Tomorrow's Energy Scenarios Northern Ireland 2019 Consultation

Planning our Energy Future

SONI

The current. The future.

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Foreword

SONI, as transmission system operator for Northern Ireland, is pleased to present its first consultation on Tomorrow's Energy Scenarios Northern Ireland 2019 (TESNI 2019).

As the body responsible for planning the future of the electricity grid and ensuring that power flows where and when it is needed, SONI has an instrumental role in developing and delivering a decarbonised economy. This Tomorrow's Energy Scenarios document sets out a range of possible future scenarios each reflecting different levels of ambition for decarbonising the energy sector.

Energy policy is a devolved matter and the Department for the Economy (DfE) is currently working with stakeholders to develop the next Strategic Energy Framework for Northern Ireland. SONI is providing input to this important work which will inform future renewable targets and the approach to facilitating growth in renewable electricity generation. SONI trusts that this consultation will help to inform decisions that will shape the energy future for Northern Ireland, enabling us to contribute to the global drive to tackle climate change.

Since the publication of the United Nations Intergovernmental Panel on Climate Change special report on Global Warming of 1.5°C in Oct 2018, there has been renewed support from governments to act on climate change. The UK government responded on 27 June 2019 by amending the Climate Change Act 2008 to ensure net greenhouse gas emissions in 2050 are at least 100% lower than the 1990 baseline. It is clear that moving to a zero emissions economy will require stronger co-ordinated efforts across the economy. This will be achieved through new policy actions, innovation in technology and changes to how we use energy, as well as the level of engagement from energy customers. This update to the Act demonstrates the UK and Northern Ireland's commitment to targeting a challenging ambition in line with the requirements of the Paris Agreement.

In acknowledging that there is no single pathway to a low carbon economy SONI has used scenario planning as a means to create a range of possible energy futures that capture the impact of societal, political, economic, technological and environmental changes. Our three scenarios for consultation reflect the possible energy futures in moving to low carbon electricity for Northern Ireland. The scenarios range from the highly ambitious Addressing Climate Change, the medium effort scenario Modest Progress, and finally to Least Effort. Once we have received and considered responses, SONI will analyse the impact of chosen options on Northern Ireland's transmission system.

This is the first 'Tomorrow's Energy Scenarios NI 2019' document and it is important to acknowledge the contribution made by industry stakeholders including NIE Networks, DfE, the Northern Ireland Utility Regulator (UREGNI) and other government departments alongside local universities and industry representatives. Stakeholder feedback is an important input to ensure the content and the context of this consultation is as inclusive as possible.

We hope you find this document informative and we very much welcome your consultation feedback in order that we can improve this document and make it more useful. All responses will be considered in developing the final TESNI 2019 report.

Jo Aston
Managing Director
SONI Ltd.

Glossary of terms

Biogas
The gas produced from the anaerobic digestion of biodegradable material such as grass, animal slurry and domestic waste. It has similar qualities to natural gas, but requires upgrading (carbon dioxide removal) before injection into the gas network.

Carbon dioxide equivalent (CO_2e)
The number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas.

Capacity adequacy [electricity system]
The ability to meet electricity demand at all times.

Capacity factor
A measure of energy production. It is calculated as a percentage, generally by dividing the total electricity produced during some period of time, for example a year, by the amount of electricity the technology would have produced if it ran at full output during that time.

Carbon capture and storage (CCS)
The process of capturing, transporting and storing the carbon dioxide produced from the combustion of fossil fuels, before it is released into the atmosphere.

Climate neutrality
Net-zero greenhouse gas emissions: when the total level of greenhouse gases emitted is offset by the greenhouse gases stored by sinks.

Coefficient of performance (COP)
The efficiency of a heating system: the ratio of energy output to energy input.

Combined Heat and Power (CHP)
An energy efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy.

Decarbonisation
The level of greenhouse gas reductions.

Decentralisation
The size and proximity of energy production in relation to the consumer. A higher level of decentralisation means that more energy will be produced by smaller scale units located close to consumers.

Decentralised generation
Generation connected to the distribution grid.

Demand side management (DSM)
The modification of normal demand patterns, usually through the use of incentives.

Demand side unit (DSU)
One or more individual demand sites, typically in the industrial or commercial sectors, that can be dispatched by the transmission system operator.

Digitalisation
The scale of the role played by digital technology and data.

Dispatch [unit commitment and economic dispatch]
A set of indicative operating points for generators, interconnectors, storage and demand side units required to meet electricity demand over a given time horizon.

Integrated-Single Electricity Market (I-SEM)
The wholesale electricity market operating in Northern Ireland and Ireland.

Distribution grid [electricity]
The network of medium and low voltage (33 kV and below) circuits and other equipment used for supplying electricity to consumers.

Electrification
The substitution of electricity for other fuels, such as oil and gas, used to provide similar services, for example heating and transport.

European Network of Transmission System Operators for Electricity (ENTSO-E)
A group of 43 transmission system operators from 36 countries across Europe with the common goal of setting up the internal energy market and ensuring its optimal functioning, and of supporting the ambitious European energy and climate agenda.

European Union emissions trading system (EU ETS)
The European market for carbon trading. The ETS scheme allows participants to buy and sell carbon emission allowances under a reducing annual limit (cap). The EU ETS covers carbon emissions from the sectors of electricity and heat generation, energy intensive industry and commercial aviation.

Flexibility [electricity system]
The ability to respond to both expected and unexpected changes in demand and generation.

Final use energy
The total energy consumed by end users, such as households, industry and agriculture. It is the energy which reaches the final consumer's door and excludes that used by the energy sector itself. It is also referred to as total final consumption.

Greenhouse gas
One of several gases, especially carbon dioxide, that prevent heat from earth escaping into space, causing the greenhouse effect.

Interconnector
A transmission line which crosses or spans a border between countries and which connects the transmission systems of the countries.

Marine generation
Generation from wave or tidal technologies.

Micro-generation
Micro-generation refers to generation that is less than 11 kW, usually for self-consumption purposes, connected to the low voltage distribution grid.

Need
A future deficiency identified on the grid that arises as a result of one or more drivers, such as additional generation or demand in certain locations. Our technical planning standards play a central role in identifying future needs.

Net load
Electricity demand minus generation from weather dependent renewables.

Power Purchase Agreement (PPA)
A long-term electricity supply agreement between two parties, usually between a power producer and a customer (an electricity consumer or trader).

Power to gas (PtG)
The process of using electricity to produce hydrogen via electrolysis, or, in a consecutive step, using the hydrogen together with carbon dioxide to produce methane via methanisation.

Repowering
Replacing a generation site's equipment with typically more efficient equipment, so that it can continue to produce electricity.

Self-consumption
Demand met by on-site generation, for example when the electricity demand of a dwelling is met by electricity produced from a solar photovoltaic panel on its roof.

Smart meter [electricity]
A meter that employs digital technology to transmit information, such as the electricity consumption of appliances, to relevant actors, for example the consumer and supplier.

SONI
The independent statutory electricity transmission system operator in Northern Ireland.

Technical planning standards
The set of standards, set out in the Transmission System Security and Planning Standards, that the transmission grid is designed to meet. Our technical planning standards are a licence obligation and are approved by the Utility Regulator (UREGNI).

Total electricity requirement
The total amount of electricity required by a country, usually defined in annual energy terms TWh/yr.

Transmission grid [electricity]
The typically meshed network of high voltage (275 kV, and 110 kV) circuits and other equipment used to transmit bulk electricity supplies around Northern Ireland. The terms grid, network and system can be used interchangeably.

Transmission system operator [electricity]
The licensed entity that is responsible for transmitting electricity from generators.

1. Introduction

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SONI, as Transmission System Operator (TSO), plays a critical role in the economy of Northern Ireland. Through the provision of a secure electricity supply, SONI is responsible for ensuring that the lights stay on for homes and businesses across the region. Sustaining a reliable supply of electricity is not just important for existing consumers, it is also crucial for attracting investment[1]. To ensure continued secure, reliable, economic and sustainable electricity supply, SONI must continue to identify the future needs of Northern Ireland's transmission grid and plan the investments needed to address these needs.

1.1. The grid

The Northern Ireland electricity transmission grid is a network of 275 kV and 110 kV (and in future 400 kV) high voltage lines and cables. It is the backbone of the power system; efficiently delivering large amounts of power from where it is generated to where it is needed, safely and reliably. Electricity supply is essential to everyday life and the local economy, and a reliable electricity network is how we move electricity around Northern Ireland. SONI has responsibility for the real time operation and future planning of the transmission system.

Northern Ireland Electricity (NIE) Networks is the Transmission Asset Owner (TAO) in Northern Ireland and is independent from SONI. As the TAO, NIE Networks is responsible for maintenance, repairs and construction of the grid. NIE Networks also provides details of planned asset replacement projects to SONI for review and inclusion in the Transmission Development Plan Northern Ireland (TDPNI), in accordance with the Transmission Interface Arrangements (TIA).

1.2. Integrated-Single Electricity Market

SONI is part of the EirGrid Group who, through the Single Electricity Market Operator (SEMO), is responsible for the operation of the Integrated-Single Electricity Market (I-SEM). I-SEM went live in October 2018 and is the all-island wholesale electricity market that replaced the old Single Electricity Market (SEM). As the TSO, SONI plays a vital role in the operation of the I-SEM.

SONI's electricity forecasts are used to ensure that there is sufficient generation capacity to meet electricity demand at all times of the day. In forecasting the balance of electricity supply and demand over the longer-term, SONI must weigh up several factors that may change the ways that the electricity transmission grid is used in the future.

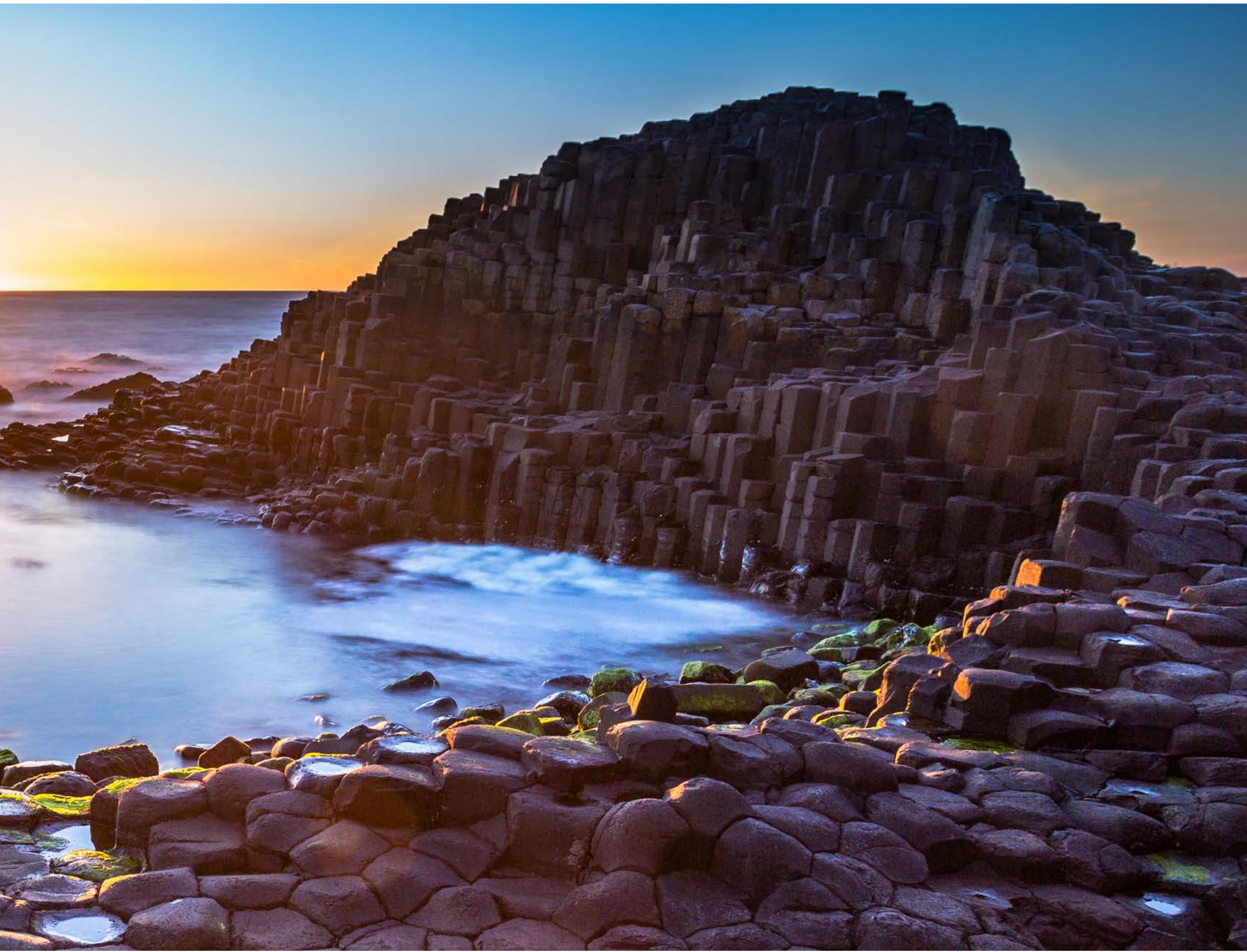
1.3. Northern Ireland's energy transition

Northern Ireland's energy industry is in a period of change. Since the mid-1990s renewables have transformed the generation fleet, increasing their market share and in doing so have decreased our reliance on fossil fuels. Society has become more energy aware. New technologies have become available, improving how consumers meet their energy needs and in some cases enabling them to generate electricity themselves.

Growing evidence suggests that our energy use presents a threat to our climate through its contribution to global warming. In 2015, a number of countries, including the United Kingdom, signed the Paris Agreement[2], committing to limit global warming to well below 2°C and to pursue efforts to limit it to 1.5°C. The UK's objective of reaching net-zero[3] greenhouse gas (GHG) emissions by 2050 demonstrates commitment to the Paris Agreement and is expected to be achieved through a range of policy measures.

1 Grant Thornton, Powering Northern Ireland, 2016.
2 UN, Paris Agreement
3 UK Government, Climate Change Act 2008 (2050 Target Amendment) Order 2019

It is expected that economic conditions, policy measures, societal change and technology will greatly influence the transition toward a low carbon future. However, there is uncertainty about how these factors will interact to influence the energy system of the future. Although it is impossible to predict the exact composition of the Northern Ireland's future electricity system over the long-term, we can project a range of credible outcomes based on the best information available today. Projecting future scenarios in this way helps to manage the risk of uncertainty associated with Northern Ireland's energy transition.



2. Scenario planning

2. Scenario planning

At SONI, one of our roles is to plan the development of the electricity transmission grid to meet the future needs of society. Paramount to this process is considering a range of possible ways that electricity supply and demand may change in the future, given the uncertainty present over the long term. We call this scenario planning. Under condition 40 of the TSO Licence, SONI is required to produce a reasonable number of future scenarios which reflect uncertainties[4].

SONI is introducing Tomorrow's Energy Scenarios Northern Ireland (TESNI) in response to the licence requirement. Scenario planning helps to ensure that the future transmission system can be planned taking account of the uncertainties that exist. Tomorrows Energy Scenarios on the island of Ireland are considered in the context of the single electricity market and as such similar modelling and analytical techniques are utilised for both jurisdictions. This is however the first set of scenarios prepared for Northern Ireland.

2.1. What are Tomorrow's Energy Scenarios?

SONI's TESNI outlines a number of credible pathways for Northern Ireland's energy transition and considers the electricity system beyond the ten-year planning horizon.

Our scenarios will be reviewed periodically to include new information.

When the TESNI 2019 consultation is complete, we will review stakeholder feedback and publish the final TESNI 2019 report. We will then test the performance of the all-island electricity transmission grid using SONI's and EirGrid's scenarios. The final step will be to publish the TESNI 2019 System Needs Assessment report. Testing grid performance using all-island models is important as this more accurately captures how the I-SEM influences power flows on Northern Ireland's electricity grid.

An overview of the TESNI 2019 scenario development cycle is shown in Figure 1.

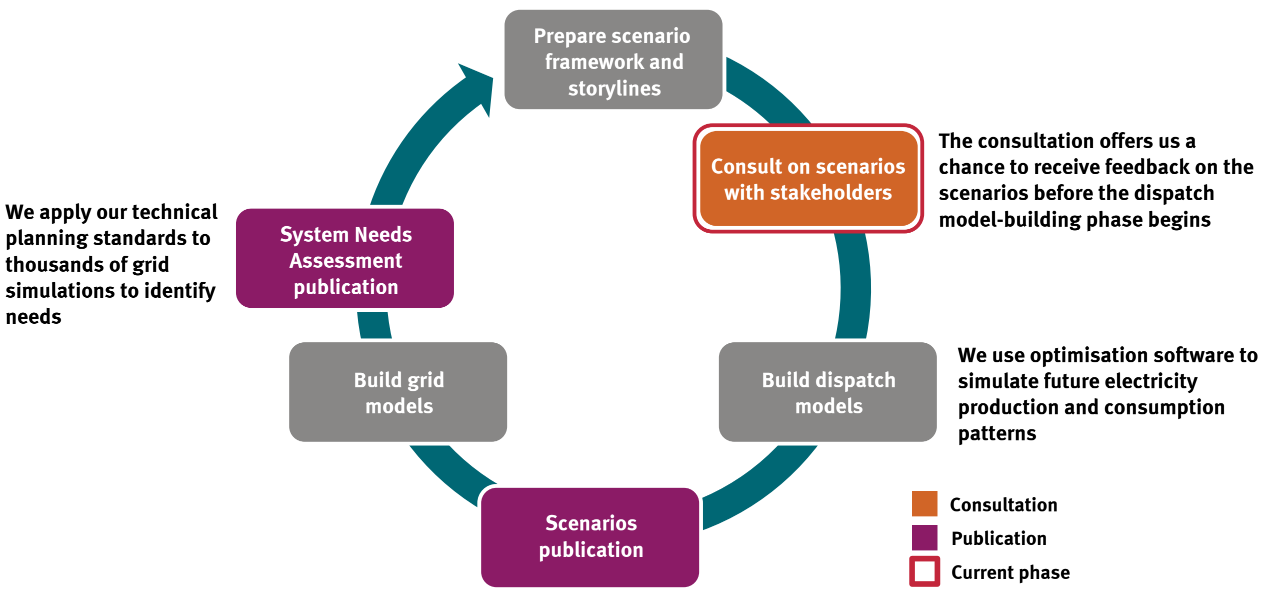


Figure 1: TESNI 2019 scenario development cycle

4 SONI's TSO Consolidated Licence

We value the feedback provided by our stakeholders and welcome the submission of evidence to support any insights and commentary. Involving our stakeholders in the development cycle helps us to ensure the continuous improvement of our scenarios.

Details of the consultation process and how to respond are outlined in Section 9.

2.2. Why do we use scenario planning?

SONI has a responsibility to achieve a safe, secure and reliable electricity transmission system in the future. In the face of unprecedented levels of change in the energy industry, SONI must continue to plan the development of the electricity grid.

As the TSO licensee, we must develop an annual Transmission Development Plan Northern Ireland[5] (TDPNI) which contains a reasonable number of future scenarios that reflect uncertainties and are consistent with scenarios used in other areas of work. Planning for a range of credible futures, through the use of multiple scenarios, helps to manage the risk of uncertainty as illustrated in Figure 2.

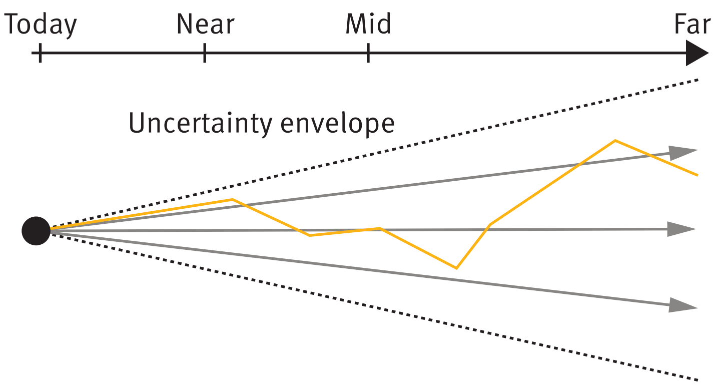


Figure 2: Uncertainty over time

The TDPNI describes our grid development process which is made up of three parts, as shown in Figure 3. In Part 1, we identify optimum solutions required to address the future needs of the electricity transmission system and the areas of the grid affected. Parts 2 and 3 are the next steps in the delivery of a project. Future needs can be driven by changes to electricity demand, generation, storage and interconnection.

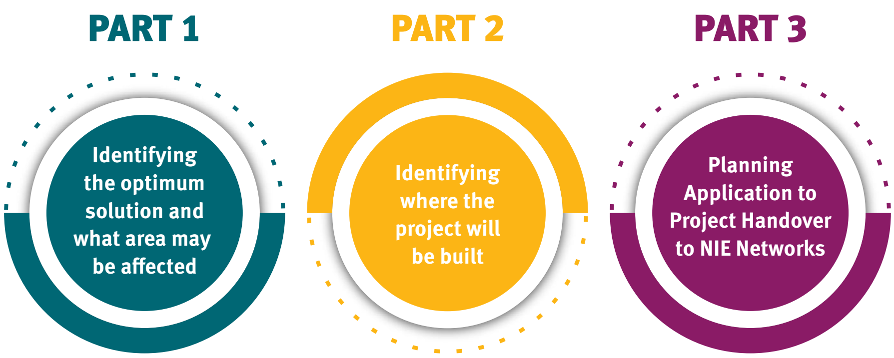


Figure 3: Grid development process

5 SONI, Transmission Development Plan 2017 - 2026

Scenarios are used to test the transmission system against a set of performance standards[6]. We use the results of these tests to identify grid development needs. Needs that may materialise within the ten-year timeframe are detailed in the TDPNI. The TESNI system needs assessment report provides an overview of long-term needs beyond those identified over the TDPNI ten year time frame.

Scenarios are also used throughout the grid development process, to ensure that needs remain valid as more information becomes available.

Our scenarios are not used directly to identify asset replacement needs. These are determined in the first instance by NIE Networks, then reviewed by SONI and integrated into the TDPNI in line with the Transmission Interface Arrangements (TIA).

Further, our scenarios are not used to identify needs or constraints which materialise on the system due to unforeseen plant closures, new connections or project delays. The grid development process adapts to these changes as they occur.

2.3. Related SONI publications

SONI, EirGrid Group and ENTSO-E produce a number of network planning documents that share a relationship with SONI's series of TESNI reports, shown in Figure 4 overleaf.

The suite of documents that are published provide a holistic view of the future electricity transmission system. The TESNI reports will compliment existing documents by providing a wider view of the electricity transmission system beyond a ten year planning horizon.

The *All-Island Generation Capacity Statement (GCS)*[7] outlines the likely generation capacity required to achieve an adequate supply and demand balance for electricity on the island of Ireland over a ten year period. This report forms the basis for underlying demand growth assumptions used in TESNI.

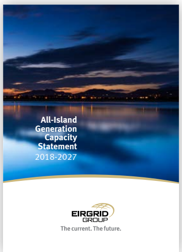
The *All-Island Ten Year Transmission Forecast Statement (TYTFS)*[8] provides detailed data by transmission network node, which provides the basis for the existing electricity grid model used in the *System Needs Assessment.*

The *Transmission Development Plan Northern Ireland (TDPNI)* outlines development plans for the transmission network that will be progressed over the ten year period. This report shares an important relationship with the *TESNI System Needs Assessment* report. The *System Needs Assessment* report, and additional analysis, may lead to projects listed in future versions of the *TDPNI*.

The Ten Year Network Development Plan (TYNDP)[9] of the European Network of Transmission System Operators (ENTSOs) for Electricity and Gas is an important reference for TESNI. The TYNDP process is legally mandated by the European Commission[10] [11] and provides guidance on the European-wide energy transition. It is central to understanding pan European energy infrastructure projects known as projects of common interest (PCIs).

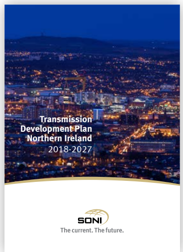
6 SONI, Transmission System Security and Planning Standards
7 EirGrid Group, GCS 2018–2027
8 EirGrid and SONI, TYTFS 2017
9 ENTSOs, TYNDP 2018 Scenario Report
10 EU Regulation 714/2009
11 EU Regulation 347/2103

Ten-year-horizon planning publications



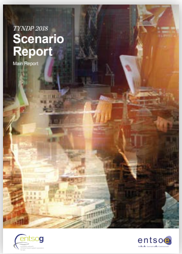
All Island Generation Capacity Statement
Ten year electricity demand forecast.

All Island Ten Year Transmission Forecast Statement
Detailed information on demand and generation opportunities.

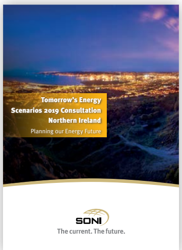


Transmission Development Plan Northern Ireland
Ten year network and interconnection development plan.

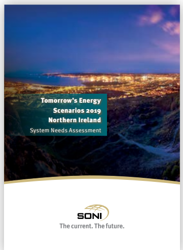
Twenty-year-plus-horizon planning publications



Ten Year Network Development Plan - Scenarios Report
Energy scenarios for Europe out to 2040.



Tomorrow's Energy Scenarios Northern Ireland
Electricity scenarios for Northern Ireland out to 2040.



TES Northern Ireland System Needs Assessment
Long-term needs of the electricity transmission grid in Northern Ireland out to 2040.

Figure 4: Related planning publications

2.4. Energy and climate policy

2.4.1. Net-Zero ambition

The United Kingdom's Climate Change Act set a legally binding target to reduce greenhouse gas emissions (GHG) by 100% by 2050, from 1990 levels. The Act requires the UK government to implement a system of carbon budgeting and form a Committee on Climate Change (CCC). Carbon budgets[12] provide legally binding limits on GHG emissions over a five year period. The CCC advises the government on setting carbon budgets and monitors progress against emissions targets.

Recent CCC advice to the UK government states that it is necessary, feasible and cost-effective for the UK to set a target of net-zero, or 100% GHG emissions reduction, by 2050[13]. This revision demonstrates the UK's commitment to targeting the highest possible ambition in line with the requirements of the Paris Agreement.

The Climate Change Act 2008 (2050 Target Amendment) Order 2019 came into effect on 27 June 2019. The net-zero emissions target covers all sectors of the economy and will be reflected in advice on future carbon budgets, starting with the sixth carbon budget (2033-2037).

12 UK Government, Guidance on carbon budgets
13 CCC, Net-Zero The UKs contribution to stopping global warming

2.4.2. The fifth carbon budget

The 5th Carbon budget[14] for the UK sets an emissions limit of 1,725 $MtCO_2e$. Each of the UK regions would reduce emissions aimed at achieving the overall UK target.

Northern Ireland's contribution to the fifth carbon budget (2028-2032) requires at least a 35% reduction of GHG emissions against 1990 levels by 2030[15]. Current projections suggest that Northern Ireland will miss this target unless policy gaps are addressed. The CCC have identified policy measures that have the potential to take Northern Ireland beyond the 35% target, instead achieving a 40% reduction by 2030. These measures, along with possible emission reductions, are shown in Figure 5.

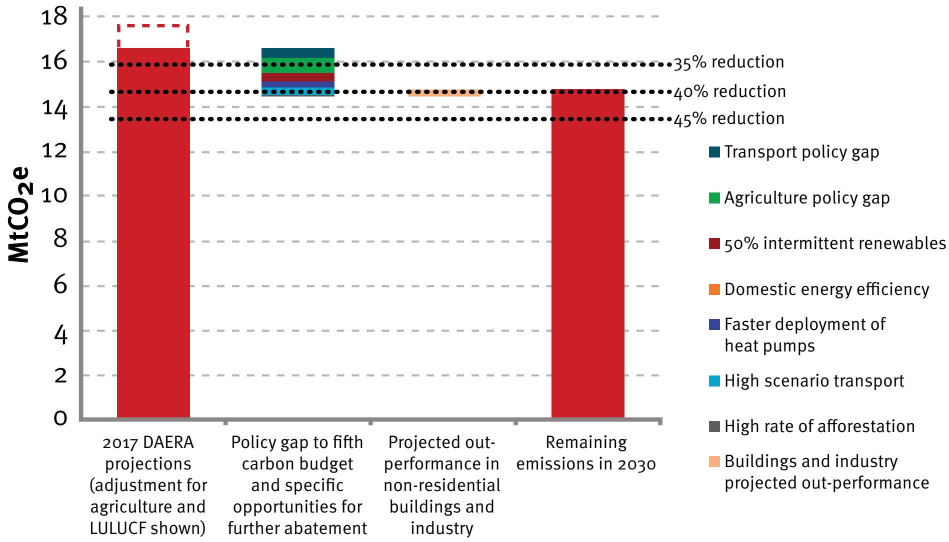


Figure 5: Policy gap to Northern Ireland's contribution to the fifth carbon budget and opportunities to go further. (reprinted with permission from the Committee on Climate Change (2019))

Policy measures related to electricity use are as follows:

- Low cost intermittent renewables,
- Low carbon heating,
- Energy efficiency in homes and businesses,
- Deployment of Electric Vehicles (EVs).

The Strategic Energy Framework (SEF) 2010-2020[16] includes a target of 40% of electricity consumption in Northern Ireland to be met from renewables by 2020. This Renewable Energy Source Electricity (RES-E) target is on track to be met if all projects with accepted grid connection offers become operational before 2020[7].

At present, Northern Ireland does not have a RES-E target for 2030. However, the CCC[17] suggests that 45% to 60% of electricity generated in the UK could be from renewable sources.

14 CCC, The fifth carbon budget
15 CCC, Reducing Emissions in Northern Ireland
16 DETI, Strategic Energy Framework
17 CCC, Reducing UK emissions 2018 progress report

The decarbonisation of heat is likely to be cost-effectively achieved through a combination of energy efficiency improvements and electrification[15]. These changes will contribute to achieving UK wide targets in buildings of 14% reduction in heat energy demand from 2016 to 2030 and for 25% of heat energy in 2030 to be supplied from low carbon technologies. Expansion of the gas grid is expected to support conversions from oil to gas with further potential for carbon abatement possible through the use of biogas.

The high share of households in Northern Ireland not connected to the gas network (76% in 2016) presents further abatement opportunities compared to the advice in the fifth carbon budget. Further annual emissions savings of 0.3 $MtCO_2$ could be achieved by converting an additional 25% of oil boiler heated homes to low carbon heating by 2030. The CCC recommends that Northern Ireland policy makers develop coordinated schemes that deliver improvements in both energy efficiency and low-carbon heat.

The CCC Reducing Emissions in Northern Ireland Report outlines that the transport sector has a target of 46% reduction in emissions by 2030. This target could be achieved by a 14% reduction in transport energy demand and reduction in the emissions intensity (gCO_2/km) of the transport fleet through electrification. Required levels of emissions reduction can be achieved, with EVs making up 60% of new cars and vans by 2030.

The CCC recommends that Northern Ireland policy makers remove financial barriers for the electrification of transport to help achieve the 60% target by 2030. Policy options include supports for charging infrastructure and financial incentives to purchase EVs along with transitioning the public sector fleet to EVs and other low emission vehicles.

2.4.3. Decarbonisation pathways

Varying GHG emission reduction outcomes by 2030 set Northern Ireland on different decarbonisation pathways toward 2050 and impact on what is possible over the long-term. In light of the UK's decision to target net-zero emissions by 2050, it is likely that the CCC's future advice on the sixth carbon budget will suggest a higher level ambition for Northern Ireland, potentially in line with a 45% reduction by 2030. Figure 6 shows decarbonisation pathways to 2030 for a range of credible GHG emission reduction levels between 35% and 45%.

Our scenarios are framed against the backdrop of Northern Ireland's changing climate and energy policy. The storylines and the underlying data reflect the sensitivity to the types and effectiveness of policy measures that may be introduced to achieve Northern Ireland's decarbonisation targets. Our scenarios use a composite approach where each scenario is an incremental increase in the uptake of low carbon technology in both the supply and demand side. The impact is that we achieve lower emissions through a credible range of outcomes for the electricity system. This credible range is captured in our inaugural set of Tomorrow's Energy Scenarios Northern Ireland.

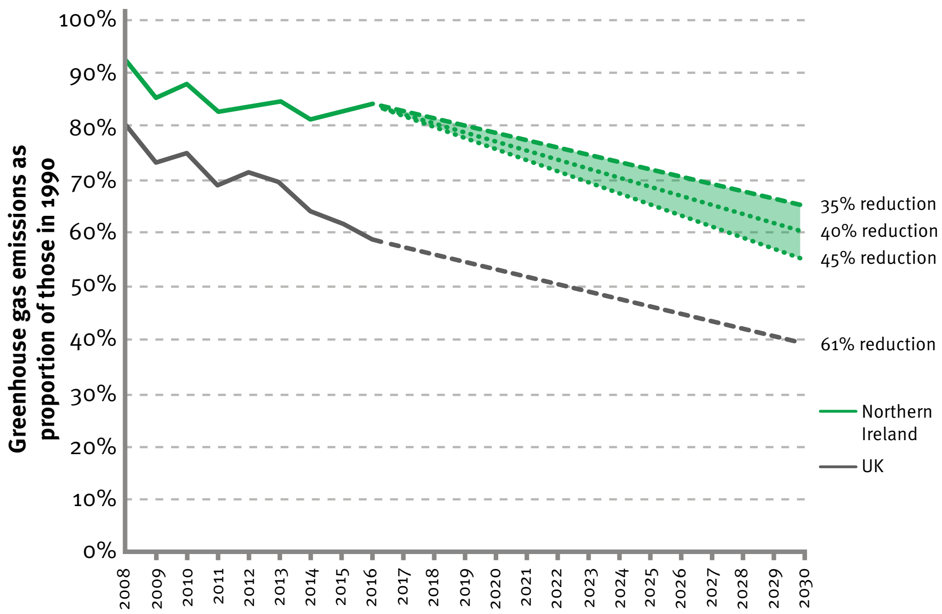


Figure 6: Potential emission reduction pathways for Northern Ireland (reprinted with permission from the Committee on Climate Change (2019))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3. Scenario storylines

3. Scenario storylines

SONI is pleased to present Tomorrow's Energy Scenarios Northern Ireland: three discrete scenarios that provide a range of credible outcomes for the electricity grid here. We aim to use these scenarios to demonstrate how Northern Ireland's energy transition may impact the electricity grid, and its use over time. Reducing power sector emissions is a strong theme within our storylines. We have developed the scenarios by mapping out projected levels of decreased emissions, based on the emissions reduction pathways shown in Figure 6. This provides each scenario with an interim GHG reduction aim for 2030.

Our scenarios share a close relationship with EirGrid's Tomorrow's Energy Scenarios[18]. The combined scenarios are used to create all-island power system models suitable for planning the system in the long term. However, different political, economic, social and technology drivers in Northern Ireland and Ireland have resulted in two sets of scenarios - one for each jurisdiction. This ensures flexibility to capture key differences in factors such as existing and future policies, electricity demand growth rates and varying levels of decarbonisation ambition. The relationship between SONI's and EirGrid's scenarios is shown in Figure 7.

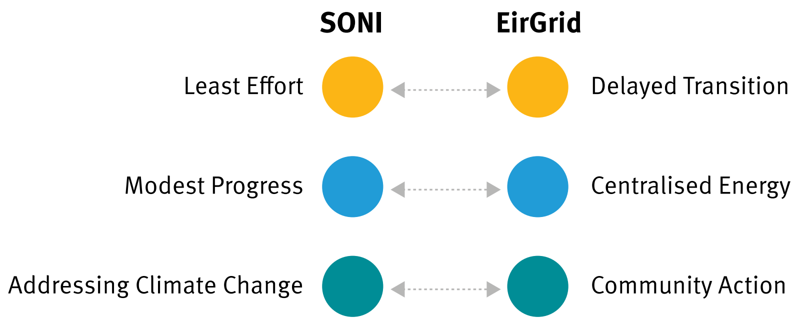

Figure 7: Relationship between SONI and EirGrid scenarios

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3.1. Least Effort

Least Effort is a scenario in which Northern Ireland reduces overall emissions by 35% and reaches 50% RES-E in 2030. The Least Effort scenario is defined by the key points below.

1. High electric vehicle prices and range anxiety result in a market share of 10%.
2. Fuel switching away from oil-fired boilers in households is restricted due to cost barriers and a lack of confidence in the heat pump technology resulting in 2030 targets being missed.
3. Renewable electricity growth is restricted due to a lack of financial supports. The renewable generation mix diversifies with growth in distribution connected onshore wind and solar PV.
4. Adoption of consumer-based smart technologies is slow, restricted by unfavourable economic conditions and cost barriers.
5. Rates of efficiency gains are low in this scenario as customers are not incentivised appropriately and the adoption of new technologies is slow.

3.2. Modest Progress

Modest Progress is a scenario in which significant decarbonisation progress is made in electricity, heat and transport helping Northern Ireland to reduce emissions by 40% and have 60% RES-E in 2030. The Modest Progress scenario features the following characteristics.

1. Economic conditions are favourable to stimulate increased demand for EVs. Policies and incentives help roll-out home charging infrastructure to accommodate the EV growth.
2. Driven by new builds and upgraded efficiency of existing housing stock, the quality of insulation improves and one in four oil-fired households transition to heat pumps by 2030.
3. Low electricity demand and high growth of renewable electricity generation leads to significant decarbonisation of the power sector.
4. New policies and cost reduction results in the growth of large scale onshore wind and solar PV driving down the carbon intensity of the power sector.
5. Climate change awareness leads to changes in consumer behaviour reflected in more efficient use of electricity. This is supported by smart metering and the growth of demand side management solutions.

3.3. Addressing Climate Change

Addressing Climate Change is a highly coordinated scenario in which well integrated government policies empower the UK to achieve net-zero emissions by 2050. Northern Ireland contributes to this by reaching RES-E levels of 70% and obtaining a 45% greenhouse gas reduction. The Addressing Climate Change scenario is characterised by the key points below.

1. Individuals and organisations commit to minimising climate change by choosing to adopt low carbon technologies to meet their transport and heating needs, leading to a rapid increase in the use of EVs and heat pumps.
2. Heat energy efficiency improves substantially due to changes in building regulations and high participation in retrofit schemes.
3. High conversion of oil-boiler to heat pump heating results in lower emissions in domestic buildings compared to the rest of the UK.
4. Policy measures and corporate Power Purchase Agreements (PPAs) stimulate growth in renewable generation leading to renewable generation targets being met, despite high electricity demand growth.
5. The renewable generation mix becomes diversified with growth in offshore wind, tidal, solar PV and onshore wind connections. The use of carbon capture technology contributes to reduced emissions.
6. Smart metering and internet of things (IoT) enable increased demand side flexibility and demand management whilst micro-generation and storage solutions facilitate high electricity self-consumption.

4. Scenario development

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4.1. Scenario framework

The scenario framework provides the high-level rules required for scenario building. These include:

- the defining design characteristics;
- the number of study years;
- the number of scenarios per study year.

When developing scenarios, we identify key factors that will influence the future usage of the electricity grid, such as location, size, quantity, type and/or pattern of electricity generation and/or consumption.

The characteristics selected for instructing the high-level design of TESNI 2019 are decarbonisation, decentralisation and digitalisation, due to their significant influence on the future electricity system.

Decarbonisation refers to the level of carbon abatement. A higher level of decarbonisation yields a lower carbon dioxide (CO_2) emissions level. Reducing electricity system CO_2 emissions can be achieved in a range of ways, such as the integration of renewables, the deployment of carbon capture and storage (CCS), and energy efficiency measures.

One of our scenarios explores what it would mean for the electricity sector to support Northern Ireland equitably contributing to the UK meeting net-zero greenhouse gas emissions by 2050. In order to do so, we assume that the electricity sector has the potential to become net-zero, therefore outperforming other sectors that are more difficult to decarbonise.

Decentralisation refers to the size and proximity of energy production in relation to the consumer. A higher level of decentralisation means that more energy will be produced by smaller scale units positioned close to consumers. This means generation is connected to the distribution network, with micro-generation playing a considerable role. A lower level of decentralisation means that more energy will be produced by larger scale units connected to the transmission system or dedicated cluster substations.

Digitalisation refers to the scale of the role played by digital technology and data. A higher level of digitalisation means more smart meters are deployed, contributing to a greater IoT network. This enables the optimised use of consumer-owned technologies, such as rooftop solar photovoltaics (PV) panels, EVs, and other appropriate residential loads (water, heating). For example, owners can coordinate the use of their devices to reduce electricity bills, while also offering services to the system operator(s), allowing for decentralised technologies to be harnessed in compliment with centralised technologies.

A mind map that illustrates the high-level interaction between the scenario design characteristics is shown in Figure 8.

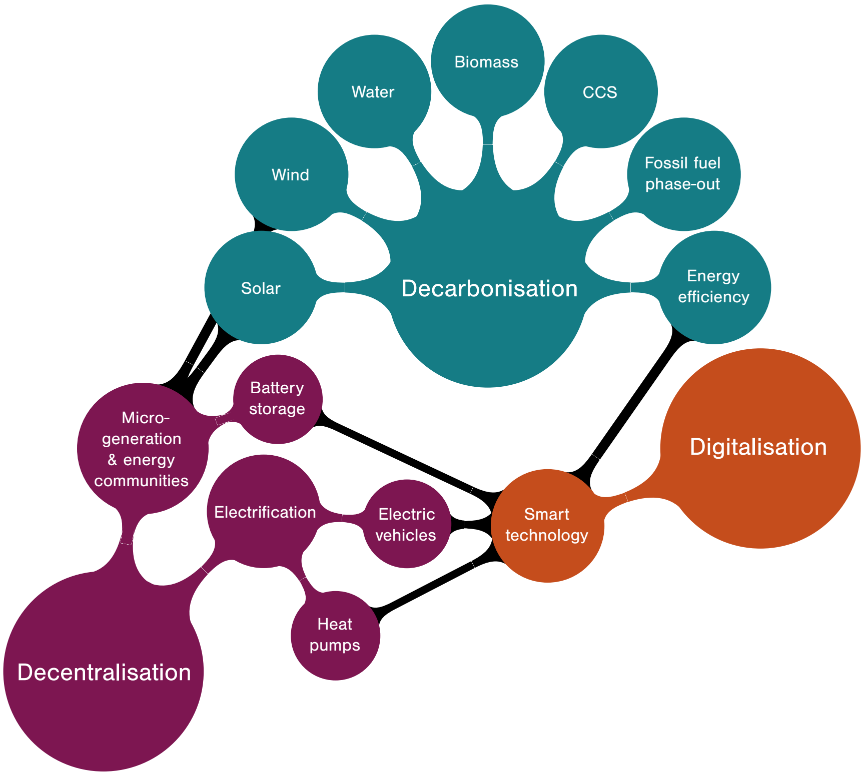

Figure 8: Scenario design characteristics

The evolution of scenarios across study years is shown in Figure 9. The principle behind the framework design aims to capture a broad range of possible futures relating to the composition of the future Northern Ireland energy system. The number of scenarios is constant at each time horizon. The increase in 'distance' between the scenario nodes further along the study horizon represents the growing differences between the scenarios over time.

The 2025–2040 timeframe is selected as it allows for the long-term needs of the electricity system to be adequately assessed, whilst also identifying potential pathways towards 2050 GHG emissions targets.

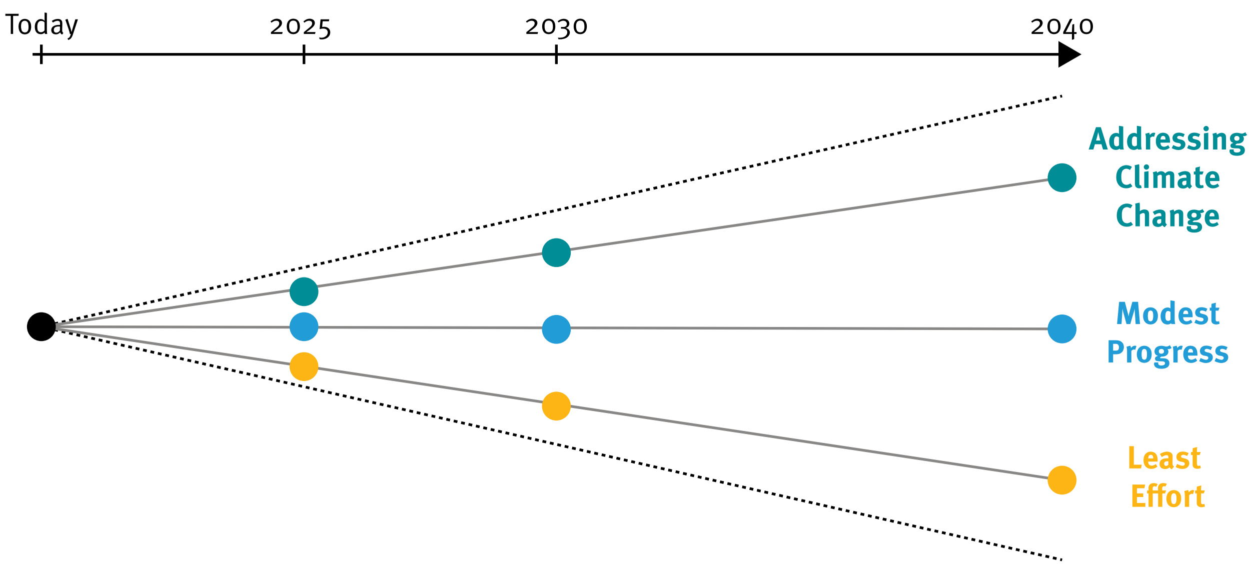

Figure 9: TESNI 2019 scenario evolution

A breakdown of the design characteristics for each scenario is shown in Table 1, summarising the high-level variations between the scenarios.

Table 1: Scenario design characteristic matrix

	Least Effort	Modest Progress	Addressing Climate Change
Decarbonisation	**Low**	**Medium**	**High**
Toward a zero-carbon electricity system by 2050	No	Progress made	Yes
Percentage RES-E in 2030	50%	60%	70%
Coal generation phase-out	Timely	Timely	Timely
Greenhouse Gas emissions reduction by 2030	35%	40%	45%
Carbon capture and storage	No	No	Yes [2040]
Energy efficiency gains	Low	Medium	High
Electrification of heat and transport	Low	Medium	High
Decentralisation	**Medium**	**Low**	**High**
Distribution-connected generation growth	Medium	Low	High
Self-consumption	Medium	Low	High
Enablers	**Low**	**Medium**	**High**
Demand-side flexibility	Low	Medium	High
Smart Meter uptake	Low	Medium	High

Translating the scenario design decisions into scenario storylines occurs via the use of political, economic, social and technological (PEST) analysis, which provides a mechanism to explore the enablers of a scenario. Coupled with the design characteristic matrix (Table 1), PEST analysis acts as a qualitative consistency check for the scenario storylines. PEST analysis is described in the bullet points below:

- Political refers to the energy and climate policy written into legislation and the policy measures used to facilitate the energy transition, such as regulation and financial instruments.
- Economic refers to the national economic growth assumed in the scenario, and the consumer spend.
- Social refers to the decisions taken by citizens, such as action taken to reduce individual carbon footprint and willingness to adopt new technologies.
- Technological refers to the technology options that feature in the clean energy transition mix, which out to 2040 includes a range of technology readiness levels.

5. Demand mix

5. Demand mix

As per the GCS, SONI forecasts that underlying electricity demand will grow steadily over the next ten years. However, variations in average temperatures, energy efficiency and economic factors could lead to an increase in the rate of demand growth or a decrease in demand growth. Over the long-term, electrification of heat and transport is expected to lead to increases in electricity demand.

Demand projections for each scenario are informed by historical energy balance data recorded at a national level and provided to the EU commission. SONI has referenced Northern Ireland statistical data based on relevant Department for the Economy[19] and Department for Business, Energy and Industrial Strategy[20] data sources. This Northern Ireland specific energy balance base line serves as an important reference point for future energy balance projections.

5.1. Energy efficiency

Energy efficiency refers to the implementation of energy saving measures, for example improvements in insulation, glazing, lighting and heating, among many others. Such measures can have added benefits such as improved thermal comfort, long-term energy cost savings, as well as reduced CO_2 emissions and energy imports.

Table 2 shows the range of year-on-year energy efficiency gains assumed. In Addressing Climate Change, more of the barriers to energy efficiency implementation, such as a lack of information, sufficiency incentives and access to capital, are overcome.

Table 2: Year-on-year energy efficiency gains

	Least Effort	Modest Progress	Addressing Climate Change
Residential	**Low**	**Medium**	**High**
Electrical appliances (%)	0.6	1.0	1.0
Thermal (%)	0.5	0.8	1.0
Commercial	**Low**	**Medium**	**High**
Electrical appliances (%)	1.0	1.0	1.5
Thermal (%)	0.5	0.5	0.8
Transport	**Low**	**Medium**	**High**
EV (%)	0.9	0.9	1.6
Industrial	**Low**	**Medium**	**High**
Aggregate (%)	1.0	1.0	1.0

5.1.1. Smart meters

The EU's Electricity Directive[21] requires member states to equip 80% of consumers with smart meters by 2020, where cost effective to do so. In Great Britain, the government has committed to offering every home and business a smart meter by 2020 as part of the Smart Metering Programme. So far the programme has delivered up to 8.71 million electricity smart meters[22].

19 Economy NI - Energy in Northern Ireland 2018
20 BEIS - Sub National Total Final Energy Consumption in the United Kingdom (2005-2016) "Sub-national total final energy consumption in the United Kingdom (2005 - 2016)"
21 EU Directive, 2009/72/EC
22 DBEI, Smart meter statistics quarterly report March 2019

There is currently no planned roll-out of smart meters in Northern Ireland. However, we have assumed that smart meters play an important role in the future consumption of electricity from 2025 onwards as the benefits of smart metering infrastructure in other jurisdictions leads to a change in Northern Ireland's policy position. The impact of smart metering on electricity use varies between scenarios resulting in different electricity consumption patterns. We will demonstrate this in the final TESNI 2019 report using net residential demand curves (time of day, week and season).

5.2. Residential and tertiary

Residential and tertiary (commercial businesses) electricity demand can be broken down into two components: (i) lighting and power, and (ii) any heating and cooling that have been electrified. Historically, heating/cooling has an energy demand five-fold higher than lighting and power[23]. Electric space heating comes in the form of direct electric, air-source heat pump, ground-source heat pump, and hybrid heat pumps. We focus on air source heat pumps as a low carbon solution that can help decarbonise Northern Ireland's heating demand, particularly oil dependent households.

5.2.1. Heat pumps

The energy demand from a heat pump is a function of the average heat demand from a dwelling and the efficiency of the heat pump (known as the coefficient of performance (COP)).

The air source heat pump COP assumptions, which are fixed across scenarios, are given in Table 3.

Table 3: Air source heat pump coefficient of performance

	2015	2020	2025	2030	2040
COP	2.20	2.31	2.43	2.54	2.77

The number of residential air source heat pumps assumed is shown in Figure 10. In Addressing Climate Change, we assume 123,000 homes will have installed heat pumps by 2030 driven by standards for low-carbon heat in new buildings and retrofits to existing homes.

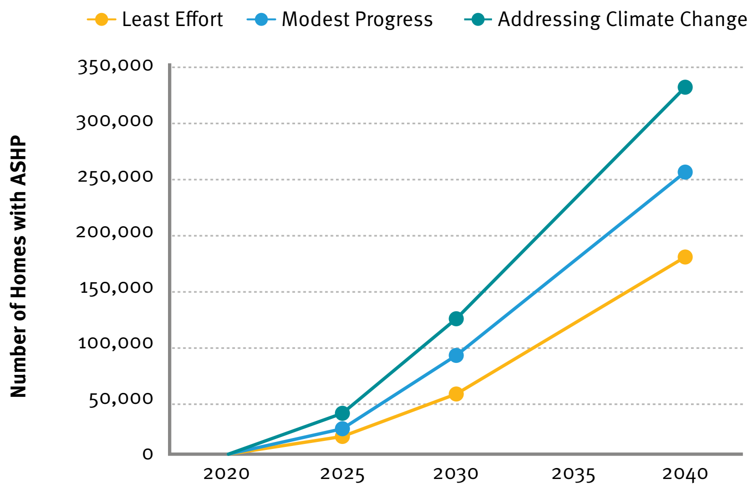

Figure 10: Number of air source heat pumps in the residential sector

23 European Commission, Energy Demand for Heating and Cooling in European Countries, 2012

5.3. Transport

5.3.1. Electric vehicles

The electricity demand from transport is a function of the types of transport that are electrified (motorcycles, cars, vans, buses, freight, and rail), the distance and type (urban, rural and motorway) of travel by citizens, and the efficiency of electric mobility technologies.

We focus on EV uptake in passenger transport (cars and vans). We will continue to monitor the potential electrification of buses, rail and freight.

The efficiency of EVs is assumed to improve over time, leading to a higher distance travelled per unit of electricity input, known as specific consumption. Table 4 shows our EV consumption assumptions.

Table 4: EV specific consumption (kWh/100 km)

	2020	2025	2030	2035	2040
Least Effort	19.13	18.28	17.47	16.70	15.96
Modest Progress	19.13	18.28	17.47	16.70	15.96
Addressing Climate Change	18.99	17.52	16.16	14.91	13.75

We assume a variation of EV uptake across scenarios to represent the range of possible rates of EV adoption, as shown in Figure 11. Higher levels of uptake are promoted by falling EV costs and an assumed ban on the sale of new fossil fuelled cars by 2040.

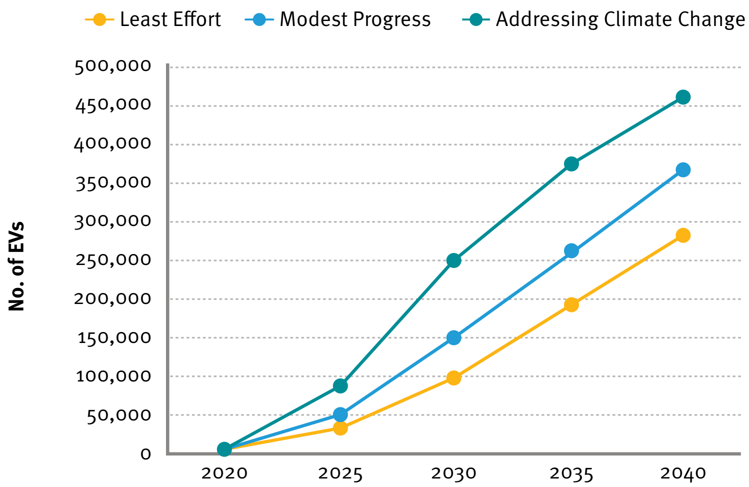

Figure 11: Number of passenger electric vehicles (cars, vans, motorcycles)

5.4. Industrial

Final use electricity demand in Northern Ireland's industrial sector is made up from various sub-sectors such as; agri-food production; quarrying and mining; manufacture of glass and building materials; agriculture, forestry and fisheries; wood and wood products; paper, pulp and print; transport equipment; textile and leather; and construction, among others. The extent of industrial demand electrification in each scenario is shown in Figure 12.

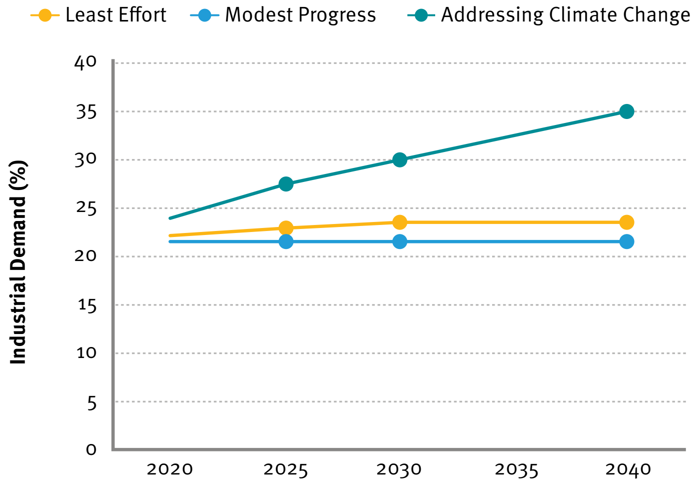

Figure 12: Electrification of industrial demand

5.5. Total Electricity Requirement

Total Electricity Requirement (TER) is the sum from electricity demand for the residential, tertiary and industrial sectors, including electricity that is produced by micro-generators operated and owned by home and business owners. TER also includes power system losses that are calculated to be approximately 8% of final use demand. Micro-generators can contribute to system power losses when they export surplus energy.

Figure 13 illustrates how demand is built up from the various components with demand growth from 2025 primarily driven by the electrification of heat and transport. Addressing Climate Change experiences significant levels of demand growth in the period to 2030 as a result of strong electrification.

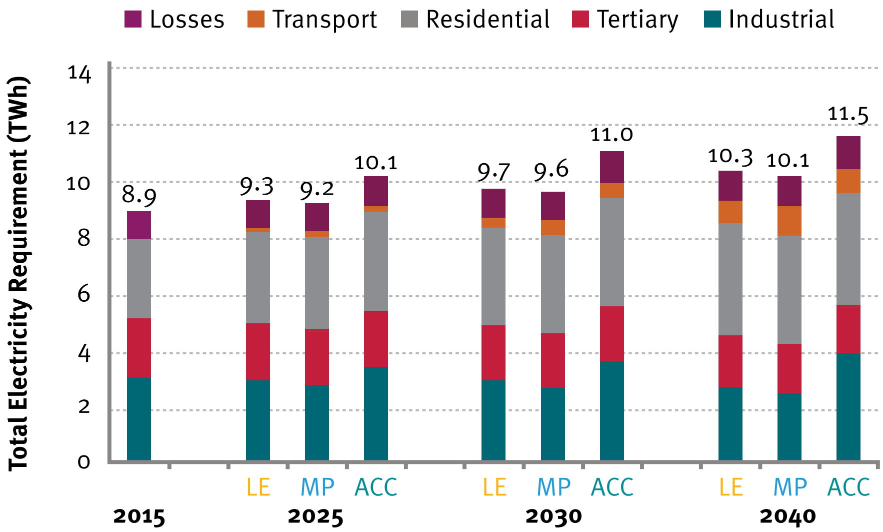

Figure 13: Annual total electricity requirement[24]

24 Appendix Summary Tables

6. Generation mix

6. Generation mix

Growth of renewable energy sources (RES) in Northern Ireland has displaced conventional fossil fuel generation in recent years, driving a 30% reduction in the carbon-intensity of electricity generation from 2006 to 2016 , as per the CCC. Emissions from the power sector must continue to fall through the 2020s and beyond, for Northern Ireland to contribute towards the new UK 2050 Net-Zero target.

The SEF 2010 has been a successful mechanism supporting the integration of renewable electricity with Northern Ireland on track for 40% RES-E by 2020. Long-term support for, and cost reduction in, low carbon technology is critical to the ongoing expansion of RES ensuring developer certainty and a route-to-market for lowest-cost renewable generation. A new energy strategy will replace the current SEF 2010 and is expected to provide a road map for emissions reductions in the power sector out to 2050.

Our scenarios provide credible envelopes for the generation mix in Northern Ireland out to 2040. Our assumed generation portfolios are informed by the CCC's recommended principles and policies for power sector decarbonisation, market trends and plans to decommission existing plant.

6.1. Renewables

6.1.1. Onshore wind

Onshore wind is the most common renewable generation technology in Northern Ireland contributing 30.7% of the total electricity supplied in 2018[7]. Onshore wind generation is comprised of a combination of large scale wind farms connected to the transmission and distribution grids and micro-generation connected to the low voltage grid.

The overall installed capacity is forecast to reach 1,400 MW in 2020 based on connected and contracted wind farm connections.

Least Effort and Modest Progress assume that grid connections of onshore wind generation accelerate post 2025 due to the positive economic conditions. Addressing Climate Change assumes the highest connection rates over the next decade due to earlier introduction of supports and growth in power purchase agreements. Onshore wind installed capacities for each scenario out to 2040 are shown in Figure 14.

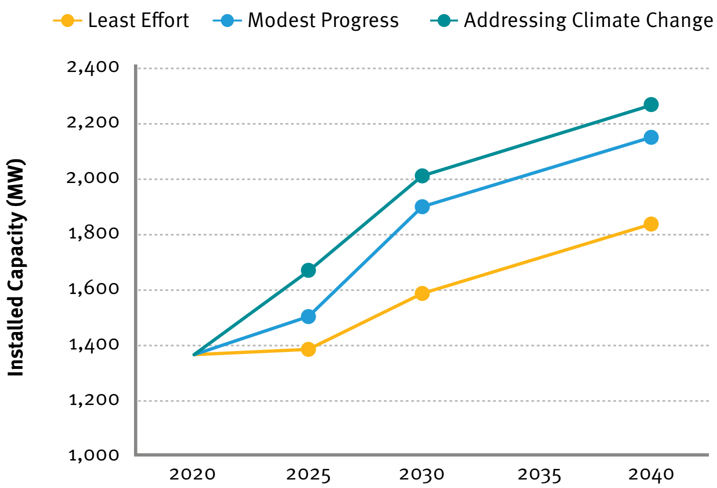

Figure 14: Onshore wind installed capacity

6.1.2. Offshore wind

There are currently no offshore wind generation connections forecast in Northern Ireland. Plans for the County Down offshore wind farm were cancelled in 2014.

According to the CCC, current estimates for offshore wind costs are below £70/MWh by 2025. We assume that the growth of offshore wind is required in Addressing Climate Change before 2030 in order to move towards a net-zero electricity system by 2050. Installed capacities in each scenario for offshore wind are shown in Figure 15.

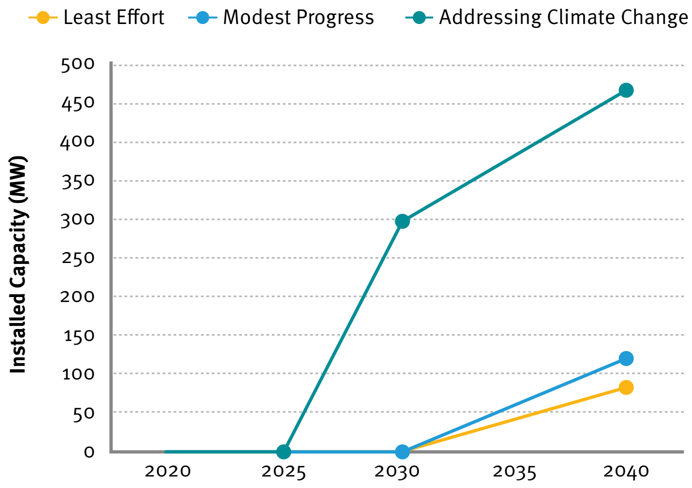

Figure 15: Offshore wind installed capacity

6.1.3. Solar photovoltaics

There is approximately 220 MW of Solar PV generation capacity connected in Northern Ireland at present according to the GCS. Just over half of this capacity is large scale PV connected to the distribution or transmission grid, with the remainder being micro-generation solar PV mainly situated on rooftops.

The total solar PV capacity, including micro-generation, is shown in Figure 16. The largest growth in solar PV occurs in Addressing Climate Change, with the highest rate of increase between 2020 and 2025.

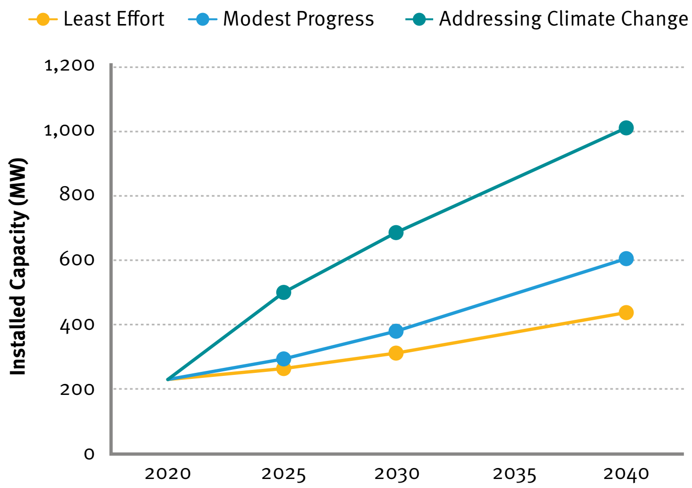

Figure 16: Solar PV installed capacity

6.1.4. Micro-generation

The Micro-NIRO[25] mechanism encouraged the use of renewable generation with a capacity of less than 50 kW to connect to the grid as part of the Northern Ireland Renewable Obligation scheme. The Micro-NIRO includes technologies such as wind turbines, hydro and solar PV. The Micro-NIRO helped rooftop solar PV become one of the most prominent forms of micro-generation, leading to an installed capacity of around 100 MW in Northern Ireland.

Micro-generation functions as a self-consumption technology in some applications, allowing home and business owners to meet some of their own electricity demand. The effect of the self-consumption is that electricity demand may reduce on the transmission and distribution system.

The installed capacity of micro-generation solar PV projected in each scenario is shown in Figure 17.

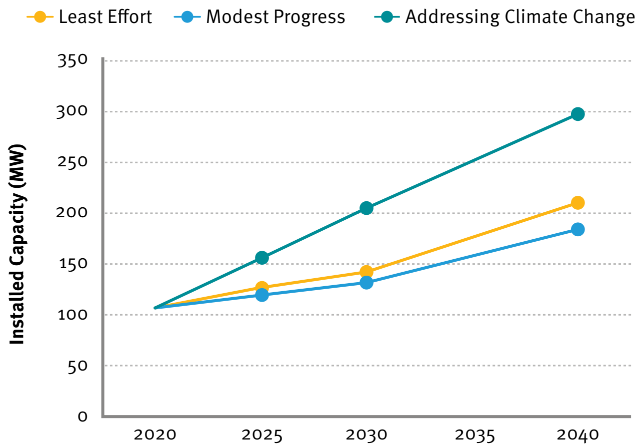

Figure 17: Micro-generation solar PV installed capacity

6.1.5. Biomass and waste

In Northern Ireland, we estimate there to be 62 MW of generation capacity powered by biomass, biogas and landfill gas, and 15 MW of waste. This is highlighted in the GCS. For biomass, we assume a modest growth in biomass CHP, and that all biomass generation meets sustainability criteria. We have assumed that additional waste units will become operational over time in each scenario.

Figure 18 shows the cumulative installed capacity from biomass and waste for the three scenarios out to 2040.

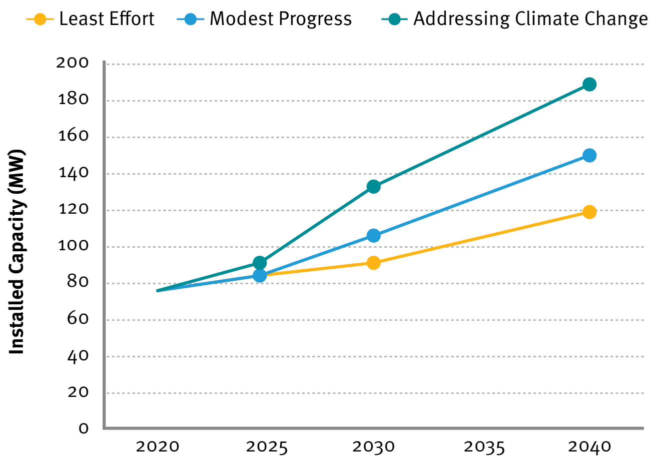

Figure 18: Biomass and waste installed capacity (including biogas and landfill gas)

25 OFGEM, Micro generators in Northern Ireland

6.1.6. Marine

The Crown Estate has previously awarded development rights off the north coast of Northern Ireland for two tidal energy projects. Although no grid connection offers are in place for these projects, we assume that these developments are underway by 2030 in all scenarios. Figure 19 shows the capacities assumed out to 2040.

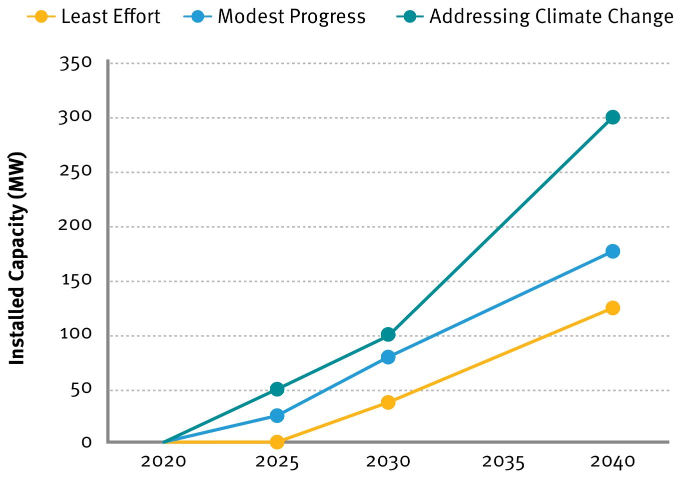

Figure 19: Marine (wave and tidal) installed capacity

6.1.7. Hydro Small Scale

The capacity of small scale Hydro in Northern Ireland is approximately 6 MW and consists primarily of a large number of small run-of-the-river projects. While hydro is a well developed renewable technology, the lack of suitable new locations in Northern Ireland brings limitations. Therefore 6 MW is assumed across the scenarios from 2025 to 2040.

6.1.8. RES-E

The following assumptions are taken for calculating RES-E.

Technologies included in the numerator include:

- Renewable generation (wind, water, solar, biomass). Waste is assumed to be 50% renewable.
- Power to gas (from renewables).

The capacity factors assumed are shown in Table 5.

Table 5: Average renewable resource capacity factors
(historical dispatch average used for biomass and waste)

Technology	Onshore wind (existing)	Onshore wind (new & repowered)	Offshore wind	Solar PV	Biomass & waste	Marine (wave & tidal)
Capacity factor (%)	31	35	45	11	85	26

For calculating RES-E from the portfolio, a dispatch-down (curtailment and constraint[26]) factor of 8% is assumed. Figure 20 highlights the respective RES-E percentage for each scenario over the time horizon to 2040.

26 EirGrid and SONI, Annual Renewable Energy Constraint and Curtailment Report 2017

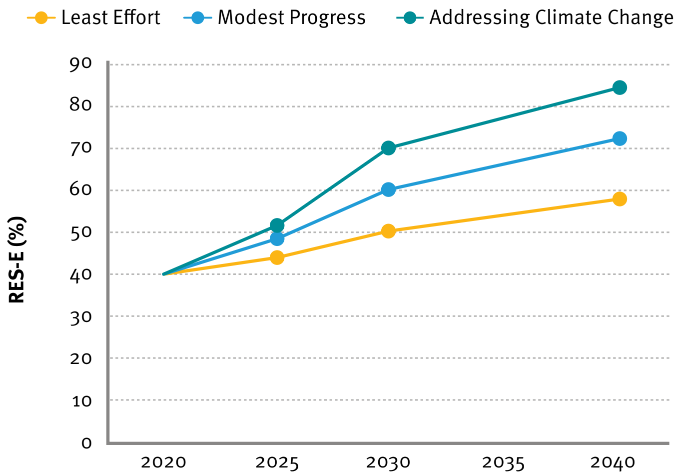

Figure 20: Electricity sourced from renewable energy sources

6.2. Fossil fuels (non-abated and abated)

Fossil fuel generation has been the foundation of the industrial revolution. However, there is a global awakening to the effect that fossil fuel based emissions are having on our health and climate. Major technological advancements have resulted in renewable generation technology being increasingly cost competitive with fossil fuel based generation.

A major advantage of fossil fuel generation is that it produces a dependable supply of electricity. Fossil fuel plants are flexible and fully dispatchable; this type of generation can provide security of supply when wind and solar resources are not available. Current and future trends suggest more integration of renewable generation is needed if decarbonisation targets are to be met. As a consequence the running hours or capacity factors of fossil fuel generation will continue to reduce.

To ensure that power system security of supply standards are met, I-SEM auctions for capacity allow fossil fuel plants with low capacity factors to recover costs. For the 2019/2020 T-1 capacity auction[27], 84% of the de-rated capacity was provided by gas and steam turbines, the remainder, in descending order, coming from interconnection, demand-side units, pumped hydroelectric storage, hydro and wind. The output from the auctions and de-rating factors are considered with the framework of the scenarios to ensure that the scenarios supply and demand are met for each hour according to the security of supply standards.

The following sections will describe how fossil fuel technologies are considered within each scenario.

6.2.1. Coal

Historically, coal generation has provided consistent baseload power in Northern Ireland. Coal power generation is a high emissions technology. Current legislation and high retrofit costs mean that it is expected to cease operation by 2024. This is reflected in our scenarios with no coal generation assumed in study years 2025, 2030 or 2040.

6.2.2. Oil

Typically oil generation provides peaking capacity to the system. The overall capacity of distillate oil generation is expected to reduce over the next two decades. The timing of changes to the oil fleet varies depending on the scenario storyline, changes in the peak demand and availability of alternative peaking capacities such as battery technologies, demand side response, interconnection or other flexibility options.

27 EirGrid and SONI, Quick Guide to the 2019/2020 T-1 Capacity Auction Results

In Addressing Climate Change, two of the five existing distillate oil units are assumed to be still in operation by 2030. Least Effort and Modest Progress assume that by 2030 three and four units remain respectively. By 2040 all distillate oil generation is assumed to have ceased operation.

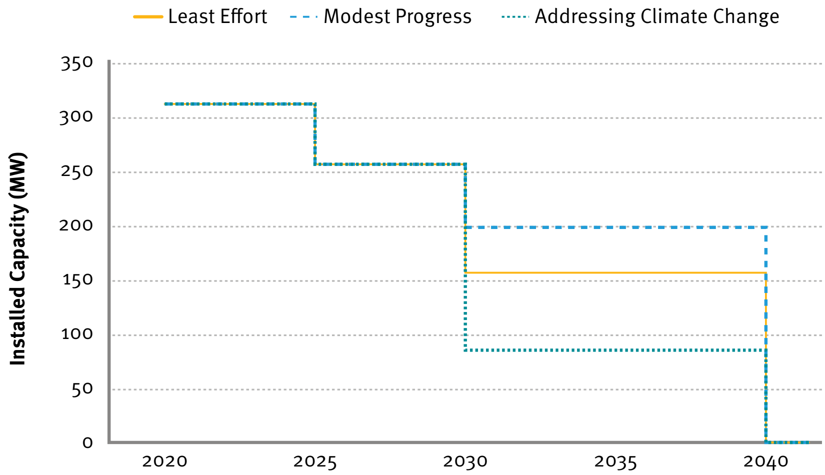

Figure 21: Distillate oil generation installed capacities

6.2.3. Gas

Gas fuelled power stations are a lower carbon alternative to coal-fired power stations. Fuel price forecasts, such as the IEA WEO 2018 Sustainable Development Scenario[28], show that low carbon scenarios result in increased carbon costs. This makes gas power generation more cost effective than coal power stations for baseload generation. Gas is often viewed as a transition fuel in the pathway to a low carbon economy. Gas power plants will continue to have a strong role in maintaining the demand and supply balance within the context of Northern Ireland's scenarios out to 2040.

In 2018, the gas-fired generation was 45.6% of the overall fuel mix[29]. Gas-fired generation consists of combined cycle gas turbines (CCGTs), open cycle gas turbines (OCGTs) and CHP. Gas-fired generation will operate to ensure security of supply in Northern Ireland following planned closures of major coal-fired units. Flexible gas-fired generation is also expected to help manage the integration of high levels of intermittent renewables.

Figure 22 shows that new OCGT capacity is assumed to be installed by 2030 in all scenarios.

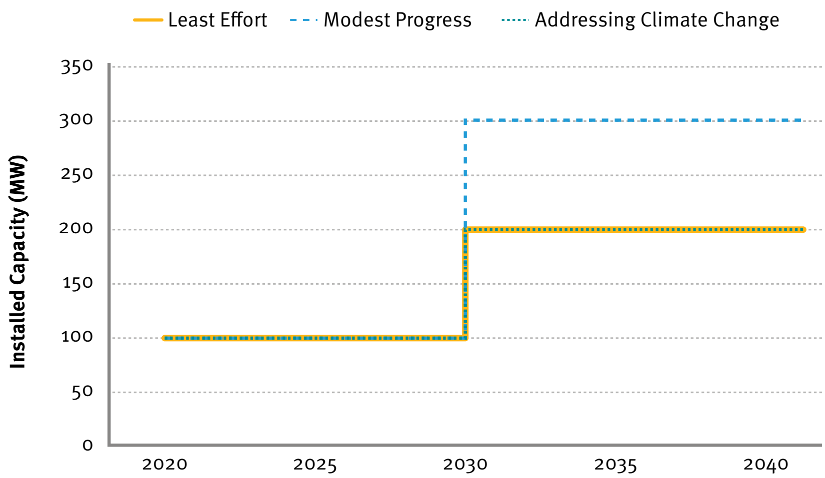

Figure 22: OCGT installed capacity

28 IEW WEO 2018 - https://www.iea.org/weo2018/
29 EirGrid Group, System and Renewables Reports

A new 500 MW CCGT is assumed to connect in Least Effort and Addressing Climate Change as shown in Figure 23.

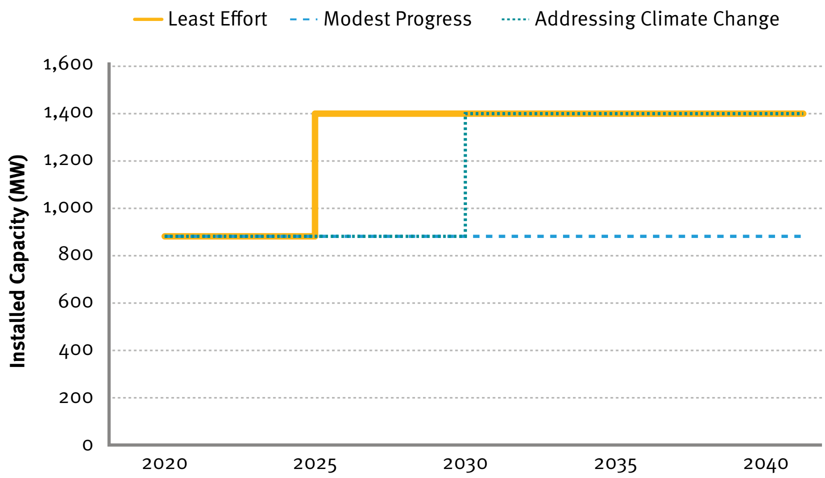

Figure 23: CCGT installed capacity

6.2.4. Carbon capture and storage

CCS is the process of capturing, transporting and storing carbon dioxide before it is released into the atmosphere. CCS is a technology which may be required to take the power system to net-zero emissions. The economics of CCS mean that a high utility of the CCS process is required, along with a suitable infrastructure to store the compressed gas. Up to 100% of emissions released from burning fossil fuels in generation can be captured from the flue. Carbon transportation is via pipeline or ship, with geological formations, such as depleted oil and gas fields, acting as storage sites. The CCC has recommended that carbon capture technology is investigated as a potential method for decarbonising Northern Ireland's power sector.

In the electricity sector, it is assumed that CCS is deployed on new or existing CCGTs[30]. We assume that CCS is operational in Addressing Climate Change by 2040, capturing emissions from 50% of the gas generation fleet.

The delayed or non-deployment of CCS in Least Effort and Modest Progress reflect uncertainty factors regarding what policy, regulatory, legal and business model frameworks make CCS commercially viable[31].

30 Ervia, CCS
31 IEA, Five Keys to Unlock CCS Investment

7. Non-generation flexibility mix

7. Non-generation flexibility mix

7.1. Interconnection with neighbouring systems

Interconnection allows the transport of electricity between two transmission systems. It can provide multiple benefits, such as renewable integration, wholesale electricity price reduction, adequacy improvement, as well as a source of reserve.

Northern Ireland has existing interconnector ties to Ireland that use high voltage alternating current (HVAC). The North South Interconnector project[32], planned for 2023, would increase the total transfer capacity between Northern Ireland and Ireland to approximately 1,100 MW. We assume that the current 500 MW HVDC interconnector with Scotland remains operational beyond 2040 in all scenarios. No additional HVDC interconnection is assumed.

7.2. Storage

A sizeable range of storage technologies exist. For TESNI 2019, storage is categorised in a generalised manner, placing the focus on the use(s) of the storage mix, as outlined in Table 6. The exact breakdown of storage installed capacity (MW) and energy storage volume (MWh) will be determined from the dispatch modelling to be conducted before the final publication of TESNI 2019.

Table 6: Storage uses

Use	Note	Typical Duration (h)	Grid Location
Adequacy and flexibility	Security of supply and net load ramp management.	1–6	Transmission and distribution
Reserve	Frequency containment and restoration.	0.5	Transmission and distribution
Self-consumption	Battery storage coupled with micro-generation.	2.5	Low voltage

7.2.1. Seasonal storage

In the longer term, seasonal storage will play an important role in electricity systems with high levels of weather-dependent generation.

Power to Gas (PtG) is the process of using renewable electricity to produce hydrogen, or in a consecutive step, using the hydrogen with carbon dioxide to produce methane. Such developments may allow for the seasonal storage of gas produced from renewable electricity.

The share of methane (CH_4) and hydrogen (H_2) sourced from PtG is given in Figure 24. Addressing Climate Change has the highest shares of PtG due to a higher consumer demand for renewable gas in heating and transport.

32 EirGrid Group, North South 400 kV Interconnection Development

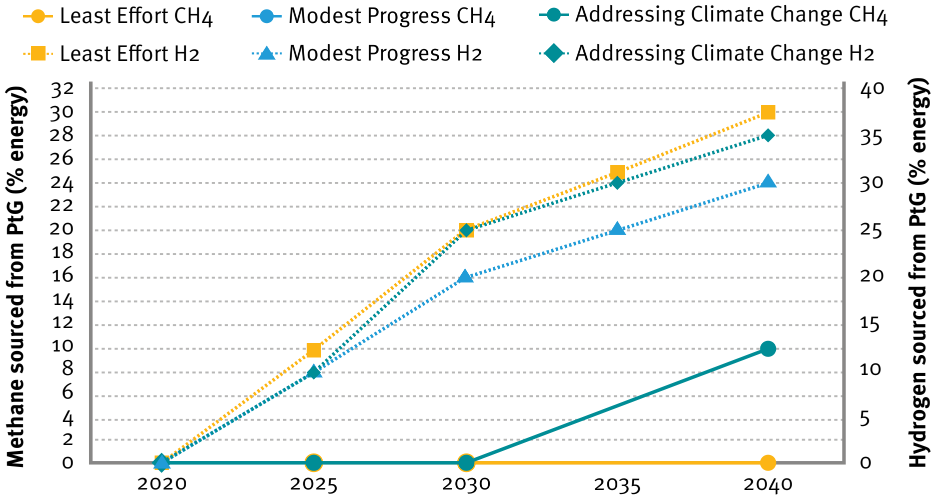

Figure 24: Proportion of methane supplied by power to gas

7.3. Demand side management

As with energy storage, there are a range of technologies which can deliver demand side management (DSM), for a number of uses. For DSM, two categories are proposed, as shown in Table 7. The exact breakdown of DSM installed capacity will be determined from the dispatch modelling to be conducted before the final publication of TESNI 2019.

Table 7: DSM categories

Category	Note	Typical Duration (h)	Grid Location
Demand reduction	Consumption capable of reducing for a period of time, e.g. a DSU.	3	Transmission and distribution
Demand shifting	Consumption that can be moved to another moment within the day, subject to comfort constraints, e.g. EV charging.	1-12	Low voltage

8. Locations

8. Locations

This section outlines the assumptions regarding where various demand and generation technologies may connect in the future. Modelling future locations is a key feature of the scenarios. Understanding the locational aspect of generation and demand provides insight into potential areas of stress on the network that require further investigation by SONI.

8.1. Northern Ireland's regions

SONI uses planning areas, or regions, to help communicate the development of the transmission system in Northern Ireland, as highlighted in the TDPNI. Two different regions have been identified:

- The North and West; and
- The South-East.

Both regions are illustrated in Figure 25 and are used in this chapter to display locations assumptions for different technologies.

Figure 25: Northern Ireland's regions.

8.2. Locations storylines

Assumptions relating to future generation and demand locations are linked to the scenario storylines.

Least Effort

Generation locations become more decentralised with an increase in small scale RES connecting to the distribution grid. This means that generation units are positioned closer to demand locations and urban centres. Quantities of new micro-generation locations, mostly in the form of rooftop solar PV, are moderate in this scenario.

The diversity of demand changes at a slow pace. This slow transition towards electrified heat and transport limits the quantity and scale of new demand locations.

Modest Progress

Recent trends in renewable generation connections continue, with large scale onshore wind generation mostly connecting to locations on the transmission grid with good levels of wind resource. This centralised scenario experiences relatively low levels of micro-generation growth and the fewest number of renewable generation connections to the distribution grid.

Step changes in the uptake of electrified heat and transport drives more diversity in electricity demand. Heat pumps locations are largely limited to new housing builds and electric vehicle demand grows relative to existing residential and commercial demand.

Addressing Climate Change

The scale and diversity of renewable generation is highest in this scenario. There is a sharp increase in the number of RES locations due to growth in offshore wind, tidal, solar PV and onshore wind generation. The scale and quantity of distribution connected RES and micro-generation is highest in this scenario.

Heat pump locations are most numerous in this scenario due to uptake in new homes and conversions of existing oil heated homes. There is an increase in both the concentration and dispersal of heat pump electricity demand. Electric vehicle uptake is assumed to occur consistently across the grid on a per capita basis. The amount of electricity demand from EVs is highest in this scenario both at a local and aggregated level.

8.3. Generation locations

Future generation locations are modelled predominantly based on connection applications. Data contained within connection applications, and the observed connection patterns in recent years, are used to estimate potential future connection patterns and the locations on the grid that might experience changes in installed generation capacity.

There are no connection applications for offshore wind generation currently in process. Assumptions for future locations of offshore wind farms are based on the offshore renewable energy strategic action plan[33].

The regional distribution of onshore wind, offshore wind and solar PV installed capacity is shown in Table 8 for each scenario and year up to 2040.

Table 8: Onshore wind, offshore wind and solar PV capacity locations (MW)

		2025			2030			2040		
		LE	MP	ACC	LE	MP	ACC	LE	MP	ACC
Onshore wind	North & West	1,248	1,279	1,361	1,303	1,546	1,614	1,484	1,755	1,796
	South-East	140	207	297	284	348	398	354	391	475
Offshore wind	North & West	0	0	0	0	0	0	0	0	0
	South-East	0	0	0	0	0	295	83	117	465
Solar PV	North & West	37	69	203	62	122	323	110	259	534
	South-East	245	246	302	263	265	363	323	336	478

33 Offshore renewable energy strategic action plan, DETI.

8.4. Demand locations

Electrification of heat and transport influences the future locations of electricity demand. Electricity demand forecasts and regional population projections are used to determine future locations of EV and heat pump demand. Regional population projections[34] are assumed to indicate locations of new housing developments that are likely to be fitted with low carbon heating technologies such as heat pumps.

The regional distribution of EV and heat energy demand is shown in Table 9 for each scenario and year up to 2040.

Table 9: EV and heat pump annual energy demand locations (TWh) locations

		2025			2030			2040		
		LE	MP	ACC	LE	MP	ACC	LE	MP	ACC
Electric vehicles	North & West	0.051	0.083	0.083	0.141	0.217	0.220	0.321	0.422	0.344
	South-East	0.077	0.124	0.124	0.209	0.323	0.328	0.478	0.630	0.513
Heat pumps	North & West	0.040	0.065	0.080	0.055	0.087	0.099	0.118	0.159	0.134
	South-East	0.148	0.239	0.312	0.224	0.356	0.465	0.639	0.864	1.134

34 Population projections for areas within Northern Ireland, NISRA.

9. Next steps

9. Next steps

We look forward to receiving your feedback on Tomorrow's Energy Scenarios Northern Ireland 2019 Consultation. Feedback received will be used when developing the final TESNI 2019 publication, the associated dispatch modelling and the subsequent system needs report.

9.1. Dispatch assumptions

The proposed dispatch-modelling approach for operational constraints in TESNI is to determine what set of constraints facilitate the RES-E levels presented (see Section 6.1.8 for RES-E assumptions). While these constraints may not be those that ultimately transpire in future years, this method aims to provide a starting point to facilitate discussion regarding the innovation required to integrate high shares of renewable electricity.

Current operational constraints, such as the system non-synchronous penetration (SNSP) limit and the minimum number of conventional generation units online, will be examined to see which constraints may need to change to deliver higher RES-E levels.

9.2. How to respond to the consultation

To respond to the consultation please use the consultation response form which is available for download on the Energy Future Web page[35]. **Please follow the return instructions provided within the form**.

We look forwarding to engaging with you as part of TESNI 2019 scenario development, and thank those who have provided their insight to date.

For more information on TESNI, please visit our Energy Future Web page[35]. Alternatively, you can email your views on TESNI to: **scenarios@soni.ltd.uk** and one of our team will be in touch.

35 www.soni.ltd.uk/customer-and-industry/energy-future/

Appendix – Summary tables

Appendix – Summary tables

The following tables summarise the key generation and demand components for TESNI 2019 scenarios.

Table 10: Generation mix summary (MW)

Technology	2025			2030			2040		
	LE	MP	ACC	LE	MP	ACC	LE	MP	ACC
OCGT (gas)	101	101	101	201	301	201	201	301	201
OCGT (DO)*	258	258	258	158	200	84	0	0	0
CCGT**	1,400	900	900	1,400	900	1,400	1,400	900	1,400
CHP**	0	0	0	0	0	0	0	0	0
Coal	0	0	0	0	0	0	0	0	0
Peat	0	0	0	0	0	0	0	0	0
Renewables	1,759	1,915	2,308	2,048	2,469	3,234	2,608	3,194	4,242
Total (MW)	**3,515**	**3,171**	**3,565**	**3,804**	**3,867**	**4,916**	**4,205**	**4,392**	**5,810**

*Distillate oil. ** Includes abated and non-abated generation.

Table 11: Renewable generation mix summary (MW)

Renewables	2025			2030			2040		
	LE	MP	ACC	LE	MP	ACC	LE	MP	ACC
Onshore wind	1,388	1,486	1,658	1,587	1,895	2,012	1,839	2,145	2,270
Offshore wind	0	0	0	0	0	295	83	117	465
Solar	282	315	505	325	388	687	434	595	1,012
Biomass*	83	83	89	90	105	134	121	151	189
Hydro	6	6	6	6	6	6	6	6	6
Marine **	0	25	50	40	75	100	125	180	300
Total (MW)	**1,759**	**1,915**	**2,308**	**2,048**	**2,469**	**3,234**	**2,608**	**3,194**	**4,242**

*Including renewable waste, biogas and landfill gas. **Tidal and wave.

Table 12 : Demand mix summary (TWh)

	2025			2030			2040		
	LE	MP	ACC	LE	MP	ACC	LE	MP	ACC
Transport	0.1	0.2	0.2	0.4	0.5	0.5	0.8	1.1	0.9
Residential	3.2	3.3	3.5	3.5	3.5	3.8	4.0	3.9	4.0
Industry	2.9	2.7	3.3	2.8	2.6	3.5	2.6	2.4	3.8
Tertiary	2.0	2.0	2.0	2.0	1.9	2.0	1.8	1.8	1.7
System Losses**	1.0	1.0	1.1	1.0	1.0	1.1	1.1	1.0	1.2
TER*	9.3	9.2	10.1	9.7	9.6	11.0	10.3	10.1	11.5

*Total Energy Requirement. **Losses include Distribution, Transmission and Energy Branch Losses

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