land. The role of the sector in the journey to net zero and reversing biodiversity loss though a more joined-up 'circular economy' approach were noted.

    Despite protections for methane, the wider decarbonisation of the sector is required due to supermarket and consumer pressures. Future farming systems are expected to result with new opportunities available to communities to maintain a connection to the land and generate new farming incomes.

24. It has been noted in the biodiversity (Dasgupta) review[57] that over the period from 1992 to 2014, the capital per person doubled, but the stock of natural capital per person in the UK declined by nearly 40%. This was termed the 'Impact Inequality' which is amplified by an imbalance between societal and economic demands and nature's supply.

    The report identified that addressing this imbalance requires the establishment of accounting and management systems which change the way society measures economic success to enable and sustain positive change for future generations. This has been recognised by different organisations from the IPCC to the OECD as well as numerous academic studies where there is growing advocacy for developing new economic metrics and objectives beyond traditional GDP measured economic growth.

25. The £45m Soil Nutrient Health Scheme was opened by DAERA in March 2022 with the aim of creating a unique baseline on soil nutrient status, including carbon, across Northern Ireland agricultural land. It is the largest baseline soil sampling programme ever undertaken, operating across four zones beginning with County Down and parts of Counties Armagh and Antrim in 2022 and completing in 2025-25[58].

    While the schemes purpose it to provide a valuable dataset for farmers to measure and manage their land to improve efficiency, it could also be used to baseline the regional carbon stocks within the existing land assets and hence help to support carbon sequestration. This is important not least since the CCC found that unlike other parts of the UK, land use in Northern Ireland is a net emitter of carbon, not a sink.

26. Carbon market trading systems in which carbon credits are sold and bought are growing in global importance. At present, mandatory markets such as European and UK emissions trading schemes are used for large emitters with voluntary markets (VCMs) operating in parallel allowing companies to buy credits to offset their carbon footprints.

27. The CCC has reported on *Voluntary Carbon Markets and Offsetting*[59] and noted the potential risks if such immature and evolving markets are used as a substitute for emissions reduction, particularly when the integrity of the credit may be in doubt.

28. It was further noted that high-integrity carbon could play a small but important role, especially in relation to difficult to decarbonise economic sectors and activities, but that the Government would need to establish stronger guidance, regulation, and standards to improve the integrity and transparency of carbon credits.

    The Voluntary Carbon Markets integrity initiative[60] is one example of a platform being supported by UK government to drive credible, net zero aligned participation in voluntary carbon markets. There are potentially significant opportunities within Northern Ireland to develop a regional VCM which encourages projects to increase forestry and carbon sequestration. It is, however, noted that there is risk as well as opportunity for Northern Ireland in VCMs particularly when credits compete for resource within the agri-food sector.

29. The recent *Mission Zero* report[61] used evidence from the CCC and National Audit Office to highlight the need to reform the relationship between central and local government, and empower regions to deliver place-based and place-sensitive actions to unlock local net zero ambition.

    The report recommended that the Government "should introduce a statutory duty for local authorities to take account of the UK's net zero targets, based on a clear framework of local roles and responsibilities". Furthermore, it recommended that the "Government should undertake a rapid review of the bottlenecks for net zero and energy efficiency projects in the planning system, and ensure that local planning authorities are properly resourced to deliver faster turnaround times".

    It was also identified that a simplification of the net zero funding landscape would "consolidate different funding pots, reducing competitive bidding processes, giving longer lead-in times where bidding remains and providing funding over the medium rather than the short-term."

30. The 2021 Northern Ireland Water report, *The Power of Water*[62], was a visionary report showing how national infrastructure can respond to the challenge of climate change. Northern Ireland Water set out not only routes to decarbonising using renewable electricity, but also examples of how these could be integrated within water infrastructure.

    These included leveraging assets such as reservoirs to act as energy stores, managing electricity grid demands by switching off heavy plant, and co-locating electrolysers for the production of green hydrogen such that the oxygen co-product could be used to improve the efficiency and capacity of wastewater treatment plants.

31. The Bryden Centre worked closely with Northern Ireland Water to model how best to site electrolysers at wastewater treatment works across Northern Ireland[63]. This project developed a performance model for Northern Ireland's water treatment plants from available annual data including a speculative performance uplift from the use of oxygen enriched aeration gas.

    The project investigated the benefits of co-locating electrolysers with the aim of selling hydrogen to offset the cost of production of the oxygen by-product which is normally vented to the atmosphere. Injection of concentrated oxygen significantly increases the efficiency and throughput of the water treatment process.

    A network analysis of treatment plants under a hub-and-spoke oxygen distribution model assessed the balance between locating for maximal network benefit and locating for optimal on-site benefit.

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June 2023