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Northern Ireland Science Industry Panel

Decarbonisation of the NI built environment

June 2025

TRAJECTORY

Contents

Foreword

In the face of ever-pressing climate change, Northern Ireland stands at a key moment in its history, with the opportunity to lead the way in transforming its built environment into a beacon of sustainability. This report, commissioned by Matrix on behalf of the Department for the Economy, seeks to illustrate the path forward for Northern Ireland in decarbonising its built environment—a sector that contributes significantly to carbon emissions.

The built environment, encompassing our homes, workplaces, and the infrastructure that binds our communities, is both a challenge and an opportunity in the journey towards a sustainable future. Infrastructure throughout the UK is responsible for a significant proportion of the UK's total carbon emissions, underscoring the need for a strategic approach to reducing both operational and embodied carbon. This report takes a 25-year view, identifying the market opportunities and potential pathways for businesses and policymakers to navigate this complex landscape.

Through a scenario planning methodology, we explore four distinct futures, each presenting unique challenges and opportunities for decarbonisation. These scenarios are not mere predictions but are frameworks designed to help stakeholders envision different possibilities and prepare for a range of outcomes. Each scenario underscores the importance of collaboration across sectors, the need for innovation, and the critical role of government in signalling clear and stable policy directions.

The insights and recommendations presented in this report are the culmination of wide engagement with experts across academia, industry, and government. They reflect a collective understanding that while the journey to decarbonisation is fraught with challenges, it is also ripe with opportunities for economic growth, innovation, and enhanced quality of life.

As we look to the future, it is imperative that we seize readily accessible opportunities of energy efficiency and retrofitting, invest in skills pathways, and reframe decarbonisation as a driver of economic and social benefits. The path to a decarbonised built environment is not just a technical challenge, but a societal one that requires the commitment and cooperation of all stakeholders.

I am confident that Northern Ireland has the potential to harness its unique strengths, leverage its geographic and political position, and lead by example in the global effort to combat climate change. Together, we can transform our built environment into a sustainable legacy for future generations.

Dr. Michael Shaw
Chair of Steering Group

Executive Summary

The Decarbonisation of the Northern Ireland Built Environment report, commissioned by Matrix on behalf of the Department for the Economy, explores how Northern Ireland can reduce carbon emissions in its built environment. The study outlines opportunities, challenges and case studies. It also identifies four plausible, possible scenarios for decarbonisation over the next 25 years, out to 2050.

The Built Environment and its Carbon Footprint

Northern Ireland's built environment includes all man-made structures and infrastructure: housing, commercial properties, energy and water systems, and transportation networks.

Carbon emissions from this sector arise from:

- Operational carbon – emissions from energy use in buildings.
- Embodied carbon – emissions from materials and construction processes.

Reducing both is essential to achieving net zero targets by 2050.

Challenges Unique to Northern Ireland

Decarbonisation is high on the agenda for many nations, but Northern Ireland faces several unique challenges as a result of key characteristics in its built environment.

- Demographic trends: NI's significant rural population and prevalence of single-occupant households impact building demand and energy use. Over the next few decades, the population will age, with a notable increase in older, single person households
- Housing stock: The dominance of detached and semi-detached homes (89%) presents challenges for energy efficiency.
- Infrastructure gaps: Insufficient transport and energy systems limit the region's readiness for large-scale electrification.
- Industrial composition: Agriculture is a significant part of the NI economy, and is a hard-to-decarbonise sector.

Strategies for Decarbonisation

The report identifies a range of strategies for different components of the NI built environment.

For existing buildings and infrastructure the core focus is on reducing operational carbon. This means retrofitting is essential. Strategies here include improving insulation, replacing fossil-fuel boilers with heat pumps, introducing smart energy systems, and using low-emission alternatives like biomethane.

For new developments, both operational carbon and the embodied carbon need to be reduced. This means designing new buildings and infrastructure to be as energy efficient as possible, if not carbon neutral, while also reducing the emissions from all stages of the building process as far as possible. Strategies here include the creative reuse of existing structures, modular construction, sustainable materials, and integrating passive design principles. This requires systemic coordination across policy, industry, and society.

While much of the required technology already exists, innovations are enhancing possibilities:

- Switchable insulation can adapt to temperature changes.
- Biochar and green cement offer sustainable material options.
- Advanced façade systems contribute to self-regulating energy use.
- AI and smart city infrastructure can improve demand management.

The report identifies a range of national and international case studies where these strategies have been deployed.

Future Scenarios: Four Paths to 2050

The study uses scenario planning to explore four plausible futures for Northern Ireland over the next 25 years. These scenarios are determined by two key factors: the extent to which there is political stability and the extent of economic growth. Each scenario outlines a different pathway for decarbonisation of the built environment and, as a result different actions required by both government and industry.

Scenario 1: Opportunity and Rapid Change

- High political stability and economic growth.
- Strong government-industry collaboration, fast rollout of retrofitting, grid upgrades, and standardised green building codes.
- By 2050, Northern Ireland has successfully decarbonised and is regarded as a world leader in sustainable construction and redevelopment.

Scenario 2: Government Steps Up

- Stable politics but economic stagnation.
- Public sector acts as coordinator and investor; emphasis on targeted retrofitting and innovation, but slower private sector uptake.
- Northern Ireland leads the UK in decarbonisation but is facing huge challenges due to poor investment climate and slow pace of change.

Scenario 3: Crisis and Challenge

- Low political and economic stability.
- Minimal progress due to short-termism, lack of investment, and loss of public trust in Net Zero policies.
- The argument on decarbonisation is essentially lost in this scenario. Businesses and the public abandoned Net Zero, no longer convinced that the target is affordable or workable.

Scenario 4: Progress and Polarisation

- Economic growth but political instability.
- Private sector innovation drives decarbonisation, but lack of government coordination causes uneven progress and social inequalities.
- Northern Ireland struggles to achieve its ambitions and decarbonisation is held back by political uncertainty and bottlenecks in skills and infrastructure.

Recommendations

The report makes six overarching recommendations for policymakers and industry, in addition to dozens of scenario-specific recommended actions and policies.

1. **Capture readily addressable opportunities**. Immediate actions for the Northern Ireland Executive include increasing energy efficiency standards for new builds and existing housing stock, carry out whole life carbon assessments for new buildings and encourage creative reuse of existing buildings.
2. **Reframe decarbonisation**. The Northern Ireland Executive should consider how it describes decarbonisation, reframing it alongside wider and more tangible benefits – such as cost savings, energy efficiency, energy security and clean air.
3. **Work across government**. Decarbonisation is a grand challenge that will affect virtually every part of the economy. Departments should be collaborative and different tiers of government should be aligned.
4. **Develop long term frameworks that can withstand periods of uncertainty.** The Northern Ireland Executive should promptly establish frameworks and long-term plans that are designed to withstand periods of heightened political uncertainty.
5. **Begin driving domestic retrofitting now.** Much of the future built environment is already here. Retrofitting and updating existing buildings to reduce the operational carbon will be a key component of successful decarbonisation.
6. **Invest in skills pathways now.** Skills shortages are a major potential bottleneck to progress. Policymakers should partner with industry and educations institutions to develop skills pathways in new methods of construction, retrofitting and new energy systems to mitigate against this.

Introduction

Matrix is the Northern Ireland Science and Industry Panel and was established to advise government and inform academia and industry on the commercial exploitation of R&D and science and technology in Northern Ireland.

In this study, Matrix, on behalf of the Department for the Economy, sought to assess the market opportunities for businesses in Northern Ireland to develop capabilities in decarbonising the built environment.

The built environment is a significant contributor to carbon emissions. Presently several reports identify that emissions linked to the overall built environment may exceed 50% of all GHG emissions. In 2022, Northern Ireland's buildings emissions from fuel combustion alone contributed to 15.3% of all emissions.[1] Typically, the built environment sector includes a wide range of different buildings and structures, including (but not limited to): residential dwellings, offices and commercial buildings, public buildings, industry facilities, roads and other features of the transport network, energy systems and water facilities.

Decarbonising these structures requires reducing both the operational carbon and the embodied carbon within them. Operational carbon is the energy demand within buildings and infrastructure. Embodied carbon is the emissions associated with the building and construction materials and processes. In the UK as a whole, embodied carbon accounts for 20% of built environment emissions.[2] A building that was 'net zero' would be one with high energy performance, requiring zero or a very low amount of energy, producing zero on-site carbon emissions from fossil fuels and producing zero or a very low amount of operational greenhouse gas emissions.[3]

Considering the legislative imperative to decarbonise by 2050, our project takes a 25 year view and identifies different possible futures for decarbonisation. We used a scenario planning methodology to construct four different but plausible narratives that describe the landscape in Northern Ireland out to 2050. In each, the ambition – to decarbonise the built environment in Northern Ireland – is the same, but the options available to policymakers and businesses are very different.

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[1] https://www.daera-ni.gov.uk/news/northern-ireland-greenhouse-gas-statistics-1990-2022-released
[2] https://ukgbc.org/our-work/topics/advancing-net-zero/embodied-carbon/
[3] EU definition: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive#anx_%C2%A0I

The Built Environment in Northern Ireland

Defining the Built Environment

At its core, the built environment refers to any and all human-made spaces – anything we've built to live in, to work in, to facilitate our movement, our energy use, the production and transport of materials and goods, or develop and build upon the landscapes around us.

That's a wide net to cast and it's perhaps useful to engage more directly with both more nuanced definitions – as well as a clearer breakdown of their applications to the Northern Ireland context itself. At a more granular level we describe the built environment, in line with both the UK government and academic research, as all forms of buildings (residential, industrial, commercial, healthcare, and educational), all forms of infrastructure (above and below ground) and the urban spaces and landscapes between and around said buildings and infrastructures.

The built environment does not *only* refer to urban regions or developments – instead also applying to any and all developments across urban, semi-urban and rural areas. A rural farmhouse and its associated developments (e.g. storage sheds, livestock barns or housing, or animal product production facilities) or a small village are as much a part of the wider built environment as a city centre or a coastal port facility.

Energy generation and storage facilities, whether they be clean energy or fossil fuel related, play a key role in both contributing to and providing energy for the wider built environment. Transportation networks, both for public and private transport and for the transport of goods, must be included within the definition – including road, rail, air, and water. Industrial material extraction and storage, manufacturing, and commercial storage also contribute. Perhaps less obviously apparent are the wider utilities systems that underpin modern society – from water networks, to electricity and gas distribution – and are also included.

What then, is not included in a definition of the built environment? There remain a few things that, whilst often impacted and effected by the built environment, remain outside of it and outside the scope of this report. Natural landscapes and protected natural areas, both on land and in and around the waterways and seas, fall outside the definition, as does agricultural land not otherwise built on. Some areas related to the built environment, such as electricity generation and vehicular transport emissions are also outside the scope. Undeveloped rural land or currently unextracted natural resources are also not included, although there is a role for nature-based solutions, such as those that encourage bio-diversity and provide resilience to climate impacts.

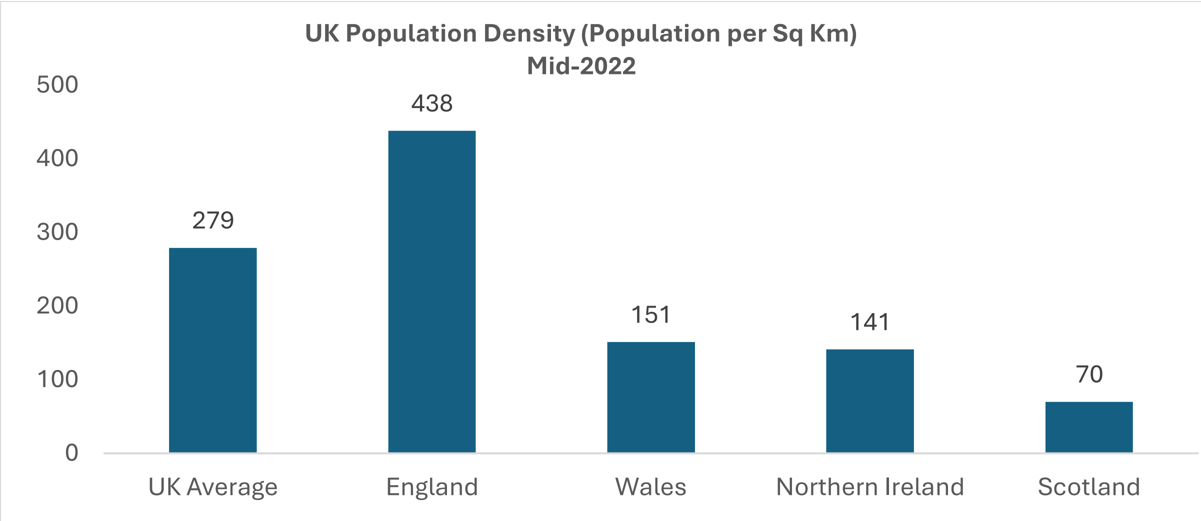
The Landscape of the Built Environment in Northern Ireland

The built environment in Northern Ireland includes several unique aspects that differ from other parts of United Kingdom. This includes the rural-urban mix, population density and demographics (and their impact on its current and likely future built environment), the large agricultural sector, and the importance and scale of the construction, extraction and manufacturing industries.

Before engaging with other aspects of the Northern Ireland built environment it is worth providing a broader context for Northern Ireland and the population.

Office for National Statistics analysis of the 2021 UK census, extrapolated out to provide population estimates for mid-2022, sets Northern Ireland's total population at 1,911,000 individuals and with a population density (members of population per square kilometre) of 141. As such, despite Northern Ireland being the smallest UK nation by area, it is relatively non-intensely populated when compared to the rest of the UK (bar Scotland) – below the UK average population density of 279 individuals per square kilometre and significantly lower than the 438 individuals per square kilometre seen in England.[4]

Population density (people per square kilometre), UK and Nations, 2022 (ONS)



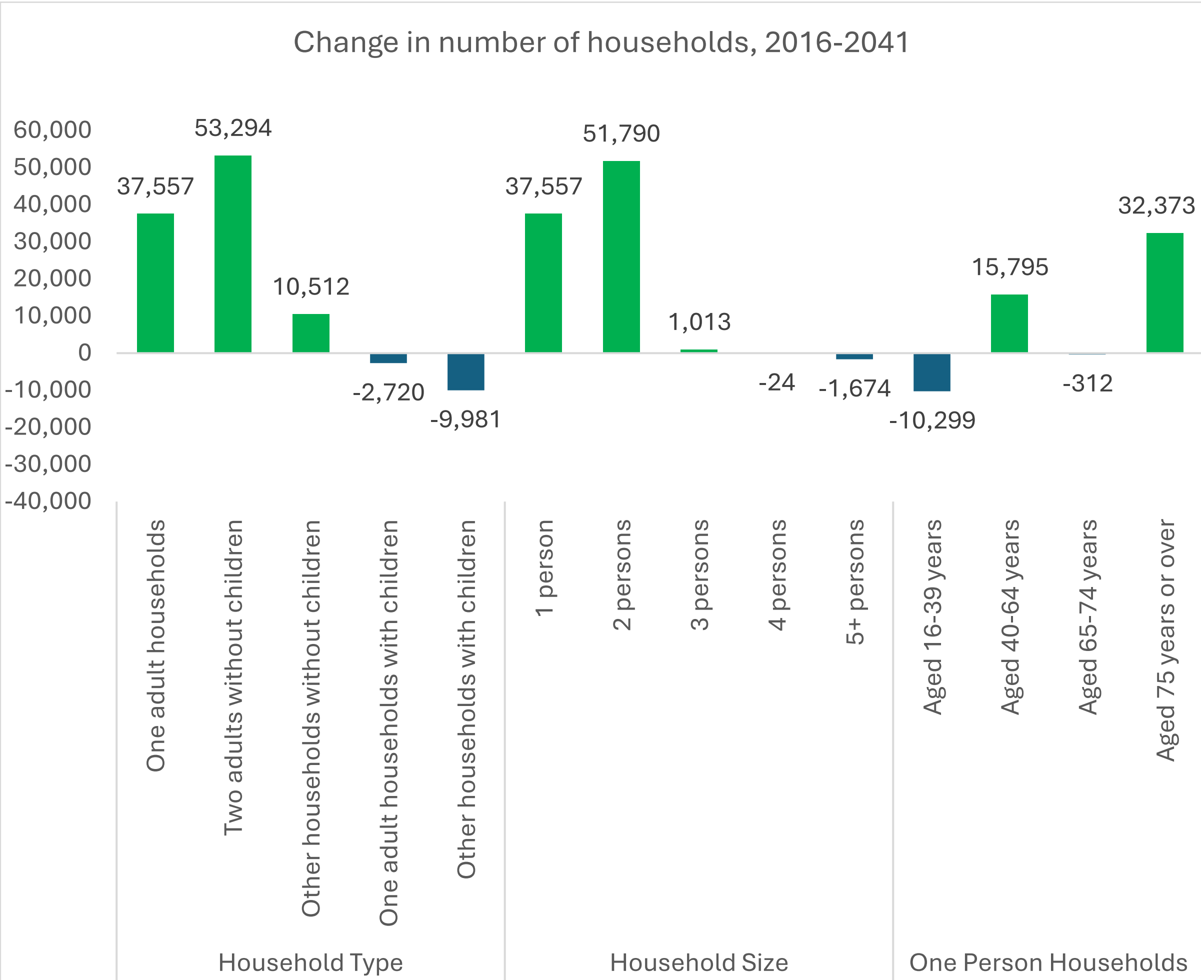
Where that population is located is also a key part of the existing built environment. Compared to the UK average, a far larger proportion of the population reside in rural or semi-rural communities (defined by the Northern Ireland Executive as population centres of populations below 5,000 individuals). Unlike the rest of the UK, where urban population growth has outstripped rural growth, research from the Department for Agriculture, Environment, and Rural Affairs for Northern Ireland (DAERA) indicates that rural population growth within Northern Ireland outstripped urban population growth between 2001-2020 – growing by 20% compared to 7% in urban areas.[5]

That population is also ageing – recent research by the Commissioner for Older People Northern Ireland (COPNI) indicates that the over-60 population is projected to rise by 49% by 2050.[6] That rise will bring with it new needs and demands on housing and on wider social and health care provision – with much of the rise centred around the generally more at-need over-75s age cohort.

[4]https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2022
[5] https://www.daera-ni.gov.uk/news/key-rural-issues-2023-publication
[6] https://www.niassembly.gov.uk/globalassets/documents/visiting/older-peoples-parliament/raise-topical-digest-older-people.pdf

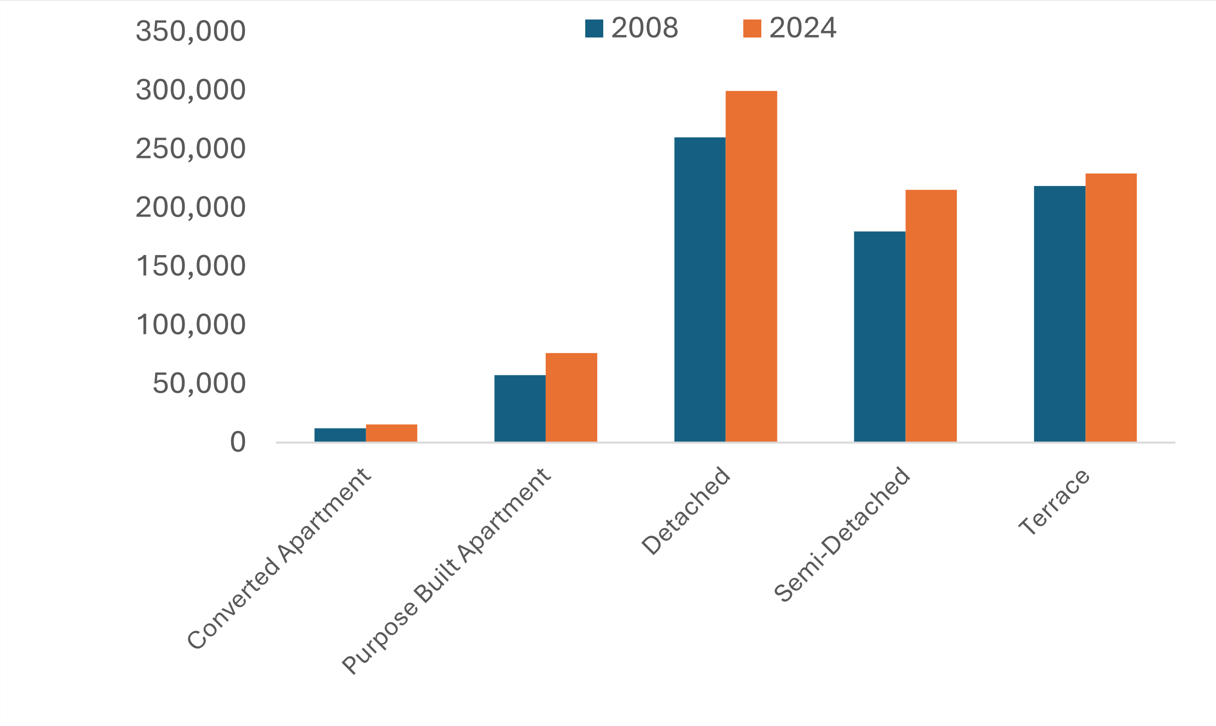
Analysis of Northern Ireland Statistics and Research Agency (NISRA) data indicates that households with members over the age of 75 are set to grow significantly out towards the middle of the century. In total, there is set to be an additional 88,000 households in Northern Ireland by 2041, with over a third of these are likely to be single-person households where the resident is 75 or over – adding further complexities to both care needs, development and planning requirements, and per-person energy consumption.

Change in number of households in Northern Ireland by household type and size, 2016-2041, based on 2016 population projections (NISRA)



With the vast majority of housing in Northern Ireland being detached, semi-detached or terraced houses (c.89% as of 2022/23 according to Department for Communities Northern Ireland data) the lack of smaller dwellings (including flats and apartments) for single occupant households may present its own challenge going forward in regard to the country's ageing population – and also contributes to the lower population density of the country.

Northern Ireland Housing Stock by dwelling type, 2008 and 2024 (NISRA)



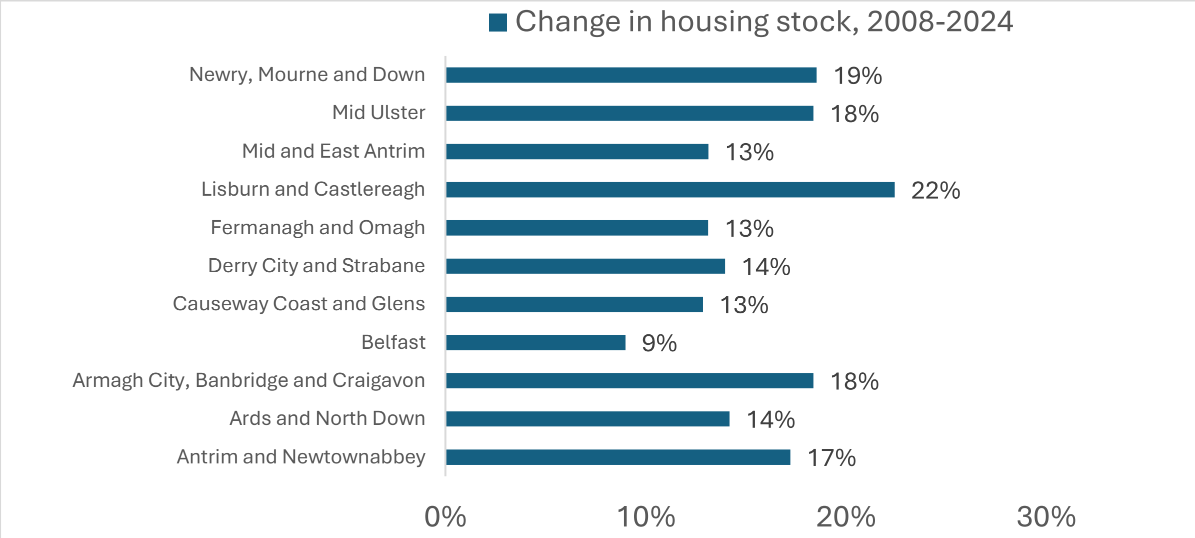
More broadly, and looking outside residential trends, Northern Ireland remains a relatively rural nation – certainly compared to the rest of the UK. Alongside the more rural population spread and lower density, over half of Northern Irish businesses are based in rural areas of the country. [7]

This presents a more diverse and diffused built environment than seen in other parts of the UK in regard to both its residential and commercial aspects – though this should be caveated with the fact that the lower distances involved in Northern Ireland, compared to England and Scotland in particular, help to reduce the impact of this on transport and logistical elements of the built environment.

With around 350,000 of the Northern Ireland population living within Belfast itself and a total of over 700,000 living within its metropolitan area (as of the 2021 Census), the Northern Ireland built environment is not one without urban areas. Whilst population density is higher here than throughout the rest of the country, with the majority of Northern Ireland's apartments within the city-region, the wider metropolitan area is one that incorporates a large volume of commuter towns with more traditional terraced, detached, or semi-detached housing and wider urban sprawl. Only a small proportion of dwellings added to the housing stock since 2008 have been apartments or flats (purpose built or converted). The inner-city remains relatively sparsely populated when compared to comparable UK cities – though redevelopments, both residential and commercial, are underway.

[7] https://www.daera-ni.gov.uk/news/key-rural-issues-2023-publication

Change in housing stock by location, 2008 and 2024 (NISRA)

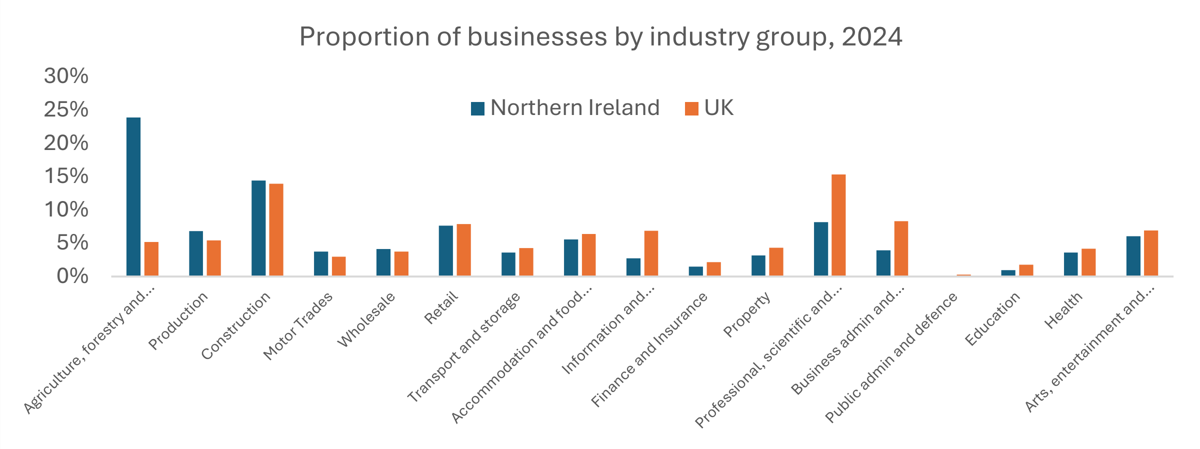


Infrastructure within Northern Ireland, both transport and utilities, is an area in which further development is likely to be required with both rail and road networks requiring both continued maintenance and further development – especially in light of planned electrification policies. Public transport networks and active travel networks are also in need of further expansion – with Northern Ireland's lower population density adding complexity to this process. More widely, utilities systems – most notably wastewater treatment and the electricity network – are in need of expansion and adaptation to meet both current demands and the requirements of the decarbonisation agenda. The region also benefits from a modern gas network and intergovernmental and cross sectoral delivery groups are currently developing plans to emulate other nations that have successfully injected green gases, namely biomethane, into the grid.[8]

Two other aspects of the Northern Ireland built environment worth looking at in greater detail are the role of both its agricultural sector and its construction (and associated supportive sectors) industry. These comprise significant proportions of the Northern Ireland economy – both indexing above the UK average – and play an important role in shaping its built environment.

[8] https://ens.dk/en/energy-sources/biogas-denmark

Proportion of businesses within Northern Ireland and UK by industry group, 2024 (ONS, Inter Departmental Business Register)

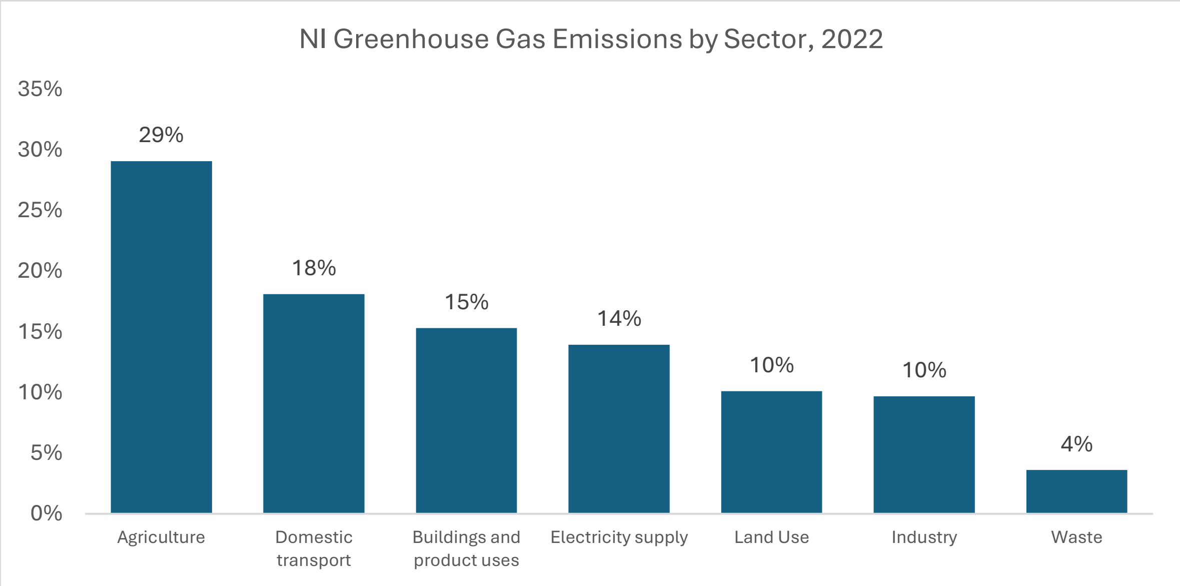


Whilst income across the agricultural sector fell significantly in 2023, it still presented a large proportion of Northern Ireland gross domestic product (GDP) and accounts for the majority of land-use through the country.[9] Whilst agricultural land per se is not included in our definition of built environment, the supportive capacity for storage, transport of livestock and produce, energy demand, and other ancillary requirements from the sector all contribute significantly to Northern Ireland's wider built environment make-up and should be included in discussions around it.

Similarly, construction and its wider supporting sectors – most notably concrete production and other mineral extraction, processing and manufacturing – must also be engaged with in any discussion of the Northern Ireland built environment. Not only are they a fundamental part of any expansion, redevelopment or maintenance of both new and existing aspects of the built environment but they themselves provide both significant built and developed locations themselves and are a large contributor to both the Northern Ireland economy and its carbon emissions – with reductions in emissions from construction and its ancillaries a central aspect of decarbonisation plans moving forward.[10]

[9] https://www.daera-ni.gov.uk/news/northern-ireland-agricultural-incomes-2023
[10] https://mpani.org/profile/facts-and-figures/

Northern Ireland Greenhouse Gas Emissions, by sector (proportion of all), 2022 (NISRA)



Globally, cement production is responsible for about 7% of the world's CO_2 emissions,[11] or 27% of industrial CO_2 emissions, and in the UK, it contributed 1.5% of the UK total emissions, and 9% of its manufacturing emissions in 2020.[12] Moreover, concrete and cement are produced locally and therefore can be influenced directly, whereas other materials (such as steel) are not produced locally and are therefore harder to control.

The unique placement of the Northern Ireland built environment – diffuse but over a relatively small geographic area, at need of further development in key infrastructural aspects, and with several key lynchpin sectors that differentiate it from other constituent UK nations – offer both challenges and opportunities to the wider decarbonisation agenda within Northern Ireland.

[11] https://unece.org/media/press/372890

[12] https://www.cisl.cam.ac.uk/files/sectoral_case_study_cement.pdf

Case Studies

Strategies for decarbonising the built environment

The breadth of the built environment means that there is no single solution when it comes to decarbonisation. Both embodied and operational carbon need to be tackled, but the salience of these vary from different types of site or scheme.

For the existing built environment i.e. the houses and buildings that are already here, it is the operational carbon that is the primary focus, although we must also be cognisant of the additional infrastructure requirements (in road, rail and water) that will be needed.

In reducing operational carbon, the strategies required involve increasing energy efficiency and electrification. This might include:

- Increasing insulation, particularly through using high efficiency insulation
- Replacing fossil fuelled energy systems, such as domestic boilers or furnaces, with heat pumps
- The substitution of fossil fuels with biomethane, blended hydrogen, or drop in renewable alternatives such as Dimethyl Ether for homes not connected to the gas network
- Changes to lighting, including use of LED lighting
- In certain types of buildings or developments (such as apartments) energy efficiencies can be achieved by through centralised heating or energy systems

None of these strategies can be achieved at scale overnight and there are challenges to implementing each one, including the relative cost of installation and the demands that a rapid shift to renewable electricity will place on energy infrastructure. However ultimately, in the existing built environment – those buildings and structures that are currently here and likely to still be here in 2050 – the core strategy is retrofitting: making these buildings as energy efficient as possible and to introduce renewable energy sources to reduce the operational fossil carbon footprint.

New developments will have to integrate these measures into their plans. Buildings being planned and constructed now and in the future will need to be designed in such a way that their operational carbon impact is as low as possible: that means modern energy and heating systems, insulation, consideration of glazing ratios and form factors that allow that building to operate in an energy efficient way.

New developments also have an additional consideration: embodied carbon. This is the carbon used in the entire process of planning and construction. It accounts for the material used, the energy dispensed to source them and the carbon used in construction itself. Due to the carbon-intensive nature of many building materials and processes, embodied carbon is difficult to reduce.

However, there are several strategies available, covering the entire supply chain and process. They include:

Challenge need for new build. Creative reuse and redevelopment of existing buildings can preserve core elements of the building, meaning embodied carbon retained. For new buildings, bringing flexibility and adaptation into the design will mean a longer life as they can be adapted for future use without demolition and reconstruction.
Decarbonising the building process. This includes transitioning from fossil fuelled to renewable alternative construction equipment, carbon capture and storage, use of renewables for steel and cement production, reducing waste in construction and using locally sourced materials wherever possible.
Use of sustainable materials. Alternatives to carbon-intensive materials such as concrete can be used, including green steel, cross laminated timber, supplementary cementitious materials, fly ash and ground granulated blast furnace slag (GGBFS).
Modular construction. Some new materials also lend themselves to new methods of construction, which can be done off site and in a more standardised way. However, there is not currently reliable evidence whether modern methods of construction have yet realised significant carbon savings.[13]
Collaboration across the value chain. Aligning developers, manufacturers and policymakers on standardisation of low carbon practices. Such a whole-system approach is also likely to lead to resource efficiencies and facilitate support circular economy principles – where one industry's byproducts become another valuable materials.

All of the strategies listed above can be deployed with existing technologies and processes. However, it is also possible that in this time frame new opportunities are created by emerging technology or processes.

Advanced façade technology. New intelligent glazing systems using glass prisms could be used to generate solar energy that is used for cooling when hot and heating when it is cold.
Natural refrigerants in HVAC systems. Natural refrigerants, like ammonia, carbon dioxide or hydrocarbons can meet growing demand for cooling and air conditioning in a way that is much more energy efficient than fluorinated gases.
Creating lower carbon cement. Current methods, like GGBFS, used to decarbonise cement and concrete are time limited, as they rely on coal byproducts. Other emerging methods may have to take their place, such as CO2 mineralisation and biochar.

Heating, Energy, and Housing

Whilst decarbonising the built environment will require a whole systems approach and one that touches on almost every aspect of that environment in one way or another, there are three key areas which are set to be central to the wider agenda; heating; energy; and housing.

Heating

Residential and other forms of property heating present a significant proportion of Northern Ireland's energy use and reductions in heating need or the introduction of renewable heating solutions can significantly reduce overall energy use.

[13] https://journal-buildingscities.org/articles/10.5334/bc.515

Heat pump led solutions will require further thought, exploring the use of hybrid systems in conjunction with green gas and strengthening, energy infrastructure as well as support for the wider rollout of heat pumps such as access and installation and improvement in the maintenance supply chain.

Reskilling around heating retrofit and wider heat approaches (e.g. heat shares) is a major drag on current processes.

Energy

Greener energy targets within Northern Ireland will require significant spend but ultimately reduce long-term costs and will support wider adoption of renewable energy vectors elsewhere in the economy.

2030 stands as a key date for the transition to low-or-no carbon energy systems in public and private buildings – with strengthening of both clean energy production and of the wider electric grid likely to be required in the longer-term.

Northern Ireland benefits from having a modern efficient gas network, increasing access to the grid and the continuous strengthening of infrastructure can reduce emissions in the short-term – but renewables are the long-term aim.

Housing

Improving insulation in new builds and existing stock is an accessible opportunity – with lower cost outlays and short-term returns for both decarbonisation and tenants.

Retrofitting will be critical in the longer-term but major blockages remains, including around non-standardisation, upfront costs (and split incentives between owners and occupiers), as well as challenges around heritage assets.

Northern Ireland's housing mix, with its relatively low volume of homes designed for single occupants and its large volume of detached or semi-detached homes, provides a challenge for heating and energy efficiency improvements.

Air tightness and more passive housing can be key wins, both in terms of new builds and existing housing.

With these three, and other aspects of the decarbonisation agenda in mind this next section looks at more specific strategies and technologies that have the potential to be impactful within these spaces.

Case Studies

Many of these strategies are deployable right now. The case studies outlined below demonstrate how decarbonisation of the built environment is being performed already, both within Northern Ireland and beyond. These examples are drawn from a range of sectors and encompass different techniques, including urban design, creative reuse, new methods of construction and new technologies and materials.

	Name	Location	Strategy used	Sector
1	The Keep	Belfast	Creative re-use, challenging need for new build	Construction, retrofitting
2	Merchant Square	Belfast	Creative re-use, challenging need for new build	Construction, retrofitting
3	Paradise	London	New methods of construction, sustainable material	Construction
4	HyDensity E-Fuels	Northern Ireland	New materials and processes, decarbonising processes	Infrastructure, Transport
5	Oxygen-Enrichment Water Treatment	Belfast	New materials and processes	Infrastructure
6	Bio Binders	UK	New materials and processes	Infrastructure, Transport
7	Passive Housing	Global	New methods of construction	Residential
8	BioChar	Global	New materials	Construction
9	Switchable Insulation	Global	New technology	Residential and commercial buildings, retrofitting
10	Heat Mapping	Bilbao	Collaboration across system	Urban planning, energy management

11	Positive Energy District	Strabane	Collaboration across system	Urban planning, energy management
12	Gemini Project	Northern Ireland and Republic of Ireland	New energy sources	Infrastructure, energy sources
13	National Retrofit Plan	Republic of Ireland	Retrofitting, collaboration across system	Residential
14	Foundation Re-use and Building Extension	London	Challenging the need for new build	Construction, retrofitting

<table>
<tr><td colspan="2">The Keep & Merchant Square, Belfast</td></tr>
<tr><td>Type</td><td>Creative Re-use, Hospitality & Commercial</td></tr>
<tr><td>What it is</td><td>The Keep (Like Architects, Alterity Investments)
The Keep is hospitality, leisure and retail scheme that rejuvenated a vacant lot in Belfast city centre. The original structure was built in the 1960s as a British Home Stores department store, but had been vacant since 2016.

The redevelopment was planned to restore the site to make it viable for new occupiers from retail, leisure and hospitality. Rather than demolish and rebuild from the ground up, the building was reconfigured and redeveloped, providing retail units on the ground floor, a mix of leisure and hospitality uses on the upper floors and a restaurant use on the rooftop terrace (making use of all available space). The new scheme has attracted major retailers including Apple, H&M and Deichmann, with King Pins (a bowling venue and restaurant) occupying the second and third floors.

  </td></tr>
<tr><td></td><td>Merchant Square (Like Architects, Oakland Holdings)

Three existing buildings in one block in the heart of Belfast were redeveloped to provide more than 230,000 square feet of premium office space, accommodating 3,000 workers over ten floors. The project was planned and delivered with sustainability at its heart and was the first privately built commercial building in Northern Ireland to be awarded ‘Excellent’ status by BREEAM UK. It is entirely let by PWC and is their largest office outside London.

The three existing buildings did not meet modern standards for premium office space. However, they did provide strong concrete frames built to withstand bomb damage. This made the core of the buildings retainable and meant that a creative reuse viable. A project of this nature provides efficiencies in cost and carbon.

The redevelopment involved the removal of concrete panels and the creation of a new façade incorporating more glazing to provide better light throughout the enlarged building. The BREEAM ‘excellent’ was awarded in recognition of not just the design and construction of the site, but also considerations about the way in which the building would be used. This includes elements key to the operational carbon footprint of a building, such as energy systems, efficiency of water and waste management, energy use and the extent to which the building facilities carbon neutral access (e.g. through close links to public or active transport).</td></tr>
</table>

	 
Potential Impact	These developments are examples of how the embodied carbon of an existing building can be retained while the appeal and functionality can be restored with redevelopment. According to the World Green Building Council, 72% of energy related carbon emissions are operational carbon and the remaining 28% is embodied carbon.[14] Creative reuse preserves that embodied carbon and enables buildings to take steps to decrease their operational carbon footprint by investing in new light, water, waste and heat systems. Whatever the size or scale of the development, the principle is the key one: there is often plenty in the existing superstructure that can be retained and used as a core for reinvigoration. Doing so provides efficiencies for developers in cost and time and helps make such projects more commercially viable. It also contributes to decarbonisation by retaining a great deal of the embodied carbon in the existing building.
What next?	Not all existing buildings are suitable for this kind of redevelopment. In some cases there will be problems with structural stability that make such redevelopment unsuitable. In other cases, redeveloping the building might provide embodied carbon efficiencies but not allow for the operational carbon use of the new building to be minimised – such as if floor to ceiling heights aren't sufficient to allow for new energy or heating systems. However, in many cases, redevelopment or creative reuse is a viable option. To encourage developers to consider redevelopment policy initiatives, enforced through the planning system, can play a role – for example, in mandating that reuse options must be considered before demolition and rebuilding. This approach would bring its own challenges in extensive testing of reused structural materials and new risks or liabilities for those assessing them.

[14] World Green Building Council

Paradise, London (Bywater, Sumitomo Forestry, Feilden Clegg Bradley, Webb Yates)	
Type	New methods of construction, Commercial
What it is	Paradise is a new sustainable office building that has replaced a former Costa Coffee Roastery on Old Paradise Street in Lambeth, London. The site is a six-story cross-laminated timber structure with an extruded terracotta façade. The project has been designed to ensure that it is carbon negative both in terms of its operational and embodied carbon. Timber was chosen partly to stand out but also to ensure that it is in sympathy with the local environment, as it directly borders a park. The project has incorporated local materials, and sustainability is built into the design – ribboned, eye height windows, articulated gears in the lifts (which recycle energy back into the building) and reusable materials – so if the building is eventually replaced, the elements of it can be used again.  
Potential Impact	Paradise is a model for how timber construction can allow for carbon negative building. However, such projects are difficult to scale. There are four main barriers: material supply, skills, fire safety and insurance. The production line for CLT or equivalent materials is relatively small, meaning lower supply. As a relatively new building material, particularly for projects of this kind of scale, there are also likely to be bottlenecks on available skills in design and construction. Paradise is insured, but the developers advised early conversations with insurers – including at design stage – to ensure that projects don't end up being uninsurable. Finally, the likely requirement for a fire test might put off developers who would prefer a safer, tried and tested method. Despite these challenges, Paradise is an example of how to reduce not just the operational but also the embodied carbon in a building, and is a blueprint for decarbonisation of the built environment.
What next?	Not every project will be able to follow this blueprint. Bottlenecks in supply and skills, as well as the increased capital requirements (to fund testing and insurance) will mean purely CLT or glulam projects remain isolated examples. Additionally, there are likely to be significant challenges in insuring timber buildings against fire and flood damage. The construction and insurance sectors have collaborated on

	the Mass Timber Construction Playbook to guide designers, owners through the process of insuring mass timber buildings. [15] However, these forms of construction should be encouraged as models of what it is possible to do. Beyond flagship developments, Paradise offers an example of how to decarbonise through consideration of form factors, glazing ratios and material choice.

[15] https://asbp.org.uk/project/mass-timber-insurance-playbook

HyDensity E-Fuels (Catagen, Terex & Wrightbus)	
Type	New materials and processes, Infrastructure
What it is	Launch of £8.1 million Project HyDensity to demonstrate decarbonised quarrying operations through Hydrogen & E-Diesel. CATAGEN, Terex and WRIGHTBUS have been awarded £6.27 million funding by the UK Department for Energy Security and Net Zero (DESNZ) as part of the Red Diesel Replacement Phase 2 competition. In total this is part of a £8.1 million project to decarbonise non-road mobile machinery. Decarbonised end-to-end demonstration of a Terex crusher and screener, powered by green hydrogen and e-diesel at a site in Northern Ireland in November 2024. Two new electrified systems comprising a crusher and a screener. The hydraulic driveline will be replaced with more efficient electrical components, improving efficiency and lowering power requirements. The current diesel engines will be used for operation on e-diesel as standalone similar to current operation but with electrified powertrain. Will utilise hydrogen e-fuel production from a e-fuel generator – designed by CATAGEN to produce hydrogen e-fuel that is safer to transport and denser (to enable easier storage). This opens up an avenue for e-fuel use in heavy duty vehicles, where energy density has previously meant that e-fuel use has largely been impractical. This is also aligned a compressor system designed for said e-fuel to further increase energy efficiency and reduce the complexity of delivery from storage to engines. A mobile refueller, designed and operated by Wrightbus will also be incorporated.
Potential Impact	The scalability and use cases of e-fuels within heavy duty machinery, especially but not limited to mining and quarrying operations, have been minimised by issues around storage, transport and the lower density (i.e. tank size requirement) of e-fuels when compared to traditional fossil fuels. This test and demonstration to provide a scalable use case for this new, denser, e-fuel as well as provide explicit evidence of its usability in relatively high intensity, heavy machinery, contexts. Reducing carbon emissions from traditional energy sources within this, and similar, sectors through a shift to e-fuel can help reduce emissions.
What next?	Further scaling and testing within the sector, tests have been completed through 2024 with results yet to be announced.

Bio-Binders	
Type	New materials and processes, Infrastructure
What it is	The use of alternative materials used in place of asphalt to reduce emissions. Over 96% of the UK's strategic road network is surfaced with asphalt. In 2020, an estimated 77,300tCO_2e of greenhouse gases were emitted from the use of asphalt on roads in the UK. National Highways, who manage England's road network, aim to achieve net zero emissions for construction and maintenance activities by 2040 – the decarbonisation of asphalt production and installation is a key part of their plan. Bio-based binders, also called biogenic or bio-binders, offer a lower carbon alternative to bitumen, a key binding component of traditional asphalt. Bitumen is made from crude oil, meaning the embodied emissions from its production contribute significantly to the high emissions of asphalt (this can sometimes be >25% of the total emissions). Bio-binders are produced from a natural material that absorbs and stores CO_2 throughout its life, effectively turning roads into carbon sinks. In 2023 National Highways commissioned AtkinsRealis to carry out trials of bio-binders on the A30, testing two binders, as well as a control surface using conventional binder. The trial bio-binders delivered a potential carbon saving of 13.75kgCO2e/t, relative to the control, which equates to a 20% reduction over lifecycle stages A1 (raw material extraction and processing) to A3 (manufacturing). Additionally, after 18 months, the materials showed similar performance to the traditional asphalt in the control section.
Potential Impact	In 2023 National Highways commissioned AtkinsRealis to carry out trials of bio-binders on the A30, testing two binders, as well as a control surface using conventional binder. The trial bio-binders delivered a potential carbon saving of 13.75kgCO2e/t, relative to the control, which equates to a 20% reduction over lifecycle stages A1 (raw material extraction and processing) to A3 (manufacturing). Additionally, after 18 months, the materials showed similar performance to the traditional asphalt in the control section.
What next?	Two further trials began in the summer of 2024, using biogenic asphalt in combination with other lower-carbon technologies – warm mix asphalt (produced at lower temperatures than traditional asphalt), and the inclusion of up to 30% reclaimed asphalt in the mix. National Highways aims to reduce the embodied carbon in bitumen by 20% by 2030, 40% by 2035 and 50% by 2040.

Oxygen-Enrichment Water Treatment (NI Water, Lagan Meica JV & Arup)	
Type	New materials and processes, Infrastructure
What it is	NI Water, working with Lagan MEICA JV & ARUP, is undertaking innovative liquid oxygen trials at its major wastewater treatment works in Belfast as part of its wider Hydrogen and Oxygen Demonstrator Project. The ground-breaking demonstrator project is paving the way for the deployment of a state-of-the-art, 1 Megawatt (MW) electrolyser which will help the growth and development of the hydrogen economy in Northern Ireland. LaganMEICA has designed and tested a hybrid system to use an oxygen blend which will avail of existing delivery systems to enhance the sewage treatment process process. This will give water companies and operators the benefit of a more economical, efficient process that treats more effluent, produces less sludge whilst maintaining the existing aeration equipment as back-up. The capital cost will also be less prohibitive than for a plant designed solely to use oxygen. This 10 kw pilot plant will be scalable and pave the way for the 1MW demonstrator Electrolyser which LaganMEICA will be installing in Belfast WWTW for NI Water. Oxygen is vital for the survival of the biomass and required for the consumption and stabilisation of contaminants in wastewater. Oxygen enrichment will provide very robust treatment process, increase reaction rates in the aeration tanks and potentially reduce sludge production and odour problems Historically, the cost of oxygen enrichment has been prohibitive. Using oxygen has a few inherent risks that need addressing and the plant design will be subject to rigorous Risk Assessment and Hazard & Operability Study (HAZOP) . There are numerous pure oxygen plants around the world but have been designed as pure oxygen treatment works. This is where the hydrogen element plays its part. On site Hydrogen production provides 8 tonnes of Oxygen for every tonne of hydrogen produced.
Potential Impact	The completion of this project as a reference plant could prove to be ground breaking to the future of WwTW design development in Northern Ireland and thereby help the industry prove its resilience and fitness for purpose in the low carbon economy.
What next?	Further testing within the demonstration site – with longer term tracking of feasibility and scalability across wider sector.

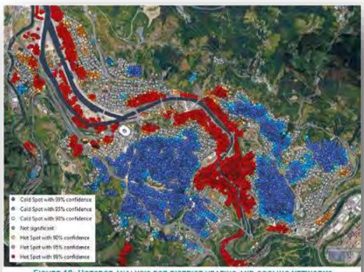
Passive Housing	
Type	Construction, Residential
What it is	Passive housing (German: Passivhaus) creates highly energy efficient buildings, which require minimal heat to maintain a comfortable temperature. A passive house needs up to 90% less energy than an existing house (and 75% less than average new builds), with the 10% needed being predominantly produced by passive heat sources such as human body heat, the sun and heat from household appliances.[16] Features of a passive house include: Thermal performance insulation – improves energy efficiency by reducing heat loss and maintaining consistent indoor air temperatures High quality triple glazed windows and doors – keeps heat in Thermal bridge free design and construction – reduces heat loss and prevents condensation, with a certified Passivhaus designed to mitigate mould growth Airtightness – minimises air leaks, draughts and improves building performance Mechanical ventilation with highly efficient heat or energy recovery – improves indoor air quality by filtering fresh air in to replace stale air.   *Images: Fraser Millar*
Potential Impact	Significant potential to reduce operational carbon footprint of residential buildings. While some passive housing standards (such as Passivhaus EnerPhit or AECB CarbonLite) have been designed for retrofit these are difficult to apply, meaning greatest impact is likely to on new builds.
What next?	Ready and already being rolled out in Northern Ireland by both developers and NIHE. Policymakers could apply selected Passivhaus principles to building regulations (e.g. air tightness) to ensure broader based benefits on new builds and redevelopments without throttling supply.

[16] https://passivehouse.com/02_informations/01_whatisapassivehouse/01_whatisapassivehouse.htm

BioChar	
Type	New Materials
What it is	Biochar is a product of the thermal conversion of biomass and can be added to soil or concrete for carbon storage. Biochar production breaks the carbon cycle by converting carbon to a form resistant to decomposition and can therefore lock in carbon that would otherwise be released into the atmosphere. Biomass sources can include grass silage digestate, miscanthus and short rotation coppice willow. If biochar is stored appropriately, it can trap carbon for hundreds or thousands of years. This case study looks specifically at the use of anaerobic digestate biochar as a cement replacement material. Anaerobic digestion (AD) is the standard bioprocess for turning organic feedstocks into biomethane-rich gas. The value of the process could be enhanced by utilizing biochar, which would increase the effectiveness and operation stability of AD. The properties of biochar mean it may be considered is a partial replacement to cement and can act as a self-repairing agent in concrete. Initial tests and indicated that Biochar has been found to have beneficial structural and functional properties, such as flexural strength and fire resistance, showing promise for its use in buildings. It could therefore potentially be used within the built environment for long-term carbon storage. Recent CASE funded research has shown the potential for biochar to not only offset the carbon impacts of both concrete brick and roof tile manufacture but also play a significant role in managing nutrients thus addressing the algal bloom formations prevalent in many of Northern Ireland's watercourses.  *Image: CASE, Queen's University Belfast, AFBI, Irish Cement, MPA Northern Ireland, United Renewables, Mannok, Breedon*
Potential Impact	Biochar is one of many carbon capture methods but given NI's large agricultural sector, could provide both reliable and inexpensive carbon dioxide capture. It could also provide an income stream for farmers and reduce the carbon footprint of NI's concrete industry. The AD sector currently produces 110 kt of digestate dry matter, which equates to 32 kt of biochar. This works out to a potential carbon dioxide reduction of 118 ktCO_2e, or around 2% of the current emissions from Northern Ireland's agricultural sector.

	Cement manufacturing in NI emits up to 900kt of CO_2e, and this could be reduced by 54-160kt (6-18% reduction) annually if digestate biochar is used.
What next?	Whilst there have been small scale experiments, there have been few large scale trials of pyrolysis on digestate from AD processes. Future research is required to investigate the structural properties when used in concrete production

Switchable Insulation	
Type	New Tech
What it is	Developing switchable insulation panels (SwIPs) for commercial use. SwIPs can be built into building facades and roofs as an alternative to conventional insulation materials. Theoretically, more insulated buildings can encounter two problems, greater internal heat during the summer, and less transfer of heat when the sun is shining in the winter. *"Switchable insulation deals with both problems by being able to switch the insulated properties of the façades on and off."* – Adrian Pugsley, CEO, Switchable Insulation Innovations Their use would reduce heating and cooling energy demands by 30-50%. Switchable Insulation Innovations Limited is a commercial spin off from the University of Ulster, with funding from the Innovate UK ICEURe programme. It is aiming to bring a step change in energy consumption, with the technology saving energy in buildings by being switched on or off depending on temperature. The project has moved from university lab testing to field based trials, evaluating thermal performance. The data from these trials will be used to shape the final design and data models.
Potential Impact	Potential for significant impact on energy efficiency of all buildings. Advances in AI and smart energy management systems would maximise potential efficiency. Still at early stage of development and costs likely to present significant barrier to take up. Cooling benefits are less relevant in Northern European climate but export opportunities are there.
What next?	The project has moved from university lab testing to field based trials, evaluating thermal performance. The data from these trials will be used to shape the final design and data models. Following this, they aim to engage with investors to begin rolling out the early market product. It will be critical to ensure accurate fire rating certification, assessment and insurability.

Heat Mapping, Bilbao	
Type	Urban Planning
What it is	An energy strategy to decarbonise heating in Bilbao, Spain. The city is aiming for an overall 55% CO_2 reduction by 2035, and to be climate neutral by 2050. Plans include renovation of public buildings, heat pumps, and the creation of district heating and cooling networks. In 2018, nearly half of the city's energy consumption and 33% of CO_2 emissions came from its building sector, with many buildings not meeting high energy-efficiency standards. Building upgrades are being prioritised through the Decarb City Pipes 2050 project, which is focusing on decarbonising the heating and cooling sector. Through this, a strategic Heating and Cooling 2050 plan has been developed, along with a Transition Roadmap. This roadmap includes essential information of the heating and cooling sector, identifies barriers and strengths and outlines the most relevant instruments to accomplish an emission-free heating and cooling sector. It also involves data-intensive spatial mapping of the city, to understand its current energy use and the suitability of potential solutions. Analysis includes urban planning data, energy data and potential renewable production, and buildings characteristics. The heatmap was developed from a range of information sources, starting with mapping the energy demand per square meter, the configuration of the heating distribution within buildings and the current energy source. Hourly heating and cooling demands were then calculated, as well as fuel consumption and its associated costs and emissions. Results were adjusted using real data for total energy consumption of the city, which were provided by energy distribution companies. The heatmap was developed from a range of information sources, starting with mapping the energy demand per square meter, the configuration of the heating distribution within buildings and the current energy source. Hourly heating and cooling demands were then calculated, as well as fuel consumption and its associated costs and emissions. Results were adjusted using real data for total energy consumption of the city, which were provided by energy distribution companies.  FIGURE 16: HOTSPOT ANALYSIS FOR DISTRICT HEATING AND COOLING NETWORKS  Heating demand [kwh/m2] for buildings in the City of Bilbao *Image: EU Mayors*

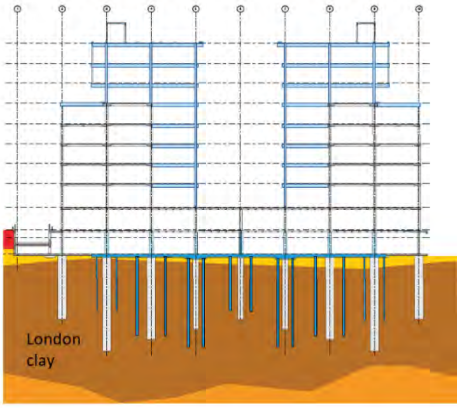
Potential Impact	An equivalent project in NI's urban areas would help planners and policymakers target domestic and commercial decarbonisation solutions, possibly supporting a retrofitting triage system by helping identify priority areas and areas where retrofitting would be difficult (e.g. protected buildings).
What next?	The geospatial analysis of Bilbao will be used to part inform decisions over which technologies for the electrification of heat (heat pumps or district networks) are most suitable in creating an electrified heating and cooling system. Implementation will also require a cost-benefit analysis, and involving the right stakeholders, with most buildings in Bilbao being privately owned condominiums.

Positive Energy District, Strabane	
Type	Urban Planning
What it is	Derry has been part of the European Commission's Intelligent Cities Challenge (ICC), and in January 2025 the Strabane Positive Energy District Local Green Deal (LGD) was officially signed. The LGD plans to create a Positive Energy District (PED) in Strabane Town centre. The LGD is aimed at promoting net zero, creating a 'living laboratory' pilot in Strabane, focusing on energy generation, distribution, storage, forecasting and balancing across different energy sources. This will include local businesses, as well as residential, public and community sector properties. The PED aims to eliminate fossil fuel reliance, and become a net exporter of renewable energy, as well as lowering energy bills for residents, businesses and public services. Key goals include achieving at least a 50% greater renewable energy share within the PED energy mix by 2029, rising to at least 75% by 2031, and to export a net annual surplus of renewable energy equivalent to at least half the amount of fossil fuels consumed by 2031. *"The creation of a PED in Strabane fits perfectly with our goals and objectives for City Deal in terms of sustainability and we are delighted that as part of our development plans for Strabane we can now include energy efficiency measures across the proposed three public service buildings, retrofits of nearby town centre buildings and the deployment of renewable energy generation and storage infrastructure."* – Cllr Lilian Seenoi Barr, Mayor of Derry City and Strabane District Council,
Potential Impact	PED schemes have the potential to make significant contributions to decarbonisation and have other strategic benefits, including aligning public and private sector interests to a shared goal. By being rooted in local communities, they can also connect local residents to schemes and foster engagement and understanding.
What next?	The Strabane PED challenge is at a very early stage. Monitoring of results should provide direction on other schemes, including potential scalability and application in larger areas.

Gemini Project	
Type	Energy
What it is	This project plans to use geothermal energy as a near-zero emissions energy source in Ireland and Northern Ireland, providing an alternative to fossil fuels. Over 4 years the project aims to use geothermal energy to power large-scale heating and cooling systems in public sector buildings. The project will also include activities centred around longer term sustainability and development of geothermal energy across the whole island of Ireland, such as education, skills, research, public engagement programmes and information to support policy. The Gemini project involves both 'shallow' and 'deep' geothermal energy: Shallow – three <500m geothermal energy systems to be installed in Sligo Regional Sports Centre, the Northern Ireland Housing Executive Centre of Excellence (Belfast) and Northern Ireland Water (Belfast). These will be used to provide near-zero emissions heat to public buildings. Deep – a geothermal system to be developed at the TU Dublin University campus. This pilot aims to demonstrate the feasibility of a larger scale heat network in Ireland, and will invest in a 2km deep borehole to do so. It will also collect data on potential geothermal resources to determine future opportunities in the Antrim area.
Potential Impact	If successful, the project will have two potential impacts. Firstly, identification of a viable, near zero emissions energy source. Secondly, an example of a whole-Ireland approach to infrastructure development. Likely to be suited only to larger private / public sector buildings.
What next?	Four year project only just launched. If successful, other candidate buildings and sites could be identified.

National Retrofit Plan (Republic of Ireland Government, Sustainable Energy Authority of Ireland)	
Type	Retrofitting, Residential
What it is	Plan to retrofit 500,000 homes to a building energy rating (BER) of B2 and to install 400,000 heat pumps to replace less efficient heating systems by the end of 2030. The strategy is implemented through: ***The One Stop Shop Service*** Also called the National Home Energy Upgrade scheme, One Stop Shops are an integrated upgrade service for homes built post-1940s, providing an end-to-end solution to private homeowners, private landlords and approved housing bodies that want to upgrade their homes to a BER B2 or higher. One Stop Shops assess the home, provide advice to the homeowner on suitable options, apply for the grant, complete the works, and claim the grant from SEAI. The value of the grant is discounted upfront from the cost to the homeowner. The service focuses on interventions such as cavity wall insulation and mass-produced retrofitting solutions, and is delivered by companies registered with SEAI. ***Grant supports*** Grants are available to a value of up to 50% of the cost of a typical deep retrofit (to B2 BER). Additionally, a special enhanced rate (equivalent to 80% of cost) is available for attic and cavity wall insulation for all households. There are also free energy upgrades for those at risk of energy poverty (up to 400 households per month). ***Sustainable Energy Communities*** Expanding the number of SECs supporting local communities in the transition to a low carbon society. Making both new and existing community organisations (incl. civic, religious and sports organisations) 'activators' in the community to drive collective retrofitting efforts. Supported by the communities energy grant – assists new approaches to achieving high quality improvements in energy efficiency within communities. Whilst the scheme's primary objective is to support and maximise the number of home energy upgrades, non-domestic projects are also supported to encourage engagement within communities. Eligible categories for this grant include residential housing energy efficiency upgrades, private sector non-residential building works, community-based organisation and public sector non-residential works.
Potential Impact	In ROI, as in Northern Ireland, the majority of the future built environment is already here. Retrofitting is therefore an essential strategy to bringing down the carbon emissions of the residential sector. If successful, schemes like the national retrofit service could support residents to achieve a significant reduction in domestic carbon emissions.

What next?	Identify the costs and benefits of different levels of support for households. If grants are unaffordable, explore potential for low interest loans, or even just the benefits of acting as a national convener for domestic retrofit solutions.

Foundation Re-use and Building Extension	
Type	Construction
What it is	An example of where this process has been used is 1 Triton Square, London, an ARUP refurbishment project. The building was originally designed in the 1990s, but the client wished to modernise the building and increase its size. The original build had six storeys above ground and a single storey basement. There were extensive records of the original building (which was also designed by ARUP), meaning risks could be minimised and could be used to inform the new design - the modifications added three stories and a five-storey infill to a central atrium, increasing the floor area by 70%. As well as strengthening existing columns and walls, the new design reused the existing foundations through the use of retrofitted raft, using both existing piles and new pile caps. Much of the façade was also refurbished and reused, producing additional cost and carbon savings.  *Image: ARUP*
Potential Impact	Reusing the foundations of an existing building when refurbishing, rather than completely demolishing/ removing the existing building can save on costs, time, and materials and make the construction process more sustainable.
What next?	Not all sites will be suited for foundation reuse, as its feasibility of depends on the load-carrying capacity of the existing foundations. Determining the existing capacity can be complex as it depends on the availability of site records/ foundation, the condition and durability of the existing foundations, the geotechnical capacity of the foundations and the load required by the new building. In some cases (such as if adequate geotechnical safety of the new building load on the existing foundations cannot be demonstrated), the existing structure may need to be reinforced. However, as an approach, foundation reuse could help to make creative reuse of existing buildings more viable, in turn speeding up development and reducing the embodied carbon impact of schemes.

Key Forces of Change

Expert perspectives

Discussions with built environment experts, stakeholders and the steering group provided extensive information and context on the opportunities and challenges in decarbonising Northern Ireland's built environment.

Several areas emerged very strongly from this stage of the research:

Retrofitting – essential but complex

Much of the 2050's built environment is already here. Any successful decarbonisation of the built environment therefore needs to involve a major retrofitting strategy to improve the energy use and efficiency of residential and non-residential buildings in Northern Ireland.

This is a complex task. Northern Ireland has a wide range of different kinds of housing stock in different kinds of condition, meaning that there is no single solution. There is a broader skills challenge in the kinds of work that will need to be done to get most value from retrofitting. A major retrofitting effort could have other, negative consequences, including on circularity and resource use in the short term.

No need to wait for technology

Many of the strategies needed to decarbonise are materially available or commercially viable already. This means that the industry does not need to 'wait' for new technologies to become available. Rather, the challenges are broader: political direction and certainty and capital, which can fund new or more expensive modes of construction.

At the same time, the wheels of innovation should keep turning, because any further developments can make the process of decarbonisation quicker, easier and more profitable. A challenge in this area is to progress new technology from concept and trial to market readiness. This may require changes to building standards that make it more feasible to use, for example, low carbon concrete.

Public sector needs to signal the direction of travel

A clear message from these conversations was the importance of government direction. There is optimism that the private sector wants to fully embrace renewables, and is feeling commercial pressure to decarbonise from investors, staff and employees. However, clearer direction is needed in policy terms.

The last decade has been politically turbulent, in both Stormont and Westminster. The current landscape, looking out to the late 2020s provides a little more certainty and opportunity for longer term planning. If policy successes build, then policymaker confidence and ambition could grow.

Capture low hanging fruit

In the short term, while waiting for step changes in electrification, renewable energy generation and infrastructure, there are potential opportunities to be grasped that can provide significant long term benefits.

These include policy changes such as improving air tightness standards, requiring more from landlords in adhering to minimum energy efficiency levels and encouraging creative reuse before demolition.

Northern Ireland has unique strengths

Northern Ireland's size, location and geography was considered by a number of stakeholders and experts to give it distinctive strengths compared to other parts of the UK.

The presence of a land border with the EU means there is potential for trade opportunities and alignment. Many businesses work across the Island of Ireland and so can fulfil EU standards in the North quite easily. Northern Ireland's geography make it ideal for on and offshore wind generation and the nature of our coastline provides opportunities for tidal power as well. Like some other parts of the UK, Northern Ireland has the opportunity to use devolution to its advantage in the exploitation of its renewable resources and it can standardise the public sector built environment without waiting for the UK government.

Key Trends

In addition to these expert perspectives, a range of wider drivers were identified that are likely to share the future environment in which decarbonisation of the built environment will occur. These drivers are multidimensional, multistakeholder and are complex, interdependent and viewed differently by different stakeholders.

These are not decarbonisation trends, in that they do not describe new processes, sustainable technology or industry considerations. However, they are essential to building an understanding of what the future landscape might look like.

Our approach used a PEST (politics, economics, social and technology) framework to identify different trends. When creating the scenarios, each of these trends was analysed to determine the relevance and impact on that scenario.

Area	Trend	Description
Politics	Political certainty	Extent to which governments (in Stormont and across UK) are able to develop and implement long term plans/frameworks
	Devolution dividend	Ability of Northern Ireland to act independently of Westminster government, exploiting local opportunities where available
	EU Alignment	Extent to which the UK pursues either closer relationship with EU or extent of alignment on standards, policies etc
	Civil service confidence	Confidence of policymakers to develop market leading and long term policy frameworks
Economics	Economic growth	Extent of growth in GDP across UK and in individual nations/regions
	Cost of living pressures	Experiences of public in recovery from high inflation and extent of improvements in living standards and disposable income

	Longer term funding	Length of funding settlements for the Northern Ireland Executive and the resulting ability to develop longer term policies
	Skills shortages	Extent of skills shortages in key sectors relevant to the built environment, including green jobs.
	Availability of capital	Condition of investment environment and ability of firms to secure capital for new projects and development
Social	Consumer education	Extent to which the public are informed about sustainability and their agency in driving lifestyle/behaviour change
	Support for Net Zero	Level of support that Net Zero retains, at both a public and political level
	Ageing society	Changes in the age composition of the population, which includes the average age and number of older people increasing
	Single person households	Number of single person households, including those at retirement age, is set to increase
Tech	Innovation pathways	Ability of tech breakthroughs to be identified, developed, utilised by industry and scaled
	AI Development	Continued development of AI and integration into wider systems and lifestyles
	Smart Cities	Application of demand management and real time information analysis at a large scale
	Consumer attitudes to tech	Extent to which the public are willing and able to integrate new technology into their lives

Future Scenarios

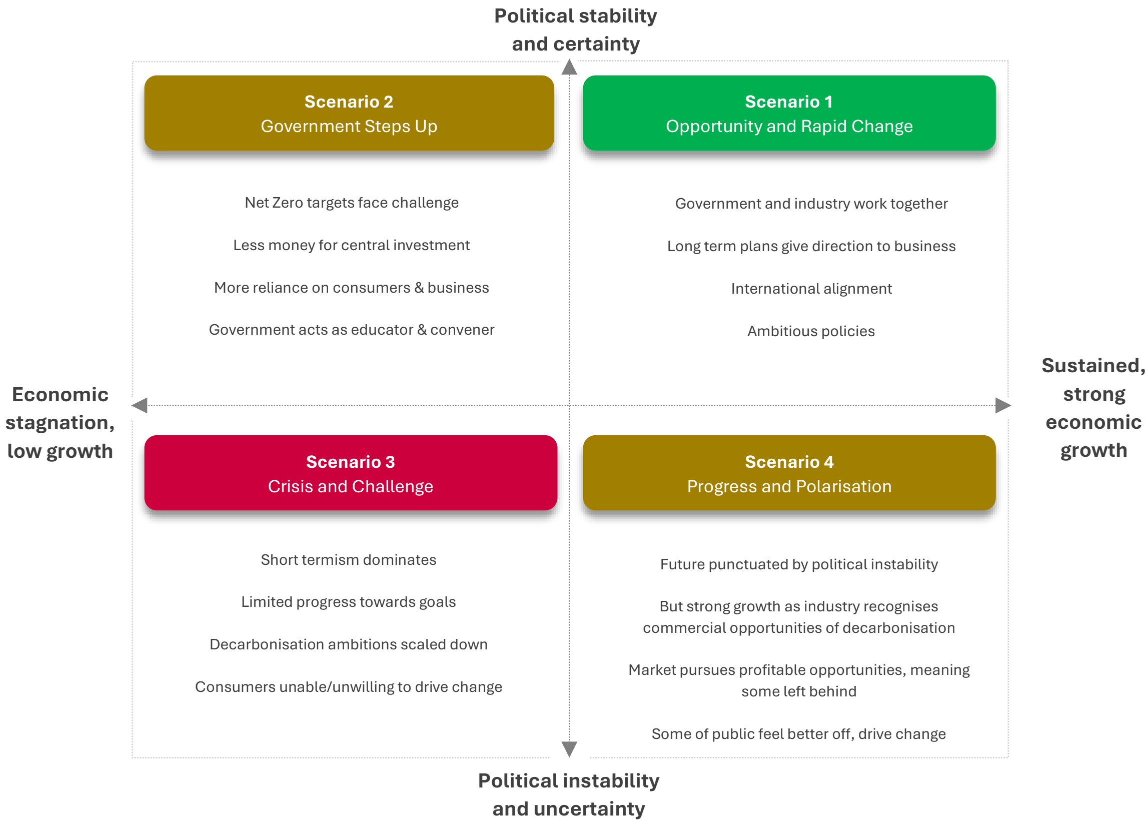
Overview of the scenarios

In the initial stages of the work, three findings emerged very clearly from discussions with experts and analysis of the available literature.

1. Firstly, unlike some strategic foresight analysis that considers a long term time horizon, there was little dependence on future technology. This is because many technologies that could assist with decarbonisation already exist. The key challenge is in deploying them effectively. Technological breakthroughs and their application are relevant to the decarbonisation of the built environment, but new tech is not considered critical to success.
2. Secondly, the stability or instability of governments and the long-term (or otherwise) nature of policy is highly important. Government stability creates a stable policy environment that allows all stakeholders to plan and implement decarbonisation measures.
3. Thirdly, economic conditions emerged as a critical factor in decarbonisation as this determines what options are available to government and the ability of the public and businesses to invest in decarbonisation strategies.

With this in mind, our scenarios are created using two variables. Firstly, an economic variable, with economic stagnation and low growth at one end and sustained, strong economic growth at the other. Secondly, a political stability variable, which has political instability at one end and certainty at the other. These created four plausible, possible scenarios in which we can consider the landscape of decarbonisation in Northern Ireland in the period to 2050.

1. **Opportunity and rapid change**. Strong, stable governments with long-term goals alongside sustained economic growth.
2. **Government steps up**. Growth disappoints, but government act carefully to support decarbonisation.
3. **Crisis and challenge**. Political instability and economic stagnation. Short term thinking dominates, progress stalls and crisis looms.
4. **Progress and polarisation**. Private sector drives rapid change while government struggles to keep up. Lots of progress, but unevenly spread.



In this next section we'll outline what each of these scenarios might look like in more detail, as well as the major challenges and opportunities for businesses and policymakers. **The scenarios are each written from the perspective of the future: 2050 looking back on the past few decades to understand how we got there.**

Scenario 1: Opportunity and Rapid Change

By 2050, Northern Ireland has become a global beacon of decarbonisation. Success has been underpinned by favourable political and economic conditions, but also by an unwavering focus Net Zero goals and increasingly confident policymaking.

Political & Economic Stability

After a turbulent decade, from 2030 onwards politics proved more stable and predictable, no doubt helped by a reasonably strong return to economic growth in the late 2020s. The chop and change that had characterised Westminster politics between 2016 and the mid 2020s gave way to a succession of strong parliamentary majorities that allowed different governments to balance short-term politics with longer term goals. The picture in Stormont was similarly much-changed on the previous period: Northern Ireland has had a functioning Executive throughout the last 25 years and enjoyed five-year funding settlements, which enabled longer term (and infrastructure) planning.

This more stable domestic political backdrop has had three major impacts on decarbonisation:

1. Across the UK, government commitment to Net Zero has been unwavering
2. This long term clarity (alongside an expectation that governments will stay the course) have given direction to industry, allowing stakeholders to plan their decarbonisation programmes with greater certainty
3. Policy maker confidence has grown, resulting in more ambitious and joined up initiatives

Bold policies with lasting impacts

In the 2020s, as economic growth was starting to improve, the Northern Ireland Executive pressed forward with a major overhaul of building standards alongside schemes designed to support other aspects of the transition. This included a retrofitting triage scheme (designed to identify and in some cases, part fund retrofitting solutions for domestic and commercial properties), a country-wide resource matching programme to ensure more efficient use of materials and green skills pathways (such as in insulation measurement and heat pump installation) both for those already in industry and young people leaving education.

By 2030, after several years of sustained economic growth, business and consumer confidence was rising. Businesses further increased investment as they became more certain that decarbonisation would remain at the core of government policy. While there was some dissent with the pace of change and upgrading of building standards when the measures were first introduced, by the 2030s these were considered major successes, with businesses falling in line behind the framework. Northern Ireland based businesses also leveraged export opportunities as closer ties and greater alignment with the EU meant growing trade opportunities with the European bloc that was equally committed to Net Zero. Northern Ireland has had a particular advantage here, as it is the only part of the UK with an EU land border.

The retrofitting triage scheme was a major success, both in terms of scaling increases in domestic energy efficiency and providing commercial opportunities for Northern Ireland businesses. The public sector led by example, adopting the same updated criteria for new buildings and investment in upgrades to existing ones.

Although it was a slow recovery from the inflationary shock of the early 2020s, by the end of the decade more people were feeling better off as economic growth gradually translated into rising disposable incomes and easing cost of living pressures. Many private homeowners took advantage of the triage scheme to diagnose and, in some cases, part fund retrofitting solutions including insulation, air tightness improvements and new energy systems. Many homeowners – including those not eligible for financial support – recognised that with the increase in building standards, retrofitting was a good investment to protect the value of their homes.

These measures meant the 2030s were defined as a decade of electrification and property adaptation in Northern Ireland as more and more parts of the built environment became more energy efficient. The uplift in building standards has ensured that new developments in the region are built to some of the highest specifications in Europe. This includes wider use of more sustainable materials (including timber frame), passive housing principles to reduce energy use and more multi-dwelling units that can utilise shared energy systems. Many new builds became modular in design, with off-site construction substantially reducing the embodied carbon associated with dwellings. Development principles have also been updated to mandate whole life carbon assessments, stepped targets for embodied carbon reduction leading to creative reuse options becoming more attractive to developers. This has resulted in more embodied carbon being retained while the built environment is updated and improved.

Speed of change leaves some behind

This transformation has not been without its challenges. The speed of change and boldness of ambition have left some households and businesses behind. Some smaller construction firms were less able to adapt to the rapid increase in standards, although they have taken advantage of opportunities in increased demand and government support for retrofitting solutions.

At a population level, not all households recovered equally quickly from the cost of living crisis or have the means or appetite to fund retrofitting improvements. In many other cases, the investment would not be worthwhile, as the cost of meaningful upgrades outweighs the value of the property. This issue has proved particularly problematic in the case of Northern Ireland's growing cohort of older, single person households. As standards of new builds and the quality of updated housing stock increases some uncomfortable inequalities are reemerging. Those living in modern, energy efficient households are typically seeing their energy costs plummet, while others – most often vulnerable and older households – are not.

There have also been major bottlenecks caused by the pace of change, especially at the start of the period. The demand for energy, and electricity in particular, threatened to derail progress initially. But changes in the energy mix have taken place alongside decarbonisation, in a variety of ways. Political stability and shared sustainability goals have helped forge strong links with the EU, meaning an opportunity for greater energy system interconnectivity with both Great Britain and the Republic of Ireland. Local renewable generation is also increasing, with a massive increase in on and offshore wind.

Public commit to behaviour change

The manifestations of climate change have become more frequent and more extreme in this period, especially from the mid-2030s onwards. From sustained high temperatures during the summer, the increased frequency and severity of winter storms and elevated risk of flooding, barely a year has gone by without a visceral reminder of the impacts of Northern Ireland's changing climate. Consistent messaging around the causes of these events has also help ensure public opinion remains on side.

These reminders, coupled with government and industry commitment to decarbonisation, have helped ensure that public support for the principles of Net Zero remains high. Where possible, government and industry have been able to drive changes that minimise an individual's carbon footprint – such as the electrification of public transport, increased EV charging infrastructure and enhanced cycle paths and walkways – and allow people to continue to do what they enjoy doing. Communications campaigns have helped raise awareness of ways the public can play their part and emphasised the local and economic benefits of decarbonisation. This was particularly important in the early part of the period, when the gains were yet to be realised.

This has helped foster a nation of responsible citizens, who are largely in step with efforts to decarbonise. The success of the transition has helped to foster excitement, optimism and no shortage of pride in the role played by Northern Ireland and the wider UK. This reinforces the positive behaviour as people are keen to play their part to keep progress going.

Decarbonisation as a platform for wider change

By the 2040s, progress in electrification and decarbonisation is acting as driver for wider social and technological changes. For the first time, the majority of housing being built in Northern Ireland are multi-dwelling units, especially in city centres. More people – especially younger people and families – are living in Belfast itself. This means more use of public transport or active travel modes and lower levels of car use.

The electrification of transport systems, rise of multi-dwelling units and growth in the younger population are also supporting increasingly impactful AI use cases, which are helping to find new energy efficiency gains. Energy demand and transport usage are mapped city-wide, meaning greater control over resources and more predictable demand.

Perhaps most significantly, the ageing of Northern Ireland's population is slowing, as the growth of the green economy is attracting foreign investment and skilled workers from both across the UK and internationally.

Ultimately, by 2050 Northern Ireland has successfully decarbonised and is regarded as a world leader in sustainable construction and redevelopment. Businesses and the population alike are enjoying the benefits of a growing green economy.

What does this scenario mean?

What does this mean for businesses?

Challenges

- Speed of change will leave some businesses behind – especially smaller firms or those with workforces with lower levels of experience in using new materials or methods of construction, or those unwilling to take risks.
- Intense demand for skills and materials – potentially causing bottlenecks in supply.
- Strong government means businesses will need to align with regulatory imperatives and government initiatives.

Opportunities

- Stability and growth mean businesses are likely to be able to invest with confidence and plan for longer term.
- Increased building standards will mean early opportunities for passive housing and sustainable materials producers.
- Businesses likely to pursue opportunities in retrofitting – strong competition and government backing may mean lower prices for households.
- Pace of change will create wider opportunities – for example, in green skills training and development, material reuse and resource sharing, and renewable energy production.
- If the population grows in response to the success of the green economy, there'll be increased demand for housing and commercial development.

Actions

- Invest in upskilling of existing workforce. This includes new methods of construction, new materials, retrofitting skills, passive housing standards, sustainable design principles, heat pump manufacture and installation.
- Liaise with professional institutions to create future-focussed training pathways to minimise risk of labour shortages.
- Adopt circular economy principles including reuse of products and materials to ensure minimal waste.
- Invest in innovation, including use of AI to assess retrofitting needs and modular construction.
- Work in partnership with government to ensure mutual benefits from rapid transition.

What does it mean for policymakers?

Challenges

- Faster progress means more challenges on grid and energy infrastructure, especially at the start of the period.
- Tension between decarbonisation and low embodied carbon agendas during rapid retrofitting progress

Speed of change means some firms and workers in carbon intensive industries or small construction firms at risk of being left behind.
Resource scarcity (of both skills and materials) likely to be particularly intense in a rapid change scenario.
Potential for rising inequalities between those households able to upgrade housing and those not able.
Requirement for commitment to bold policies in the early part of time period, before long term trends in economic growth or political stability are fully apparent.

Opportunities

Stronger public finances create opportunities for investment, incentives, and for public sector to lead by example.
Continued public support for decarbonisation principles means communication focus can be on nudges, support and benefits of change, rather than continually having to 'win the argument'.
Success creates opportunities for inward investment.
Alignment with EU creates opportunities to whole-Ireland policy and commercial partnerships.
Potential to be bolder in approach to regulation.

Actions

Create subsidised skills pathways to support young adults into green jobs and support workers in carbon intensive industries to retrain or develop new skills.
Strengthen building codes to measure and reduce both embodied and operational carbon, adopt passive housing principles for new developments.
Protect embodied carbon in existing built environment by requiring new developments to explore creative reuse options before demolition.
Support alternative and low carbon materials providers to gain accreditation to encourage sector to move away from use of tradition materials and towards novel, low carbon materials.
Introduce and scale retrofitting triage system for private households. Focus additional support on older households which may be harder to incentivise later. Provide targeted financial incentives (such as grants or low-interest loans) to stimulate demand.
Invest in passive social housing to ensure no discrepancies between standards.
Across all projects, retain focus on local benefits, financial savings (to public) and value for money.

Scenario 2: Government Steps Up

Political Certainty and Economic Stagnation

The 2030s and 2040s proved to be turbulent times for the UK. Economic growth has largely disappointed, failing to reach the heights seen before the global financial downturn in 2008 and instead continuing at the lower levels of the 2010s and 2020s – just under 1% per year on average. Successive governments have been hamstrung by a weak economy, limited fiscal headroom and poor investment climate.

Despite this, politics has proved more stable. Although governments haven't always been popular, they have been reasonably strong in parliamentary terms, able to manage their legislative agendas over 4-5 year periods, which has enabled them to keep moving forward on long term goals, including decarbonisation.

This UK-wide trend of disappointing growth but reasonable political stability has also been the case in Northern Ireland. The Executive has continued to function throughout this period, which has helped ensure longer term planning and certainty for policymakers and industry alike. The Northern Ireland economy has performed marginally better than the UK average, which has helped it attract investment from within the UK and abroad.

There have been several major impacts on the decarbonisation of the built environment in Northern Ireland as a result of this political and economic backdrop.

- Political stability has ensured that Net Zero has remained a central part of government policy throughout this period.
- The Executive in Stormont has had to adapt to its role as an educator and convener as constrained public finances limit central investment opportunities.
- The stuttering economy has meant businesses have struggled to invest and the pace of change has been slower.

Agile, innovative government

With growth disappointing throughout the 2020s, the Northern Ireland Executive took a different approach to other parts of the UK. Rather than hunker down and react to low growth by trimming budgets across the board, the Executive took the bold decision to be innovative in its approach to supporting decarbonisation in the built environment.

Fundamentally, government stakeholders in Northern Ireland recognised a need to be agile and innovative to encourage and trial new things. This has been especially true in terms of funding, which has seen the utilisation of more creative approaches. Rather than relying on one source of funding, Northern Ireland developed approaches to draw on several, including Green Banks, Sovereign Wealth funds from other nations and All Ireland funding. Where money was spent, it was focussed on those schemes which provided the biggest returns on investment and optimal impact (including consideration of savings to households).

In many cases, this has meant some tough and occasionally unpopular decisions. Plans for a national retrofitting scheme, which would have included widely available grants to support homeowners and businesses to update their properties were scaled back, with grants only available for examples where the impact was greatest. Greater use was made of low interest loans, but more older and dilapidated properties have not been updated as a result. Larger-scale overhauls of infrastructure have also been watered down, with microgrids preferred to support specific new developments.

The government also saw a greater role for technology to drive efficiencies and accelerate progress. With R&D spending in the private sector limited, the government stepped in to support funding to keep the wheels of innovation turning. In some cases this was in partnership with industry, in other cases with universities and research centres through direct funding and knowledge transfer partnerships.

Public – private sector partnerships in difficult times

With the government less able to be active in driving investments it has had to lean more heavily on industry to decarbonise. While businesses have benefitted from the certainty and clarity of the targets, they have also struggled keep pace with them, as a poorer investment climate and lower rates of growth have meant more limited capital.

In the 2020s and early 2030s sustainability remained a niche and premium part of the market. While there was some increase in the development of sustainable materials (such as CLT or low-carbon concrete) in Northern Ireland, much of this was exported rather than used domestically.

This is reflective of a wider change within industry: it is increasingly outward facing, sourcing both investment and sales opportunities abroad. In some cases, this is helping to lift standards: the EU has seen faster progress and more stringent decarbonisation requirements in this period. Northern Irish businesses working in or with the Republic of Ireland are improving their processes accordingly.

Policymakers have adapted. Where possible, regulation has been toned down to avoid stymying growth or investment. In some schemes, where seeking to raise private capital, risk sharing approaches have been utilised to nurture investment. However, the impact of this has been at a slower pace of change in all areas – including in building standards, energy efficiency, retrofitting and material reuse.

Limited infrastructure developments

One area in which decarbonisation progress has disappointed is in infrastructure and system upgrades. A lack of public investment and more cautious private sector approach to the transition meant that the late 2020s and early 2030s didn't result in the widespread electrification of Northern Ireland, as had been hoped.

Although there have been some successes such as in utilisation of geothermal energy generation in some public buildings and major offshore wind growth, Northern Ireland is reliant on GB and EU sources of energy. The lack of upgrades to the capacity of energy supply including electricity, water and waste have also acted as a block or delay on new developments. This has been hugely frustrating to businesses and communities alike, who've managed to pull funding together only to find that the project is put on hold.

Public attitudes and experiences

Consumer behaviour change has been another slow part of the transition, for the most part. Despite this, there have been localised successes. Regenerative community groups and community ownership schemes have driven both localised carbon reductions and created a template for other areas.

Net Zero remains government policy, and businesses are largely committed to decarbonisation as well. However, over the past few decades opposition has grown. A vocal minority – of both the public and politicians – are arguing that with key targets missed, it's time to change the approach. In some cases, critics advocate for the removal of decarbonisation targets completely and a switch to a strategy completely focussed on adaptation.

Public attitudes have been mixed throughout the last couple of decades. The increasingly impactful manifestations of climate change (and consistent messaging about their cause) help to keep the issue prominent in people's minds, and many consumers are positive about the benefits of embracing decarbonisation, arguing it has led to energy savings and a better quality of life. But improvements in disposable incomes and overall living standards have been slow, and many households have struggled to make the kind of changes, either to their properties or lifestyles, that would yield meaningful benefits.

The most successful communications campaigns have avoided focussing on decarbonisation at all, instead wrapping sustainability in with other benefits that the public are more likely to feel and be responsive to. In the early part of this period, with the inflation shock of the early 2020s still fresh in people's minds, this was particularly focussed on the economic and wellbeing benefits of domestic upgrades, both to reducing ongoing costs and protecting the condition and value of people's homes. As bigger projects got underway, including energy system upgrades and transport electrification, the benefits of reliability, clean air and energy security were highlighted.

Maximising progress amid huge challenges

By 2050, Northern Ireland has arguably had more success than any other part of the UK in driving decarbonisation of the built environment, but further transformation has been limited by slow, stuttering growth.

The lack of a rapid transformation has also meant that other long term trends are now proving damaging. Northern Ireland's population has aged, and in the last 15 years there has been significant increase in the number of older, single person households. Due to slower progress on retrofitting in the 2020s and 2030s this group are now largely living in properties in urgent need of updating, but due to the cost and hassle involved are the most reticent to do so.

There's been limited change in the location of the population too, with only a handful of major city-centre, multi-dwelling developments that provide efficiency benefits in terms of travel and domestic energy usage.

Ultimately, by 2050, Northern Ireland is leading the UK in decarbonisation but is facing huge challenges due to the slow rate of change and poor investment climate. There is still much work to do.

What does this scenario mean?

What does this mean for businesses?

Challenges

In this low investment and weak growth scenario, businesses will struggle to keep up with the required pace of change on their own.

Spending on innovation and R&D will likely be hit, while slower improvements in household finances will limit consumer appetite for more expensive solutions.

Businesses may struggle to navigate new regulations or meet requirements, raising the risk of declining public-private relationships.

Opportunities

Slower pace of change, especially at start of the period, might provide more time for businesses (especially SMEs) to catch up and develop new skills and adopt new sustainable processes.

Northern Ireland based firms may be able to exploit export opportunities in Republic of Ireland and EU, with the border acting as a strategic advantage for Northern Ireland while the wider UK economy struggles.

If Northern Ireland is able to outperform GB economically, businesses may have success attracting UK funding.

Opportunities for businesses that proactively invest in sustainability to position themselves as market leaders (while transition to decarbonised processes is much slower for rest).

Actions

Develop strong partnerships with universities to exploit new technologies at the earliest opportunities.

Use slower pace of change in 2020s and 2030s to prepare for transition: this includes identifying material supply chains, developing expertise in new sustainable methods of construction and management of whole life carbon and forging skills pathways.

Identify non-NI funding sources – both international and GB based and develop export opportunities, particularly with EU and Republic of Ireland.

Focus on cost-effective and affordable retrofit packages for commercial, domestic and public sector use. Solutions that offer return on investment for minimal outlay likely to be prized even in a tighter financial climate.

Play role in public education to help build long term customer base for decarbonisation solutions, particularly in event of economic improvements.

Keep dialogue with government open to make case for balanced approach to regulation that improves standards without harming limited growth.

What does this mean for policymakers?

Challenges

- Economic climate will mean challenges in retaining long term focus amid shorter term or immediate pressures on spending or public need.
- Risk of over-regulation negatively impacting already-weak growth, meaning policymakers must be cautious in balancing drive to uprate standards without choking growth.
- Public likely to lose confidence in or support for Net Zero ambition amid financial constraint and other areas of need, such as public service reform or infrastructure development.
- Lower investment means challenge to upgrade infrastructure to support broader transition.
- Fewer options available to government means punitive measures to encourage industry compliance more widely used – risking public-private collaboration.

Opportunities

- Opportunity for Northern Ireland to act as a leader, nationally, and use this position to attract funding from UK-wide and international investors.
- Political stability means public sector, unlike industry, can retain long term focus. Use this to help give direction and clarity to industry and prepare them for future stages of transition.

Actions

- Focus on high impact policies that balance transformation with cost-effectiveness.
- Maintain clarity on long term goals and ringfence support for schemes which underpin further stages of transition e.g. electrification and renewable generation.
- Target financial support at those where it is most essential and will result in the biggest impact. This might mean lower eligibility for domestic retrofitting grants, for example.
- Support SMEs free/low cost carbon audits to help them identify areas of potential improvement and provide support for achieving certificate of low carbon construction products.
- Maintain R&D investment in universities and research centres to ensure innovation continues.
- Adapt public messaging to combine benefits of decarbonisation with other positives – such as job creation, clean air, energy security. Support public to recognise potential cost savings of retrofitting and behaviour change.
- Empower local communities to drive change, such as community owned renewable energy projects to build local engagement.
- Lead by example: ensure pace of change in social housing and public sector built environment is at least as fast as private sector.
- Specify a method for whole life carbon assessment and mandate its use and reporting for all but the smallest developments

Instigate embodied carbon reduction targets that provide progress in embodied carbon reducing without overwhelming developers and stymying growth, for public sector projects and developments

Scenario 3: Crisis and Challenge

Political instability amid a poor economic landscape

In this scenario decarbonisation ambitions are almost completely derailed by a weak economy and continued political instability. Short termism comes to dominate both government ambition and efforts to kick start growth as the country lurches from crisis to crisis.

The economic stagnation and pressure on household and commercial budgets that dominated the early 2020s were still present at the end of the decade. From 2029 onwards, Westminster governments have been weak in parliamentary terms and largely lacking widespread support. No political party has been in power for more than five years at a time since then, leading to changes of direction and uncertainty. In this climate, economic growth has been largely absent.

This instability is also present in Northern Ireland. In the mid-2020s it was hoped that the political uncertainty of the past decade was consigned to history, but from 2030 onwards a similar political landscape emerged. Funding settlements became much shorter as the UK government's horizons narrowed and at several points in the 2030s and 2040s the Northern Ireland Executive collapsed, leading to prolonged periods without Executive leadership or the development of new policies.

Over the past 25 years, governments in Westminster, Stormont and across the UK have focussed on shorter term priorities, with several decarbonisation targets repeatedly delayed due to lack of progress, unpopularity or insufficient funds. As the economic situation has declined, government focus has narrowed.

This in turn had several impacts:

1. Government effectively 'lost the argument' on decarbonisation, with political and business stakeholders arguing for a change of approach away from mitigation entirely.
2. The public have rejected decarbonisation as a strategy and have largely failed to proactively invest in making their homes or lifestyles more energy efficient.
3. International funding, already limited as ambitions were scaled down, effectively disappeared in favour of other markets where decarbonisation was still being pursued.

In this climate it has been almost impossible to plan major infrastructure development or to think strategically about how to manage scarce public finance resources.

Targets delayed, arguments lost

On the surface, Net Zero has remained UK and Northern Ireland government ambition. The renewable energy generation and electrification targets were delayed, officially, to give businesses and consumers more time to prepare and mitigate the cost of transition. Regulation was dialled back to ease pressure on businesses and stimulate investment but produced inconsistency, and, in many cases, a drift backwards in terms of energy efficiency. But the result is that it became clear by the mid-2030s that meeting 2050 targets was impossible.

At the same time, the voices arguing that decarbonisation was too expensive and too unworkable to be pursued got louder. Net Zero became deeply unpopular among the public, and a cause of anger in some quarters – who saw the pursuit of it as responsible for the poor state of public services.

The impact of this was significant. Industry had been increasingly sceptical about the viability of Net Zero and delays in targets sent a signal that they could scale down their transition plans. By the mid-2030s, many plans had been effectively abandoned amid weak public demand and lack of government pressure. In response, funding evaporated, cutting off avenues to further progress.

UK increasingly isolated

Businesses in Northern Ireland have either struggled to innovate or failed to try, and as such are less competitive internationally where decarbonisation has remained high on the agenda.

At a political level, the UK is increasingly isolated on the world stage after reneging on climate agreements and beginning to pursue an adaptation strategy rather than a mitigation one. Multiple international campaign groups have started legal action against the Northern Ireland Executive (along with other UK governments) after failing to meet legally binding commitments.

The wheels of innovation and development have stopped turning in Northern Ireland. Universities and research institutions are struggling to attract staff or secure investment. Even international partnerships, especially with institutions in the EU, are difficult to maintain as Northern Ireland moves in a very different direction to its European neighbours. Skilled professionals are increasingly likely to look for work abroad – especially in the Republic of Ireland – leading to a ‘brain drain’ from the North. This is adding to the long term sense of decline in Northern Ireland: the population is ageing, and young graduates are leaving for careers and opportunities elsewhere.

Poorer, more frustrated public

More widely, Northern Ireland is a poorer and angrier place than in the 2020s. Living standards have fallen and most people’s priorities are with the dire state of public services, which the government is attempting to rescue with a mixture of cuts and tax rises.

The perception that decarbonisation is an unnecessary cost is driving anger and opposition to any attempts to kickstart energy efficiency, occasionally resulting in vandalism to heat pumps, solar panels and other accessible, visible manifestations of decarbonisation. This kind of criminality and destruction is rare, but enough to deter local governments, businesses and organisations from pursuing projects. When developments do happen such as new office or hospitality developments – they are sold to communities as providing jobs and revenue, not for their green credentials.

The public generally lack the inclination or ability to proactively upgrade their houses or change their behaviours. In some cases, this is because of the lack of available and affordable options.

Because there's been little consumer demand for retrofit packages businesses haven't pursued affordable or scalable solutions. The lack of central investment in public spaces and public transport has discouraged active travel and maintained car usage.

Unprepared for climate change impacts

The perpetual focus on the short term and lurch from crisis to crisis has had other, increasingly impactful effects as well. The poor funding landscape has meant that even projects designed to provide resilience against the worst manifestations of climate change have been delayed or cancelled, making Northern Ireland communities more vulnerable to extreme weather and rising sea levels.

Flood defences are patchy while urban environments and transport infrastructure are not equipped for Northern Ireland's increasingly hot summers. Running repairs provide another distraction from the long term need to transition to new systems and infrastructure entirely. In the last decade, a huge amount of investment and resource, from both the private and public sector, has gone on shoring up and repairing existing buildings.

In this scenario, the ambition to decarbonise the built environment in Northern Ireland has not been realised, and by 2050 is just as distant as ever. Businesses and the public have abandoned the cause, no longer convinced that the target is affordable or workable. The UK finds itself increasingly isolated and struggling to plan beyond the many crises on the doorstep.

What does this scenario mean?

What does this mean for businesses?

Challenges

This is a hugely challenging scenario that provides businesses with little to no ability to make long-term decarbonisation plans. Constant delays, changes of political direction and shifting policies stymy attempts to plan long term investments or strategies.

Consumer / public attitudes turn, with decarbonisation viewed as an unnecessary burden. This both limit demand for private demand for decarbonisation projects and make larger schemes difficult to implement due to community and political opposition.

Limited opportunity to develop skills pathways. Lack of funding for education and retraining is met with higher rates of emigration of skilled workers.

Slower pace of innovation and technological development in Northern Ireland means fewer opportunities to break cycle of decline, and businesses less equipped to exploit breakthroughs or innovations that originate abroad.

Opportunities

Some larger projects –extreme weather defences and renewable energy generation – likely to be protected from worst of uncertainty, especially in early part of the period.

Opportunity to stimulate some private demand by highlighting cost saving benefits of retrofit packages (energy efficiency, lower bills) and by offering resilience solutions (e.g. flood proofing).

Despite wider economic decline, there may still be localised demand in better-performing industry sectors or among wealthier consumer cohorts.

Actions

Identify packages that offer best return on investment and cost savings, and tailor for commercial and domestic audiences accordingly.
Communicate wider benefits of decarbonisation by reframing what decarbonisation can do – help saving money, build resilience, protect property value etc.
Identify diverse funding opportunities, including those from overseas. Expansion into more climate-committed markets in the EU and beyond will offer routes to growth. Private financing from global investors may be viable.

What does this mean for policymakers?

Challenges

Difficulty in sustaining action and following coherent long term plan.
Brain drain accelerates demographic challenges and weakens workforce (especially in green skills).
Demographic challenges and fiscal environment mean extra pressure on other areas of public spending and services – making it harder to maintain focus on decarbonisation.
Public no longer committed to decarbonisation, with widespread perception that it is cause of economic decline. Industry also moves this way, following lack of consumer demand and lack of political direction.
Political instability and a struggling economy deter private and foreign investment in green technologies and infrastructure, while government investment in innovation has stalled.
UK weakened on global stage, weakening international agreements and cooperation.
Northern Ireland likely to face legal challenges.
Any progress that does occur likely to be patchy and poorly distributed.

Opportunities

Chance for Northern Ireland to leverage geographic position to develop opportunities with EU and Republic of Ireland.

Actions

Identify and utilise public messaging that reframes decarbonisation. This could include strong messaging on the economic, wellbeing, health and community benefits of decarbonisation.

Foster local pride and community support by championing local projects and the benefits of them. Support local communities to develop small-scale programmes with lower upfront costs.

In the early part of the period, if growth is elusive and UK politics remains divided, then reinforcing long term ambitions and targets may provide certainty during instability. Ringfencing those elements of the transition – such as electrification, renewables generation and building standards – that can have long term impacts also key in the short term.

Prioritise approaches that deliver immediate cost benefits for households.

Focus on low-cost support for businesses, such as transition advisory services or facilitation of cross-industry groups.

Where cost effective, utilise public sector projects to showcase low carbon construction techniques and upskill the sector in whole life carbon assessment.

Scenario 4: Progress and Polarisation

Economic growth and political instability

By 2030, UK politics had returned to the uncertainty that had characterised the decade before 2025. Multi-party politics meant that Westminster majorities were rare and fleeting. With the major parties often failing to secure an outright majority, many administrations were hung parliaments or coalitions, and usually publicly unpopular.

This uncertainty has been a feature of Northern Ireland's politics too. Some of this was a knock on effect from the UK wide turmoil – more regular general elections and continued uncertainty about long term frameworks – but since 2030 there have been several periods without an Executive in Stormont, which meant no ability to develop new policy frameworks.

Despite this perpetual political upheaval, a return to economic growth in the 2020s meant genuine progress towards decarbonisation goals has been achieved. The private sector recognised the commercial benefits of decarbonisation and, supported by an uptick in the economy and better availability of capital, invested heavily. Initially this investment was concentrated in renewable generation and electrification, but has since driven an acceleration in technological innovation, new modes of construction and new materials.

In recent years, there have been major technological breakthroughs, including AI-driven energy management and next-gen batteries, which will underpin further progress. This innovation is often moving ahead of regulation, with policymakers struggling to keep up. The planning system, once considered a major barrier to new projects, is now a relatively minor consideration for new developments.

This industry driven decarbonisation has had several major impacts:

- Across the UK there has been progress, but this is heavily concentrated in affluent, typically urban, areas and driven by the largest companies. Some communities have been left behind.
- Political instability has meant that there's been comparatively little progress on infrastructure development or skills pathways, which have acted as major bottlenecks to further progress.
- Northern Ireland has struggled to keep up with other parts of the UK, as businesses in the region have been less able to take advantage of breakthroughs or invest in new processes or technology.

In this context, this scenario is one where progress is not distributed evenly across the UK. Some are left behind, and polarisation is widespread.

An unjust transition

Major progress on renewable energy supply in the 2020s created a pathway for more rapid electrification. Private and public investment in on and off-shore wind, as well as tidal and geothermal energy sources underpinned this. Businesses tapped into this not only to decarbonise their process but also, as they reduced the costs of and gained more control over their energy supply, to free up capital for further investment.

Some areas – particularly major cities in England – have seen significant progress in decarbonisation, with electrified public and private transport, smart city energy infrastructure and demand management, new passive housing projects and flagship developments in commercial and hospitality sectors which are helping drive further investment and growth in jobs and the local economy. As affluence grew in these clusters, more households within them invested in decarbonisation themselves, attracted by both the cost savings and the desire to be at the forefront of this exciting sustainable technology boom.

Despite these urban examples – which act as beacons for a modern, decarbonised built environment – by the 2030s, concern was growing that this was turning into an unjust transition. Those businesses that benefitted most were the biggest players that could invest more in innovation and secure new supply chains. Smaller businesses have been able to innovate, particularly as scalable innovation and new techniques become established, but this is often several years late, leaving them scrambling to keep pace with the market leaders.

Public dissatisfaction with the landscape of decarbonisation is growing. In many cases, private profits are going overseas rather than being reinvested in communities, which is undermining support for new and existing schemes. There's been little investment in skills pathways or retraining, which means job disruption and rising unemployment among people once employed in carbon intensive sectors. Those businesses driving decarbonisation naturally pursued profitable examples, meaning poorer and rural communities and harder to decarbonise sectors were left behind.

Northern Ireland falls behind

Despite pockets of progress, Northern Ireland has been one of those areas largely left behind by this rapid, market driven progress. Political instability proved to be particularly damaging for Northern Ireland as in addition to regular General Elections and changes of direction from Westminster, there were periods when Northern Ireland was left without a functioning Executive.

Businesses in the region have also been less able to take advantage of economic growth or the boom in decarbonisation. Economic growth took longer to drive higher consumer demand in Northern Ireland and the region's typically smaller businesses were less able to invest in innovation or exploit local renewable energy sources.

One of the biggest challenges for Northern Ireland has been in skills. As the pace of change picked up the lack of widespread skills pathways and retraining programmes became a major bottleneck, and led to larger businesses successfully lobbying government for changes to visa and immigration rules to support the continued transformation. These rules apply in Northern Ireland, but demand is weaker as the region is further behind the rest of the UK and there are more, and better paid opportunities elsewhere.

Consumers divided

Consumers have been driving this decarbonisation as well, although there's a growing divide between what's being termed the 'winners and losers' of the transition. The 'winners' are those benefitting from more comfortable lives, typically in a cluster of progress and innovation. The ‘losers’ are those who are left behind, with decarbonisation in their homes and communities delayed by a lack of public infrastructure and limited individual ability to pay for upgrades themselves. The left behind group also includes a growing cohort of people who’ve lost their livelihoods as a result of the transition, with few employment options now open to them.

There’s been a lack of clear communications on the need and wider benefits of decarbonisation which is reinforcing this divide and making it harder to bring those left behind on board. The ‘winners’ are interested – even excited – by new developments and keen early adopters of new habits and solutions. Those left behind are often rejectors of new technology, and resistant to changes to heating systems or new modes of construction.

Successive governments have been weak and often distracted. Although economic growth has been quite consistent in this period, the political turmoil initially came from other sources – including international events, immigration and public service reform. More recently, the growing economic inequality in the country has become a powerful driver of political trends. But decades of underinvestment in infrastructure and public services have meant many people are disengaged from decarbonisation and sustainability because other concerns seem more pressing.

Overall, by 2050, parts of the UK are beacons of decarbonisation but others, Northern Ireland included, are struggling to achieve the same level of progress. They’ve been held back by political instability, unevenly distributed growth and a failure to plan to mitigate the impacts of major bottlenecks in skills and infrastructure.

What does this scenario mean?

What does this mean for businesses?

Challenges

- Demand is likely to be uneven, meaning that competition for those areas and consumer groups able to buy in to decarbonisation solutions will be intense.
- Lack of skills pathways likely to impede continued development.
- Fragmented nature of construction industry in Northern Ireland means widening gap between major builders and smaller organisations.
- Political instability is likely to cause challenges for businesses even while the economy grows – lack of long term direction and policy incentives, especially for smaller firms.
- Growing criticism of larger organisations as transition seen as unjust. Potential to cause reputation problems and deter investment or impede recruitment.

Opportunities

- Capital available for investment in new technologies, new processes and new modes of construction.
- Business appetite for risk and innovation could grow – in turn accelerating tech development and investment.
- Cost savings from electrification and harnessing of renewable energy.
- Opportunity to influence weaker governments and advocate for beneficial policies.
- Some demand from consumers for green tech and retrofit solutions.

Political uncertainty in the UK may mean that international investment and funding is a bigger opportunity than domestic sources.

Actions

Invest in skills pathways and retraining programmes to ensure workforce remains strong and to mitigate reputational damage of an unjust transition.
Identify and target affluent urban markets, where demand is likely to be strongest.
Broaden potential appeal to those at risk of being left behind by developing affordable decarbonisation solutions to lower income households.
SMEs should pool resources and collaborate more closely to share opportunities of innovation.
Work with government to bring solutions to left behind communities to help grow market for decarbonisation.

What does this scenario mean?

What does this mean for policymakers?

Challenges

Danger of chaos and inefficient or inequitable allocation of resources as government difficulties mean regulation does not keep pace with developments. Government playing catch up with industry on tech and often feeling on ‘back foot’, wary of impeding growth.
Unequal progress as industry likely to focus on profitable areas primarily, means some communities/groups are left behind, exacerbating inequality.
Short term and ‘easy’ focus – hard to decarbonise sectors are sidelined by industry and left to public sector.
Slower behavioural change overall, as lack of strong government message and leadership makes decarbonisation feel ‘optional’ for some.
Mounting wider problems in public services and infrastructure make it difficult to retain policy focus on decarbonisation.
Resource shortages and insufficient infrastructure. Water supply likely to be a major concern as insufficient water treatment capacity in Northern Ireland for a growing population.

Opportunities

Economic growth means some improvements in living standards and public finances are likely.
Easier to attract skilled workers from overseas and retain local talent.
Some organic demand for decarbonisation from better off groups.
Industry keen to decarbonise and actively pursuing opportunities, which is likely to drive further progress towards goals.
Climate of innovation, opportunity and development ensures favourable environment to private investment.

Actions

Identify areas where industry less likely to reach – rural, lower income – and develop specific subsidies/programmes to support decarbonisation there.
Support Northern Ireland businesses to collaborate to jointly develop new capabilities to help rival those of major multinational companies.
Collaborate with businesses to pilot new schemes/tech in hard to reach areas
Mitigate political instability by creating and reinforcing clear regional decarbonisation targets, with focus on high impact areas (e.g. housing, public sector buildings, transport). Encourage businesses to set industry standards and best practice.
Invest in training programs to equip the workforce with skills needed in the growing green economy – private sector progress could stall without growing workforce
To help avoid polarisation and inequality, Northern Ireland government procurement should start to consider social value of projects.
Specify a method for whole life carbon assessment and mandate its use and reporting for all but the smallest developments
Instigate bold embodied carbon reduction targets

Recommendations

Summary of recommendations

In addition to the recommendation and implications relevant to each scenario, our analysis has also produced six overarching recommendations. These are not only relevant in any future scenario but also imperative for the short term. Action in the next few years is critical to longer term success. We recommend actioning the following to help achieve this.

1. **Capture readily addressable opportunities**. Immediate actions for the NI Executive include increasing energy efficiency standards for new builds and existing housing stock, carry out whole life carbon assessments for new buildings and encourage creative reuse of existing buildings.
2. **Reframe decarbonisation**. The NI Executive should consider how it describes decarbonisation, reframing it alongside wider and more tangible benefits – such as cost savings, energy efficiency, energy security and clean air.
3. **Work across government**. Decarbonisation is a grand challenge that will affect virtually every part of the economy. Individual departments should be collaborative and different tiers of government should be aligned.
4. **Develop long term frameworks that can withstand periods of uncertainty.** The NI Executive should promptly establish frameworks and long term plans that are designed to withstand periods of heightened uncertainty.
5. **Begin driving domestic retrofitting now.** Much of the future built environment is already here. Retrofitting and updating existing buildings to reduce the operational carbon will be a key component of successful decarbonisation.
6. **Invest in skills pathways now.** Skills shortages are a major potential bottleneck to progress. Policymakers should partner with industry and educations institutions to develop skills pathways in new methods of construction, retrofitting and new energy systems to mitigate against this.

Recommendations detail

1. **Capture readily addressable opportunities.** Immediate actions for the NI Executive include increasing energy efficiency standards for new builds and existing housing stock, carry out whole life carbon assessments for new buildings and encourage creative reuse of existing buildings

There are a number of options open to policymakers to both set a clear direction of travel for industry and to accelerate decarbonisation. While the longer term and intensive energy and process transitions take place, we recommend capturing the relatively accessible workstreams in the short term:

Increase energy efficiency standards for private landlords
Carry out whole life carbon assessments for new and existing buildings
Update building standards to increase air tightness and insulation requirements on new builds as well as promoting performance based design
Encourage or mandate creative re-use of commercial buildings. Require developers to explore reuse of superstructure or foundations to protect embodied carbon

- Incorporate green accounting principles into evaluation of new schemes, alongside traditional economic criteria and PAS2080 to drive a whole-life carbon approach
- Incorporate environmental social value requirements into public sector procurement, requiring private sector suppliers to maintain their own decarbonisation programmes in order to be considered for contracts
- Standardise public sector construction procurement (including decarbonisation targets and incentives) to lead by example and create efficiencies (across both public and private sector)

2. **Reframe decarbonisation. The NI Executive should consider how it describes decarbonisation, reframing it alongside wider and more tangible benefits – such as cost savings, energy efficiency, energy security and clean air.**

There is a continual risk of decarbonisation being seen as tomorrow's problem or as unaffordable. Even in more positive scenarios there is a risk of losing the argument if other issues dominate in the public or business mindset.

We therefore recommend that decarbonisation is reframed and communicated alongside it's wider and more tangible benefits – such as cost savings, energy efficiency, energy security and clean air. Throughout this period new schemes should focus on return on investment and value for money. Ensure that citizens are brought on this journey to provide support for principles of transition and to a create a consumer market for businesses to serve.

Specific actions include:

- Across all projects, retain focus on local benefits, financial savings (to public) and value for money.
- Talk about the impacts of decarbonisation beyond emissions, particularly by focussing on how it helps people to save money on bills or protect property value.
- Identify which kind of public messaging is most effective in reframing decarbonisation for different groups. Some cohorts could respond well to messaging around energy security, others to reductions in pollution or clean air.
- Encourage local pride and community involvement by promoting local projects and their advantages. Assist local communities in creating small-scale programmes with lower initial costs.

3. **Work across government. Decarbonisation is a grand challenge that will affect virtually every part of the economy. Individual departments should collaborative and different tiers of government should be aligned.**

Decarbonisation is a grand challenge that will affect virtually every part of the economy. Individual departments should not be working in silos and different tiers of government should be aligned. Cross departmental working groups should be created to develop holistic plans and to avoid the risk of different departments pursuing similar or competing schemes at the same time.

Specific actions include:

- Planning should be simplified and streamlined – for example, by creating separate processes for major infrastructure projects.
- Work with NI Department of Education and others in government to support public education to help build long term customer base for decarbonisation solutions
- Work with regional and local groups to provide low-cost support for smaller businesses, such as transition advisory services.
- Work with other government departments and agencies to select public sector projects that can showcase low carbon construction techniques
- Align decarbonisation strategies with other long term plans, including the circular economy strategy.

4. Develop long term frameworks that can withstand periods of uncertainty. The NI Executive should promptly establish frameworks and long term plans that are designed to withstand periods of heightened political uncertainty.

Political uncertainty, at an International, UK-wide and Northern Ireland specific level, is a major threat to decarbonisation. However, in the short term, there is relative political certainty at a domestic level. This time should be used to establish frameworks and long term plans that are designed to withstand periods of heightened political uncertainty.

Specific actions include:

- Put in place long term plans in retrofitting, skills development, building standards, carbon assessments to act as a bulwark against potential political uncertainty.
- Strengthen building codes to measure and reduce both embodied and operational carbon, adopt passive housing principles for new developments.
- Create and reinforce clear regional decarbonisation targets, with focus on high impact areas (e.g. housing, public sector buildings, transport).
- Specify a method for whole life carbon assessment and mandate its use and reporting for all but the smallest developments.

5. Begin driving domestic retrofitting now. Much of the future built environment is already here. Retrofitting and updating existing buildings to reduce the operational carbon will be a key component of successful decarbonisation.

There are challenges to retrofitting domestic dwellings, including awareness of the need, awareness of options and ability to pay. As the number of older, single person households increase, reaching communities and incentivising retrofitting may become harder.

- Promptly develop a nationwide retrofit programme, learning from existing schemes (such as that in place in the Republic of Ireland).
- Create a triage system to identify relevant housing stock and worst-performing buildings under the EPC ratings and work with industry to design packages.
- Explore funding or grant options to incentivise take up and work with communities in places where housing stock is less viable to identify support.
- Explore opportunities to use new technology, including AI to assess retrofitting needs and modular construction.

Focus on cost-effective and affordable retrofit packages for commercial, domestic and public sector use.

Identify areas where industry less likely to reach – rural, lower income – and develop specific subsidies/programmes to support decarbonisation there.

6. **Invest in skills pathways now. Skills shortages are a major potential bottleneck to progress. Policymakers should partner with industry and educations institutions to develop skills pathways in new methods of construction, retrofitting and new energy systems to mitigate against this.**

Specific actions include:

Develop skills pathways in both technical areas (carbon assessments, modular construction, heat pump installation, new materials) and in broader skills in systems thinking and public engagement.

Ensure pathways are open to those employed in carbon intensive industries to ensure a just transition.

Support businesses to invest in upskilling of existing workforce.

Support alternative and low carbon materials providers to gain accreditation to encourage sector to move away from use of tradition materials and towards novel, low carbon materials.

Government to provider more financial support for frameworks designed to further innovations.

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Glossary

Terminology	Definition
Bio-binders	Natural materials replacing bitumen in asphalt, reducing emissions in road construction.
Biochar	Charcoal-like substance made from biomass, used in soils or concrete to lock carbon.
Built Environment	All human-made surroundings including homes, commercial buildings, infrastructure, energy systems, and public spaces.
Circular Economy	System where resources are reused, recycled, or repurposed to reduce waste.
Creative Reuse	Repurposing existing structures instead of demolishing them, preserving embodied carbon.
E-fuels	Synthetic fuels made using captured carbon and green hydrogen, often used in heavy machinery.
Embodied Carbon	Emissions from production, transportation, and construction of materials used in buildings.
Modular Construction	Off-site construction of building components for faster assembly and lower embodied carbon.
Net Zero	A state where carbon emissions produced are balanced by emissions removed from the atmosphere.
Operational Carbon	Emissions from energy used during a building's operation (e.g. heating, lighting).
Passive Housing	Ultra-low energy buildings that require minimal heating or cooling to maintain comfort.
PEST Analysis	Framework analysing Political, Economic, Social, and Technological factors affecting future outcomes.
Positive Energy District (PED)	Urban area that produces more energy than it consumes through renewables and energy sharing.
Retrofitting	Upgrading existing buildings to improve energy efficiency and reduce carbon emissions.
Scenario Planning	Strategic method for imagining different plausible futures to guide long-term decision-making.
Switchable Insulation	Insulation that can alter its thermal properties based on climate conditions.

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