Tomorrow's Energy Scenarios 2019 Ireland

Planning our Energy Future

EIRGRID

The current. The future.

Disclaimer

EirGrid has followed accepted industry practice in the collection and analysis of data available. While all reasonable care has been taken in the preparation of this data, EirGrid is not responsible for any loss that may be attributed to the use of this information. Prior to taking business decisions, interested parties are advised to seek separate and independent opinion in relation to the matters covered by this document and should not rely solely upon data and information contained herein. Information in this document does not amount to a recommendation in respect of any possible investment. This document does not purport to contain all the information that a prospective investor or participant in the Single Electricity Market may need.

For queries relating to this document please contact: **scenarios@eirgrid.com**.

Published October 2019.

COPYRIGHT NOTICE

The Oval, 160 Shelbourne Road, Ballsbridge, Dublin 4, D04 FW28, Ireland.

Table of contents

Foreword

EirGrid, as transmission system operator for Ireland, is pleased to present Tomorrow's Energy Scenarios 2019.

Our revised scenarios set out three credible pathways for how the power system may transform over the next 20 years to 2040.

Our scenarios are framed against the backdrop of clear direction on climate and energy policy that will accelerate Ireland's transition toward cleaner, low carbon technologies. The European Union has set ambitious targets for decarbonisation and for renewable energy for the electricity sector in 2030. This ambition is reflected in Ireland's national policy, with the Climate Action Plan outlining commitments to achieving a target of 70% of electricity from renewable sources by 2030. This represents a significant change for the electricity industry and for EirGrid. It is an opportunity to create a sustainable electricity system that will meet the needs of future generations. EirGrid is committed to doing its part in supporting and delivering on the ambitions of Government energy policy.

In acknowledging that there is no single pathway to achieving climate and energy policy targets our scenarios present a range of possible energy futures shaped by political, economic, technological and environmental changes. We have used feedback received during a public consultation to refine our assumptions and feel that the final scenarios reflect the views of a broad and diverse range of stakeholders.

Our scenarios show that electricity demand will likely increase significantly in the future, due to new large energy users connecting and the electrification of heating and transport. The importance of smart demand side devices and their role in managing new demand growth will increase over time. The electricity generation portfolio will continue to decarbonise, as increasing levels of renewables connect, while existing coal and peat generators exit over time.

We hope you find this document informative and that our Tomorrow's Energy Scenarios 2019 reduces uncertainty surrounding our energy transition.

We very much welcome feedback from you on how we can improve this document and make it more useful.

Mark Foley
Chief Executive,
EirGrid Group

Document Structure

This document contains a glossary of terms, an executive summary, eleven main chapters and appendices. The structure of the document is as follows:

The **Glossary of Terms** explains some technical terms used in the document.

The **Executive Summary** gives an overview of the main highlights of the document.

Chapter 1 summarises the key changes made as a result of the Tomorrow's Energy Scenarios 2019 consultation.

Chapter 2 introduces EirGrid's Strategy 2020-25 and briefly describes the electricity transmission grid and the Single Electricity Market.

Chapter 3 describes scenario planning and why EirGrid uses it.

Chapter 4 presents the storylines associated with the three scenarios.

Chapter 5 describes how the scenarios have evolved since 2017 and the method used to develop our new scenarios.

Chapter 6 describes the components that make up electricity demand and how these change over time for each scenario.

Chapter 7 describes the components that make up electricity generation and how these change over time for each scenario.

Chapter 8 describes the components that make up non-generation technology mix and how these change over time for each scenario.

Chapter 9 outlines assumptions relating to the future locations of electricity demand, generation, interconnection and storage and how these change over time for each scenario.

Chapter 10 highlights key results obtained from the TES 2019 generation dispatch models.

Chapter 11 describes the next steps in the Tomorrow's Energy Scenarios 2019 process.

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.

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 utilisation and storage (CCUS)
The process of capturing, transporting and storing the carbon dioxide produced from the combustion of fossil fuels, before it is released into the atmosphere. In some cases the captured carbon dioxide becomes a feedstock for other processes.

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 carbon dioxide emission 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 system.

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.

Distribution grid [electricity]
The typically radial network of high, medium and low voltage (110 kV and below) circuits and other equipment used for supplying electricity to consumers.

EirGrid
The independent statutory electricity transmission system operator in Ireland.

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

European Union emissions trading system (EU ETS)
The market for carbon, which 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 energy use
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.

Gross national product (GNP)
The total value of goods and services produced in a country, net the amount of income sent to or received from abroad. It accounts for the effect of the profits of foreign-owned companies.

Gross value added (GVA)
A measure of the value of goods and services produced in an area, industry or sector of an economy. GVA is calculated with product taxes and subsidies removed.

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

Levelised cost of energy (LCOE)
A metric used to compare the cost competitiveness of different technologies. LCOE measures lifetime costs divided by energy production.

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.

Personal consumption of goods and services (PCGS)
A measure of consumer spending on goods and services, including items such as food, drink, cars and holidays.

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 methanation.

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

Renewable Energy Sources - Electricity
Electricity produced using renewable energy sources.

Reserve
Capacity available for assisting the balancing of deviations in generation and demand.

Sector coupling
The increased integration of energy end-use and supply-side sectors with one another. This includes the electrification of end- use sectors like heating and transport, as well as the integration of the electricity and gas sectors.

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.

System Operator Northern Ireland (SONI)
The licensed 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 Commission for Regulation of Utilities (CRU).

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

Transmission grid [electricity]
The typically meshed network of high voltage (400 kV, 275 kV, 220 kV and 110 kV) circuits and other equipment used to transmit bulk electricity supplies around 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 to regional or distribution operators.

Executive Summary

Tomorrow's Energy Scenarios (TES) outlines possible future pathways for the electricity system. Our final scenarios build on the consultation report by incorporating feedback from stakeholders. We thank those who engaged with us and shared their insights.

The increased certainty of energy policy in Ireland has led to a reduction in the number of scenarios from four in TES 2017 to three in TES 2019. Given the extent of the climate crisis as outlined by the United Nations[1], we can no longer afford to change slowly. In this light, two of our scenarios reach the 70% RES-E target by 2030 as set out in the Government's Climate Action Plan[2], and one of our scenarios reaches carbon neutrality in the electricity system by 2040. In order to achieve a carbon neutral electricity system, the provision of all capacity, energy and system services must be done without the net release of carbon dioxide emissions (net zero).

Our demand modelling indicates that incentivising and coordinating the shifting of electric vehicle charging demand will be crucial aspects of minimising increases to system peak demand.

Our connections analysis suggests that in order to hit the 70% RES-E target by 2030, the required connection rate of renewable capacity between 2020 and 2030 exceeds the current five year historical average. In the case of Coordinated Action, a doubling of the average rate is required. These figures exclude the connections of storage or other new technologies, as well as repowering.

As also highlighted in our Generation Capacity Statement (GCS)[3], new investment in generation capacity will be needed to replace forecasted closures. The North South interconnector is an important enabler of capacity sharing across the jurisdictions on the island of Ireland, while interconnection with neighbouring electricity systems also increases the ability to share capacity.

Our dispatch modelling outlines the transformation required in our operational practices to realise a secure, decarbonised real-time supply. By 2030, our ambition is to be able to accommodate instantaneous penetrations of 95% of demand from non-synchronous renewable energy sources[4]. Significant levels of flexibility are also required to accommodate such high levels of weather-dependent renewables, while interconnection plays a key role in facilitating higher RES-E levels by allowing surplus renewable energy to be exported when market prices are favourable.

The aforementioned changes to electricity system require sufficient grid infrastructure to maintain the reliability and security of electricity supply. The next step of TES, the System Needs Assessment, will outline the needs of the electricity transmission grid. Addressing these needs, in a timely manner, will be critical to ensuring that the futures projected in TES can occur. We acknowledge the scale of the challenge ahead, and, in partnership with all our stakeholders, aim to lead the way.

---

[1] UN, Climate Reports

[2] DCCAE, Climate Action Plan 2019 to Tackle Climate Breakdown

[3] EirGrid, Generation Capacity Statement 2019-2028

[4] EirGrid, Strategy 2020-2025

1. Key changes from the consultation

1. Key changes from the consultation

1.1. Tomorrow's Energy Scenarios 2019 consultation

In June 2019, we published the TES 2019 consultation report outlining three draft scenarios for Ireland's clean energy transition. We requested feedback on the assumptions used to determine these draft scenarios as part of an open consultation.

We experienced a high level of engagement from a wide range of stakeholders and received a lot of useful feedback. This feedback has been reviewed and used to finalise our scenarios. We will also use this feedback to help shape future TES publications.

1.2. Summary

This final TES 2019 report contains additional information, not detailed the consultation report, such as future electricity production and consumption patterns, installed capacities for storage technologies and assumed dispatch modelling constraints. Further to these additions, a number of changes have been made to scenario storylines and the scenario portfolios since the consultation closed in August 2019.

Table 1 summarises the key changes to scenario storylines and portfolio assumptions by report chapter.

Table 1: Summary of changes

Chapter	**Key change(s)**
Scenario planning	A new section on the security of electricity supply has been added.
Scenario storylines	The scenario name 'Community Action' has been changed to 'Coordinated Action'. The relationship between EirGrid's and SONI's scenarios has been illustrated.
Scenario building	Further detail has been provided to explain the process of scenario development using scenario design characteristics and PEST analysis.
Demand	Large energy user electricity demand has been increased in the Coordinated Action scenario in study years 2025 and 2030. Electricity demand for transport has reduced in all scenarios in 2025, in Coordinated Action in 2030 and in all scenarios in 2040. The Total Electricity Requirement (TER) has changed to reflect changes to electricity demand from large energy users and transport.
Generation mix	The assumed level of decentralisation has been reduced in the Coordinated Action scenario. Installed capacities for Solar PV have been increased in Coordinated Action scenario in 2025 and 2030. The timing for the commissioning of the first Carbon Capture and Storage facility has been updated to 2031 in the Centralised Energy Scenario. The composition of the gas-fired generation fleet has changed with increases to the installed capacity of Open Cycle Gas Turbines (OCGTs) from 2025 in all scenarios. The increases are most pronounced in Coordinated Action. The assumed expected life age for onshore wind generators has been changed from 20 years to 25 years.
Locations	Generation locations have been updated to reflect project pipeline data provided for onshore wind. Floating offshore wind installed capacities have been increased for Centralised Energy. This capacity is assumed to begin connecting from 2031.

2. Introduction

2. Introduction

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

2.1. The grid

Ireland's electricity transmission grid is a network of 400 kV, 220 kV and 110 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 Ireland. EirGrid has responsibility for the real time operation and future planning of the transmission system. ESB Networks is the Transmission Asset Owner (TAO) in Ireland and is independent from EirGrid. As the TAO, ESB Networks is responsible for carrying out maintenance, repairs and construction of the grid.

2.2. Single Electricity Market

EirGrid is part of the EirGrid Group who, through the Single Electricity Market Operator (SEMO), is responsible for the operation of the Single Electricity Market (SEM). SEM is the all-island wholesale electricity market. As the TSO, EirGrid plays a vital role in the operation of the SEM. EirGrid'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, EirGrid must weigh up several factors that may change the ways that the electricity transmission grid is used in the future.

2.3. Strategy 2020-25

The context of climate change is well understood, and beyond scientific doubt. The only question now is how fast society can respond to limit the damage, and so protect our planet for current and future generations.

The response – at a government, EU and global level – is to plan for the transition to a sustainable, low-carbon future. This is reflected in international treaties such as the 2016 Paris Agreement[5], and in the EU Climate and Energy Framework[6] to 2030. It is also visible in the Irish Government's 2019 Climate Action Plan.

The transition to low-carbon and renewable energy will have widespread consequences. There will be major changes in how electricity is generated, and in how it is bought and sold. There will also be major changes in how electricity is used, such as for transport and heat. The electricity system will carry more power than ever before and most of that power will be from renewable sources. Coal, peat and oil-based generation will be phased out in the next decade.

And while this happens, new technology will allow electricity users to generate and store power, and return any surplus to the grid. Combined with real-time consumption information from electricity users, this creates opportunities for all. Realising these opportunities will require a significant transformation of the electricity system. More importantly, these changes will need to be managed in a co-ordinated and cost-effective way.

EirGrid Group has a unique role to play in leading the radical transformation that is now required. Our response to this is described in Strategy 2020-25, which includes our revised purpose and our new primary goal. For more on Strategy 2020-25, please visit our website.

---

[5] UN, Paris Agreement
[6] European Commission, Climate and energy framework

3. Scenario planning

3. Scenario planning

At EirGrid, one of our roles is to plan the development of the electricity transmission grid to meet the future needs of society. Key to this process is considering a range of possible ways that electricity supply and consumption may change in the future, given the uncertainty present over the long-term. We call this scenario planning.

3.1. What are the Tomorrow's Energy Scenarios?

Our TES aim to outline a range of credible pathways for Ireland's clean energy transition, with specific focus on what this means for the electricity transmission system over the next twenty years and beyond.

Our scenarios are reviewed every two years to include new information. You can find all of the TES publications on our Energy Future webpage. We will use the final TES 2019 scenarios, detailed in this report, to test the performance of the electricity transmission grid and publish the results in the TES 2019 System Needs Assessment. SONI have produced a draft set of Tomorrow's Energy Scenarios 2019 which are described in a seperate consultation report. For more information on SONI's Tomorrow's Energy Scenarios 2019 please visit SONI's Energy Future webpage.

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

The consultation offers us a chance to receive feedback on the scenarios before the dispatch model-building phase begins

We use optimisation software to simulate future electricity production and consumption patterns

We apply our technical planning standards to thousands of grid simulations to identify needs

Figure 1: TES 2019 Ireland development cycle

3.2. Why do we use scenario planning?

EirGrid is responsible for a safe, secure and reliable electricity transmission system, now and in the future. To achieve this we must continue to maintain and develop the electricity grid. Scenario planning allows us to assess the performance of the electricity system against a range of potential energy transition futures.

In order to achieve the decarbonisation goals for the electricity sector set out in the Climate Action Plan, we must ensure that grid infrastructure is prepared for the future. At a fundamental level, this means ensuring the electricity system can take more renewable generation. We must also ensure it can accommodate increases in electricity demand. We will do this by optimising existing assets, and by developing new infrastructure.

Where possible, we will use innovative yet proven technologies to minimise the need for new infrastructure.

Have Your Say[7] details our six-step consultation and engagement process for grid development, as shown in Figure 2. In Step 1 of the process we identify future needs of the electricity transmission system brought about by changes to: electricity demand, generation, storage, interconnection and asset condition.

We use scenarios to test the performance of the transmission system against the changes to electricity demand, generation, storage and interconnection developed in our scenarios.

The results of the transmission performance tests are detailed in the TES System Needs Assessment which will be published in December 2019. Needs identified in this report are subsequently assessed in more detail before proceeding to Step 2 of the grid development process.

We then use our scenarios throughout the grid development process, ensuring that needs remain valid as the electricity transmission grid changes over time and more information becomes available.

Our scenarios are not used to identify network refurbishment needs. These are determined based on changes to the condition of existing electricity transmission assets. Further, our scenario planning process does not identify short-term needs or constraints which materialise on the system, for example those arising from unforeseen plant closures, new connections or project delays. The grid development process adapts to these changes as they occur.

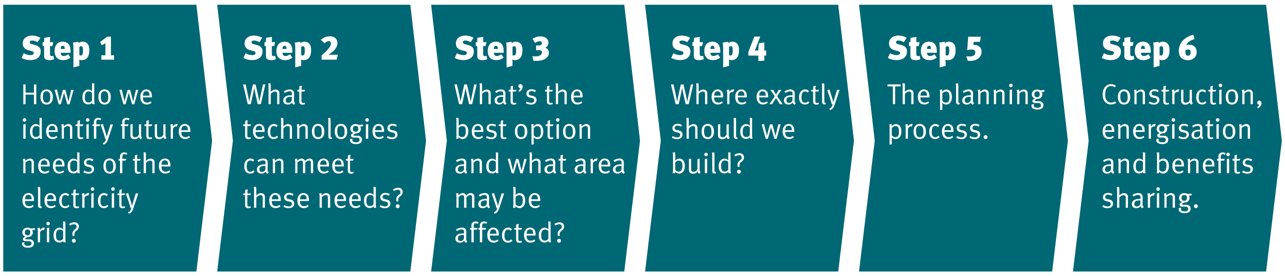


Figure 2: Grid development process

---

[7] EirGrid, Have Your Say

3.3. Related EirGrid publications

EirGrid produces a number of network planning documents that share a relationship with TES. These are shown in Figure 3.

Alongside TES they provide a holistic view of the future electricity transmission system. TES aligns with these reports and provides a wider view of the electricity transmission system beyond a ten year planning horizon.

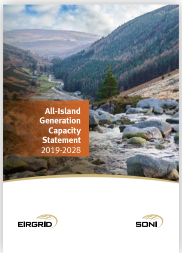
The Generation Capacity Statement (GCS) outlines the likely generation capacity required to achieve an adequate supply and demand balance for electricity on the island of Ireland over ten years. This report forms the basis for underlying demand growth assumptions used in TES.

The 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 TES System Needs Assessment.

The TYTFS also provides other information, such as demand and generation opportunities on the transmission grid.

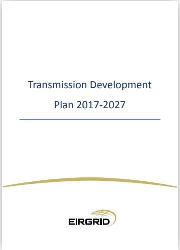
The Transmission Development Plan (TDP)[9] outlines development plans for the transmission network over a ten year period. This report shares an important relationship with the TES System Needs Assessment report. Long-term development needs, identified in the TES System Needs Assessment report, may lead to projects listed in future versions of the Transmission Development Plan. This is dependent on the identified need progressing to Step 4 of the grid development process.

Ten-year-horizon planning publications



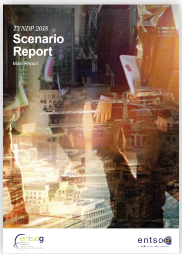
All Island Generation Capacity Statement
Ten year electricity demand forecast.

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

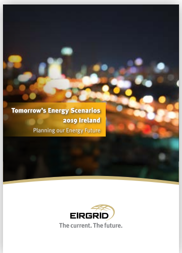


Transmission Development Plan
Ten year network and interconnection development plan.

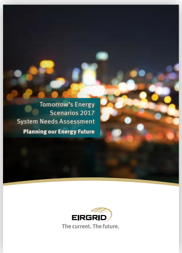
Twenty-year-plus-horizon planning publications



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



Tomorrow's Energy Scenarios (TES)
Electricity scenarios for Ireland out to 2040.



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

Figure 3: Related planning publications

---

[8] EirGrid Group, TYTFS 2017
[9] EirGrid, TDP 2017–2027

The Ten Year Network Development Plan (TYNDP) process[10] [11] of the European Network of Transmission System Operators (ENTSO) for electricity and gas is an important reference for TES. It provides guidance on the European-wide energy transition, and is central to understanding European Union (EU) Projects of Common Interest (PCIs)[12].

3.4. Energy and climate policy

Energy policy action is needed to bridge between today's policies and those required to ensure climate neutrality[13], i.e. net-zero greenhouse gas (GHG) emissions. To that end, many parties, including the EU, have agreed to a long-term goal of keeping the increase in global average temperature to well below 2°C (above pre-industrial levels) and to pursue efforts to keep it to 1.5°C.

The EU's commitment is to reduce GHG emissions by at least 40% by 2030 compared to 1990, via its Clean Energy Package[14]. This framework includes EU-wide targets and policy objectives for the period from 2021 to 2030. The key targets for 2030 include:

- At least 40% reduction in GHG emissions from 1990 level (In 2017 Ireland was 9.6% above its 1990 level[15]).
- At least 32% renewable energy share (RES) (Ireland in 2017 was at 10.6%[16]).
- At least 32.5% improvement in energy efficiency compared to projections.

The renewable energy and energy efficiency target includes a review clause by 2023 for an upward revision of the EU level target. To achieve the GHG emissions reduction target, the EU emissions trading system (ETS) is to cut emissions by 43% (compared to 2005), and has been revised so that the emissions cap reduces by 2.2% annually (previously 1.7%), post 2020.

The non-ETS sector is to cut emissions by 30% (compared to 2005), via individual binding targets for Member States. To meet these EU targets, Member States are obliged to adopt integrated National Energy and Climate Plans (NECPs) for the period 2021-2030.

The European Commission has also set a long-term vision for a climate-neutral economy by 2050. Member States are required to develop national long-term strategies, and ensure consistency between their NECPs and long-term strategies.

The Irish government is in the process of developing its final NECP 2021-2030, having submitted a draft[17] last year. The final NECP will incorporate aspects of the Climate Action Plan 2019.

The clean energy transition will have a profound effect on the electricity sector. TES 2019 attempts to capture these effects, leveraging the expertise in Irish industry, government, academia and local communities.

We hope these scenarios act as a forum for debating sensible and credible pathways for Ireland's electricity sector.

---

[10] ENTSOs, TYNDP 2020 Scenarios Consultation
[11] ENTSOs, TYNDP 2020 Scenarios Consultation
[12] European Commission, Projects of Common Interest
[13] European Commission, European Long-Term Vision
[14] EU, Clean Energy Package
[15] EPA, Ireland's Provisional GHG Emissions 1990–2017
[16] SEAI, Energy in Ireland 2018
[17] DCCAE, Draft NECP 2021–2030

3.4.1 Electricity as an energy carrier

Ireland has the fourth highest per capita GHG emissions in Europe[18]. The breakdown of GHG emissions in Ireland in 2017 is shown in Figure 4.

In 2017, 21% of final energy use was in the form of electricity, with the remaining from heat and transport.

To help meet the overall RES target, Ireland set a 2020 target of a 40% renewable energy share in electricity (RES-E). The Climate Action Plan 2019 sets a 70% RES-E target for 2030, as recommended by the Joint Oireachtas Committee on Climate Action. It is forecasted that by 2030 electricity will account for approximately 30% of final energy use. In that case renewable electricity would then yield approximately 20% of total final energy use, with further renewable share growth dependent on decarbonisation measures in the heat and transport sectors.

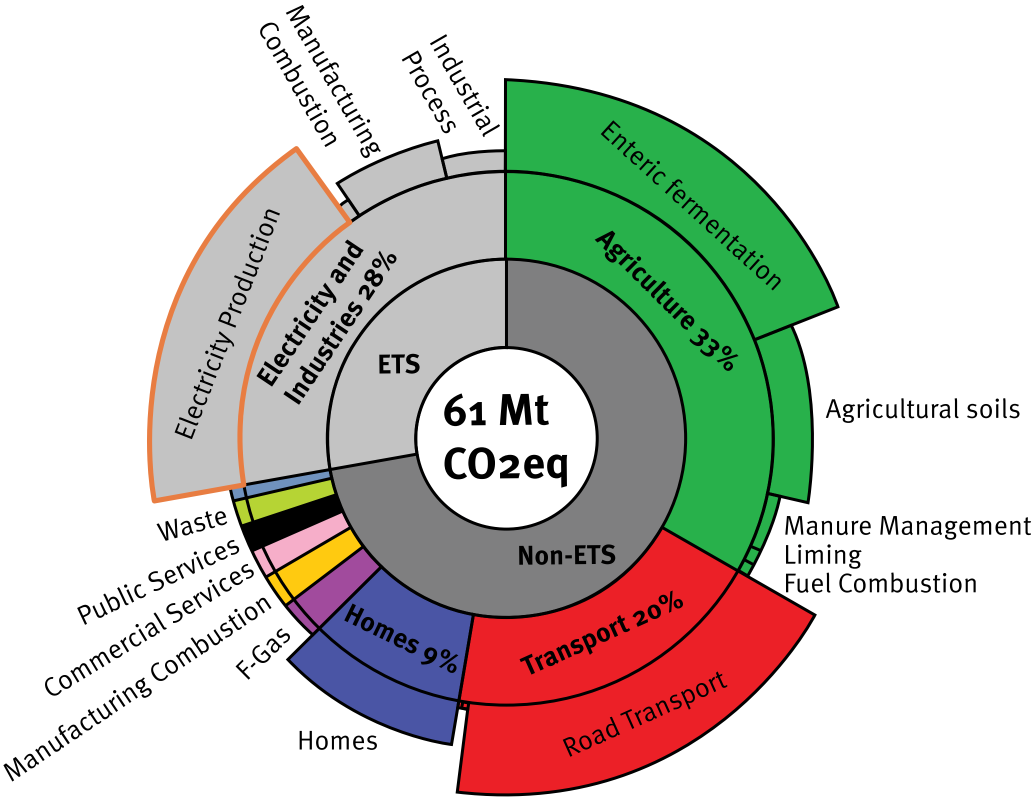


Figure 4: Ireland's GHG emissions, 2017
(reprinted with permission from the Environmental Research Institute, ERI, UCC)

---

[18] Eurostat, Greenhouse gas emissions per capita

3.4.2 Security of electricity supply

As more weather-dependent renewable energy sources connect to the electricity system the greater the impact weather patterns will have on electricity production. Weather patterns vary over different timeframes, day-night and seasonal being two of the most well-known cycles. Weather also varies over a multi-day horizon due to continental-scale patterns. One of the most onerous of these for renewable energy production in Ireland are blocking anti-cyclones, whereby wind output is consistently low for multiple days to a week. During such times, the wind outputs in our neighbouring electricity systems, Great Britain and France, will also be affected by the same weather regime[19]. To compound this challenge, such instances can be accompanied by a cold snap in winter[20].

In such cases, it is essential to have indigenous resources that can supply electricity over a multi-day, rather than multi-hour, period. TES assumes that market designs ensure that such multi-day capacity continues to play an important role in a reliable Ireland generation portfolio into the future.

SEM capacity auctions offer opportunities for fossil fuel plants to recover costs ensuring that they are available when needed. As more renewable generation penetrates the energy market over time, there will be a growing need to adapt capacity markets to ensure that generation adequacy standards continue to be met.

Ireland currently relies on gas-fired generation to meet the majority of its generation adequacy needs. This reliance is expected to increase as existing peat, heavy oil and coal plants close over time and new gas generators connect to the electricity system. In a future where the vast majority of capacity adequacy is provided by gas-fired generation, there will be a heightened dependency on the ongoing resilience of Ireland's gas supply.

Figure 5 shows that by 2030, approximately one third of the existing Combined Cycle Gas Turbine (CCGT) fleet will approach 30 years of age, the typical expected life of such assets. Multiple technical options exist for maintaining or replacing such capacity.

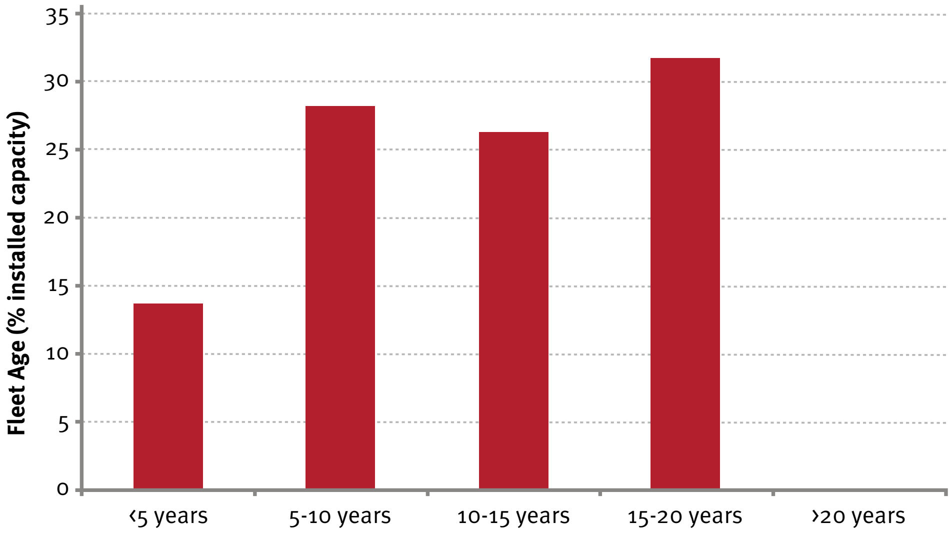


Figure 5: Existing CCGT age profile

---

[19] Grams et al., Balancing Europe's wind power output through spatial deployment informed by weather regimes
[20] Cradden et al., A weather regime characterisation of Irish wind generation and electricity demand in winters 2009–11

Broadly, fossil fuel generation capacity could take two routes toward a carbon-neutral power system, or a hybrid of both:

Large scale gas generation coupled with Carbon Capture Utilisation and Storage (CCUS)

Some of this fleet may undergo major refurbishment in order to extend their original design life. Some others may repower, replacing the existing CCGT with the latest CCGT technology. Repowering or building a new CCGT is a highly capital intensive investment. If such decisions are made without a strong incentive for deep decarbonisation technology to be a part of that investment, e.g. CCUS, large volumes of carbon will be locked into the electricity system for another 30 years.

Flexible gas generation coupled with renewable gas

CCGT capacity in Ireland may decline into the future, being replaced by higher numbers of Open Cycle Gas Turbine (OCGT) installations with mid-merit (rather than peaking) efficiencies. However, OCGTs, and their inherent high level of flexibility, are unsuitable for post-combustion CO_2 capture, meaning that in order to decarbonise such generation capacity, incentives are needed to decarbonise the fuel itself, requiring the gas supply to be 100% renewable. Renewable gas could involve an indigenous biomethane supply, further blended in the gas grid with hydrogen, or storage of hydrogen on-site.

The key assumption here is that in a more decentralised scenario, relying less on CCUS, requires an accelerated roll-out and greater volume of renewable gas, particularly given that such forms of gas are likely required for decarbonising some components of heat and transport. This pathway can only fully decarbonise if flexible generation plant, such as OCGTs, run exclusively on renewable gas.

In our most ambitious decarbonisation scenarios, we explore these two routes: for Centralised Energy we assume that the CCGT capacity does not decline and that it decarbonises mainly via CCUS. In Coordinated Action, we assume that CCGT capacity is replaced with OCGT capacity. Pursuing both CCUS and renewable gas reduces the risk of reliance on a single option, while helping to mitigate as much as possible a long-term reliance on non-abated fossil fuels.

4. Scenario storylines

4. Scenario storylines

EirGrid is pleased to present the final TES 2019: three discrete scenarios providing a range of credible outcomes for the electricity grid in Ireland. We will use these scenarios to demonstrate how Ireland's energy transition may impact the electricity grid and its use over time. Meeting decarbonisation targets in the power sector is a strong theme within our storylines.

Our scenarios share a close relationship with SONI's Tomorrow's Energy Scenarios[21]. The combined scenarios are used to create all-island power system models suitable for planning the power system over the long-term. However, different political, economic, social and technology drivers in Ireland and Northern 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. These differences are demonstrated, for example, by Centralised Energy and Modest Progress. Despite being matched together, these scenarios contain different 2030 RES-E% targets with Centralised Energy achieving 70% and Modest Progress achieving 60%. Although these differences exist, we are confident that the scenario coupling is appropriate for the TES System Needs Assessment.

The relationship between SONI's and EirGrid's scenarios is shown in Figure 6.

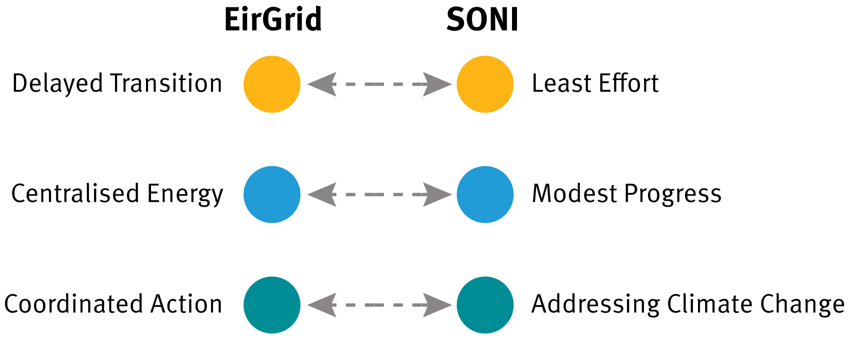


Figure 6: Relationship between EirGrid's and SONI's scenarios

---

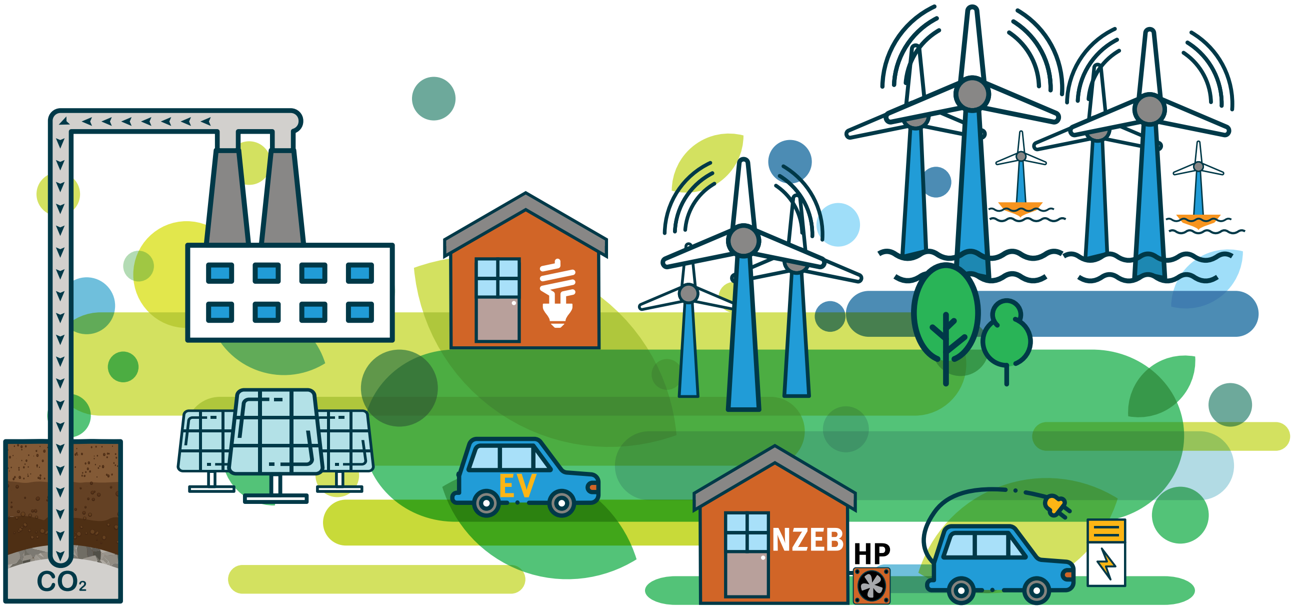
[21] SONI, Tomorrow's Energy Scenarios Northern Ireland 2019 Consultation

Centralised Energy

Centralised Energy is a plan-led world in which Ireland achieves a low carbon future.

There is a step change in the uptake of electrified transport and heating. Cost parity occurs over the next five years for electric vehicles. Electrification of the heating occurs in tandem with improved thermal efficiency due to deep retrofitting. Although uptake is significant, there is only a modest level of grid flexibility offered from consumer technologies.

Renewable electricity is mainly generated by large-scale sources. The diversity of the renewables mix increases due to reducing technology costs and auction designs. Carbon capture and storage is developed to decarbonise fossil fuel generation



Delayed Transition

Delayed Transition is a world in which decarbonisation progress is made, but the pace is not sufficient to meet climate objectives.

Policy measures fail to break down barriers to a systematic clean energy transition. Consumer behavioural change is modest, with a gap remaining between climate-change awareness and action. This means that the shift to electrified transport and, in particular, heating occurs later.

Deployment rates of renewable and low-carbon generation technologies are slower than required. This diminishes the benefits of electrifying the heat and transport sectors. Data centre growth, albeit sizeable, is lower than the median forecast in the Generation Capacity Statement.

Coordinated Action

Coordinated Action is a scenario where sustainability is a core part of decision making. Government and citizens recognise climate change as a risk and take appropriate action.

Policy measures are targeted at and embraced by all sectors of Ireland’s economy. Both large-scale and flexible generation solutions play an important role in moving toward energy and climate targets despite significant growth in demand for electricity.

Consumer adoption, the Internet of Things and artificial intelligence help realise a change in consumption patterns and help manage the daily peak in electricity demand.

There is significant growth in generation connected to the low voltage electricity network. This micro generation is accompanied by battery storage, yielding high levels of self-consumption.

5. Scenario building

5. Scenario building

5.1. Changes from 2017

Building on TES 2017, we have revised the number of scenarios and the underlying storylines. Our range of future pathways for TES 2019 is created from three scenarios. Figure 7 shows the high-level relationship between TES 2017 and TES 2019.

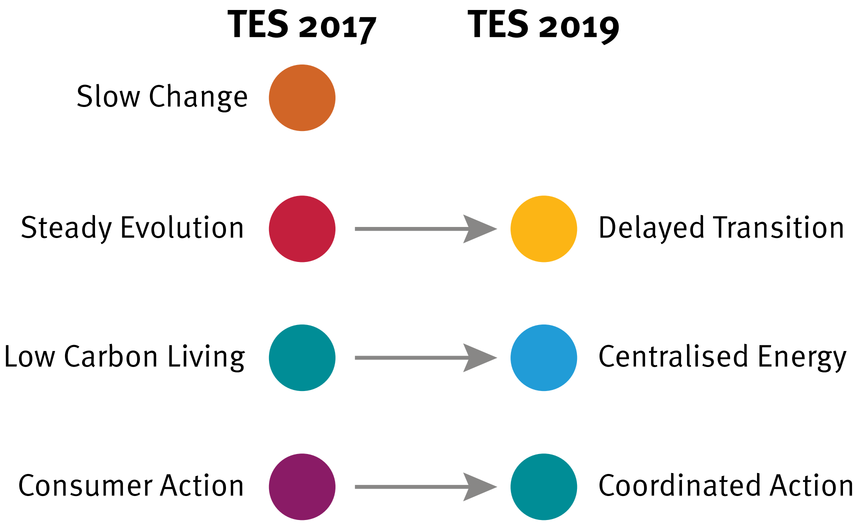


Figure 7: Illustrative similarity between TES 2017 and TES 2019

5.2. Scenario building

Building Tomorrow's Energy Scenarios is a multi-step process which has been shaped by key learnings and data captured as part of the first TES scenario development cycle, completed in 2018. The process is iterative, allowing for updates to assumptions and data as new information becomes available. The scenario building process outputs a discrete set of scenario storylines and portfolios that form inputs for use in optimised generation dispatch models. A high level view of the scenario building process is illustrated in Figure 8.

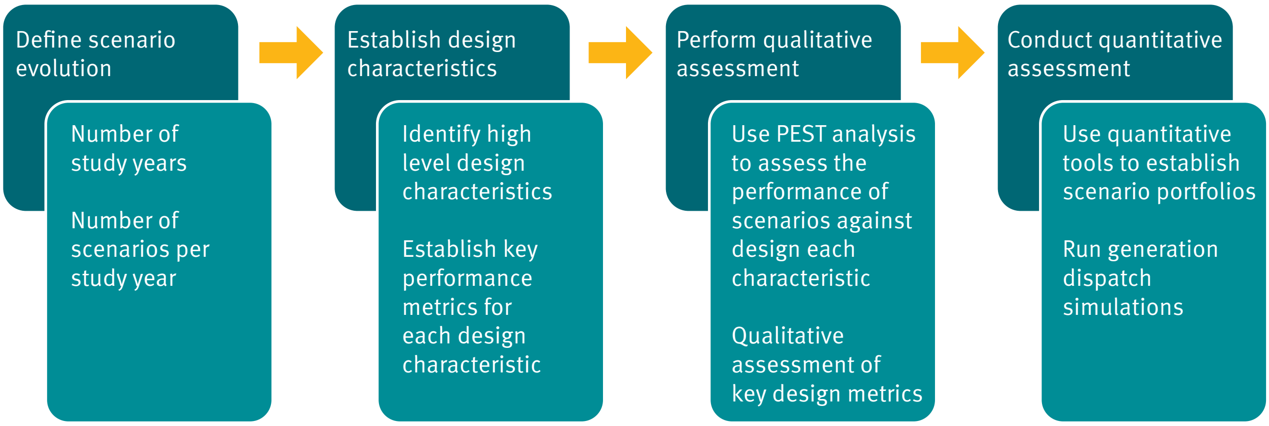


Figure 8: TES scenario building process

5.2.1 Scenario evolution

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

- the number of study years;
- the number of scenarios per study year.

The evolution of scenarios across study years is shown in Figure 9. The number of scenarios is constant with time. As we move further into the future the scenarios diverge, as the level of uncertainty regarding the composition of the energy system increases. The 2025-2040 timeframe is selected as it allows for long-term needs of the electricity system to be adequately assessed, whilst also identifying potential pathways toward 2050 GHG emissions targets.

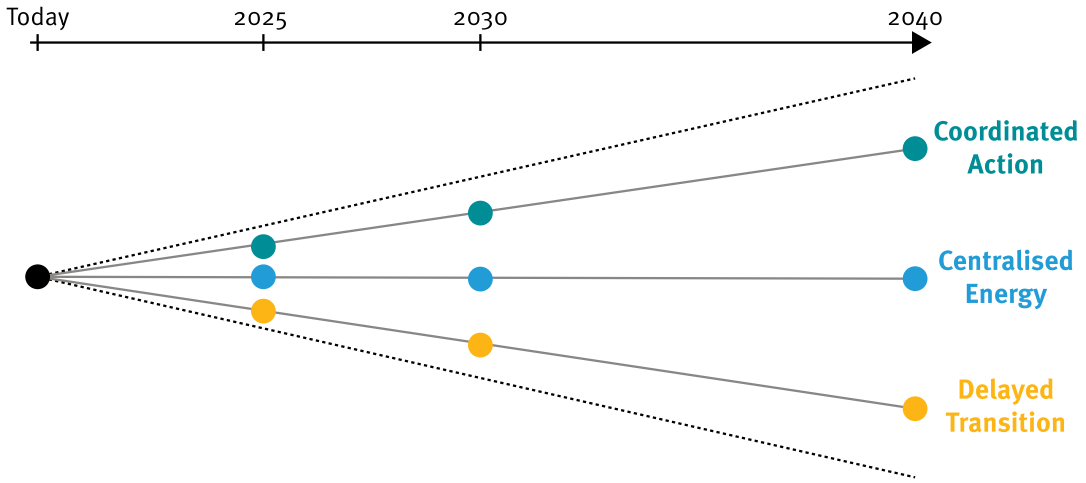


Figure 9: TES 2019 scenario evolution

5.2.2 Design characteristics

When developing scenarios, we identify key factors that will influence the future usage of the electricity grid, be that location, size, quantity, type and pattern of electricity generation and consumption. The characteristics selected for instructing the high-level design of TES 2019 are decarbonisation, decentralisation and digitalisation, due to their significant influence on the future electricity system.

The high-level interaction between the scenario design characteristics is shown in Figure 10.

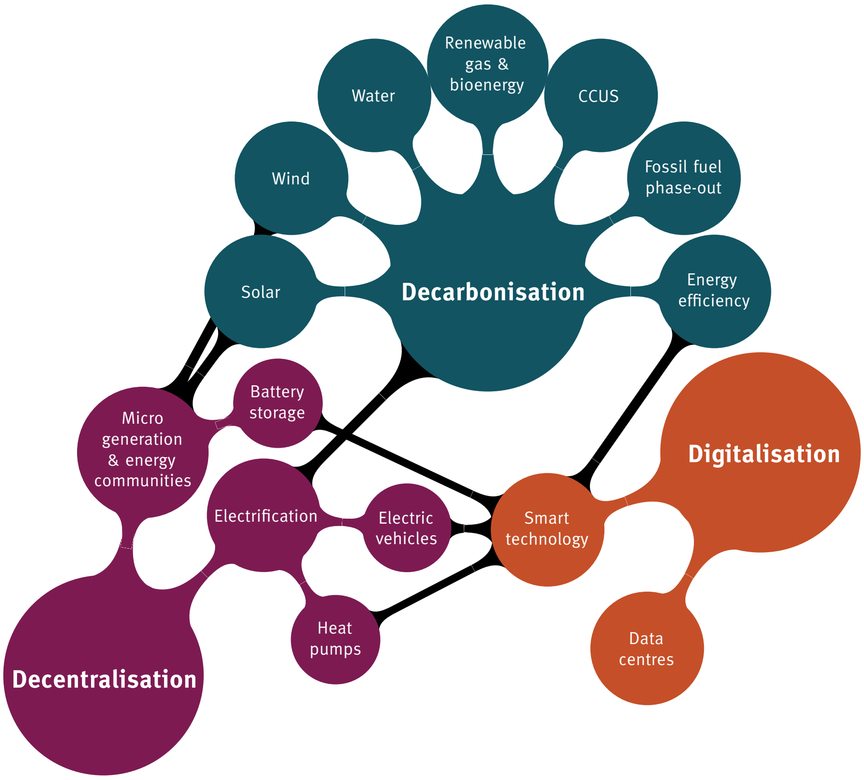


Figure 10: Scenario design characteristics

Decarbonisation refers to the level of abated carbon dioxide (CO2) emissions. A higher level of decarbonisation yields lower CO2 emissions released into the atmosphere. Reducing electricity system CO2 emissions can be achieved in a range of ways, such as the integration of renewables, the deployment of CCUS, and energy efficiency measures. In order for the electricity sector to support Ireland equitably contributing to the Paris Agreement, it would need to be CO2 neutral by 2040[22]. Key performance indicators for decarbonisation include levels of RES-E by 2030 and CO2 emissions from the power sector by 2040. These metrics help gauge the overall trajectory of each scenario against 2050 GHG emissions targets.

Decentralisation refers to the size and proximity of energy production in relation to the consumer. A level higher 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. The scale, or sizes, of generators in the fleet are a key metric for decentralisation of electricity supply whilst levels of self-consumption and electrification of heat and transport provide metrics for decentralisation of demand.

Digitalisation refers to the scale of the role played by digital technology and data. A higher level of digitalisation means a higher utilisation of smart meter data, contributing to a greater internet of things (IoT) network. This enables the participation of consumer-owned technologies, such as rooftop solar photovoltaic (PV) panels, electric vehicles (EVs), and other appropriate residential loads (water heating, etc.). For example, owners can coordinate the usage of their devices in order to reduce electricity bills, while also offering services to the system operators. Higher digitalisation also yields higher data centre growth, due to increased data usage. Data centre demand growth and demand-side flexibility are key metrics for digitalisation.

---

22 Glynn et al., Zero carbon energy system pathways for Ireland

5.2.3 Qualitative assessment

Political, economic, social and technological (PEST) analysis[23] is used to qualitatively assess how external factors influence key design characteristics for each scenario. This process step is essential to framing the scenario storylines and provides a framework for the quantitative assessment of the scenario portfolio.

PEST analysis requires a definition of each external factor in the context of the scenario building process. 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 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.

The results of the qualitative assessment are shown in Table 2 highlighting the relative performance of the scenarios against each key design metric.

5.2.4 Quantitative assessment

Electricity demand, generation and interconnection portfolios are produced for each scenario using purpose built quantitative tools. Energy balance projections for Ireland are prepared for each scenario spanning the time horizon illustrated in Figure 8. This is an iterative step involving repeated adjustments to energy balance inputs until the design criteria specified in Table 2 are met for each scenario. Quantitative tools provide flexibility to ensure that alignment exists between the scenario storylines and scenario portfolios.

Once validated, the scenario portfolios are used as inputs to generation dispatch models that simulate future energy production and consumption patterns for each scenario. We use optimisation software to establish the sets of operational constraints required to facilitate the scenario design criteria specified in Table 2. While these constraints may not be those that ultimately transpire in future years, this method aims to provide a signpost and facilitate discussion regarding the innovation required to integrate high levels of renewable electricity and decarbonise the electricity sector. Refer to chapter 10 for details on generation dispatch modelling results.

---

[23] National Grid SO, FES 2017

Table 2: Scenario design characteristic matrix

	Centralised Energy	Delayed Transition	Coordinated Action
Decarbonisation	**High**	**Low**	**High**
Toward a CO_2-neutral electricity system* by 2040	No	No	Yes
Meets 70% RES-E 2030 target	Yes	No	Yes
Coal generation phase-out	2024	2026	2024
Peat generation phase-out	2024	2029	2024
Carbon capture and storage	Yes (by 2031)	No	Yes (by 2040)
Energy efficiency improvements, including nearly zero energy buildings (NZEBs)	Medium	Low	High
Decentralisation	**Medium**	**Low**	**High**
Distribution-connected generation, including micro generation	Medium	Medium	High
Self-consumption	Medium	Low	High
Electrification of heat and transport	High	Low	High
Digitalisation	**Medium**	**Low**	**High**
Demand-side flexibility via smart meters	Medium	Low	High
Data centre growth	Medium	Low	High

*Net-zero CO2 emissions in the power sector.

6. Demand mix

6. Demand mix

Our scenarios show that electricity demand is forecasted to significantly increase over the next couple of decades. Our demand growth projections range from approximately 8 TWh to 16 TWh by 2030 compared to demand in 2018. This represents increases ranging from roughly 28% to 55%.

This chapter outlines the breakdown of demand per final energy use sectors, namely residential, tertiary (also known as commercial), transport and industry. The constituents outlined in this chapter are gross of self- consumption.

The economic growth assumptions used are shown in Table 3.

Table 3: Scenario design characteristic matrix

		2019 - 2021	**2022 - 2028**	**2029 - 2040**
Centralised Energy	GVA / GNP	3.8%	3.4%	2.8%
	PCGS	2.5%	2.6%	2.6%
Delayed Transition	GVA / GNP	3.8%	3.0%	2.5%
	PCGS	2.5%	2.5%	2.4%
Coordinated Action	GVA / GNP	3.8%	3.5%	2.9%
	PCGS	2.5%	2.7%	2.7%

Economic growth factors share a relationship with demand for electricity. Gross Value Added (GVA) and Gross National Product (GNP) are combined as indicators to influence the forecast of commercial and industrial electricity demand. Personal consumption of goods and services (PCGS) influence the forecast of residential electricity demand. These forecasts are informed by the GCS.

6.1. Total electricity requirement

Total Electricity Requirement (TER) is the sum of the annual electricity demand for the residential, tertiary, transport 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% (2% transmission and 6% distribution) of final use demand.

Figure 11 illustrates how demand is built up from the various components. Demand growth to 2025 is primarily driven by the large energy users in the industrial sector. Demand growth from 2030 is mostly caused by electrification of heat and transport.

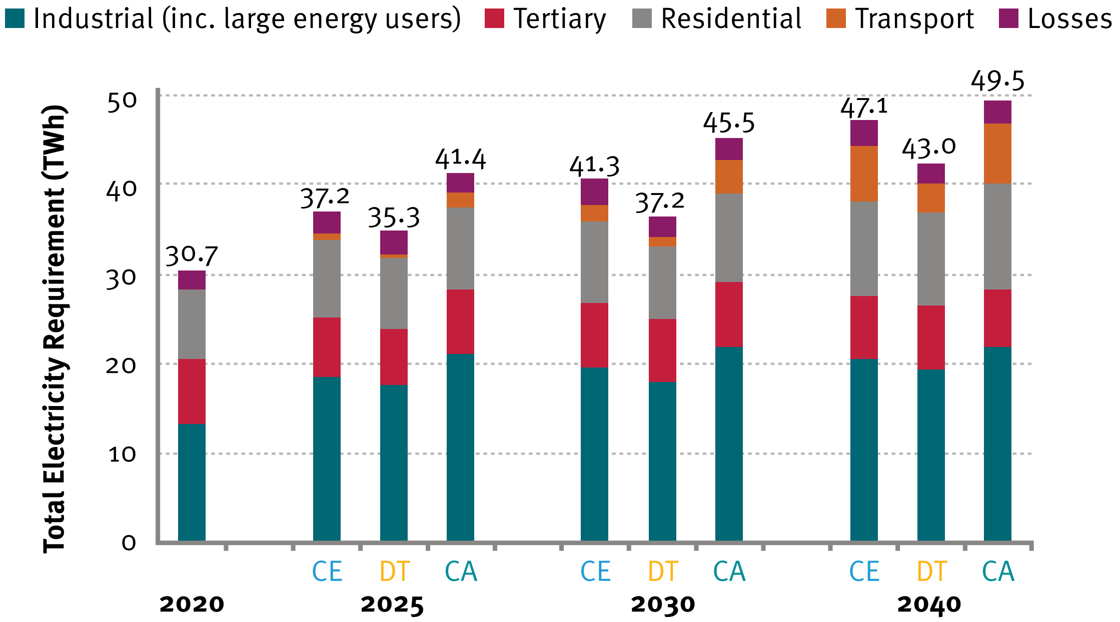


Figure 11: Annual total electricity requirement

6.2. Peak electricity demand

Ireland's peak demand for electricity generally occurs on a weeknight in winter at approximately 6:00pm. Peak electricity demand is sensitive to weather conditions and typically varies depending on the ambient temperature and irradiance level. The peak demand forecasting methodology used for our scenarios accounts for the effect of temperature using the concept of weather years. Peak demand for each scenario is forecast by selecting the average historical weather year from a pan-European climate database. This is illustrated in Figure 12 using 2015 demand data and 36 different weather years (1981-2016). Weather years are sorted ascending from highest impact on peak demand to lowest impact.

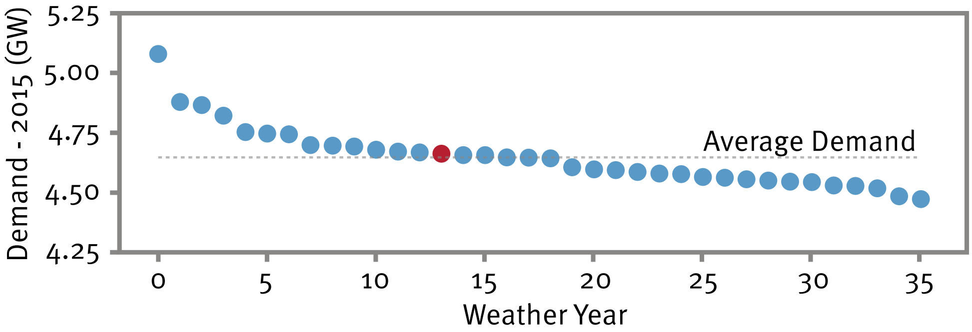


Figure 12: The effect of weather years on peak electricity demand, using 2015 for illustrative purposes

Using an average weather year means that a peak demand projection will be lower than an equivalent projection for a very cold winter or higher than that of a mild winter. This differs to the GCS 2019 forecasting method which does account for cold and mild winters and are captured in the GCS 2019 high and low demand forecasts respectively. The GCS 2019 method aids the use of demand forecast values in least worst regret analysis of capacity requirements in the Capacity Market.

Increases to peak demand in our scenarios are primarily driven by large energy users and, from 2030 onwards, by electrification of heat and transport. This growth in demand outweighs expected energy efficiency improvements enabled by smart metering data. Increases to peak demand are highest in Coordinated Action with a projected increase of 1.4 GW, or 27%, by 2030. Peak demand projections are shown in Figure 13.

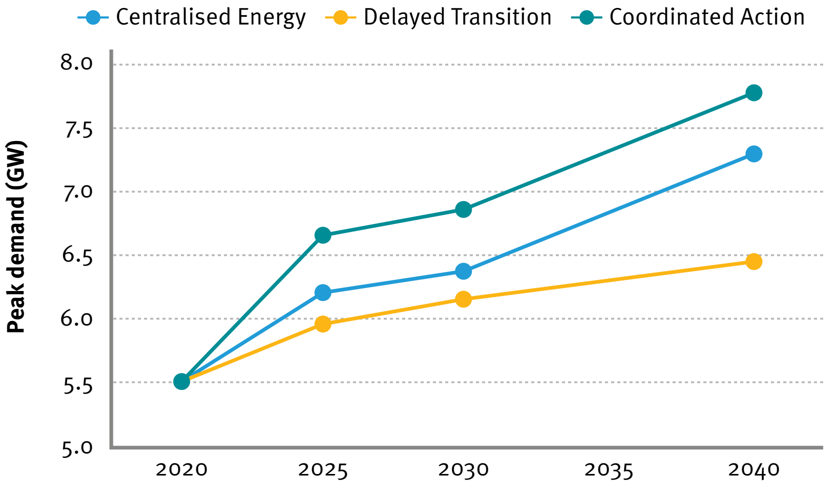


Figure 13: Peak demand

The timing, and sectoral composition of peak demand varies across scenarios, driven by adoption of new technologies such as smart meters and electric vehicles.

In the future, smart devices are expected to play an important role in assisting consumers to reduce their electricity demand at peak times when electricity prices are highest. This shifting of demand is incentivised by time-of-use tariffs and enabled by smart meter data. The ability to shift demand largely depends on the potential flexibility of new electricity demand.

Large energy user demand is assumed to be 'flat' and does not vary at different times in the day. In contrast, heating and transport demand varies across the day depending on consumer needs and behavioural patterns. There is some potential to shift heat pump demand depending on the Building Energy Ratings (BER) of the housing stock and the prevalence of smart household devices. However, as the heating demand is high during winter peak the flexibility of this demand is assumed to be low.

There is significant potential to shift electric vehicle demand away from peak times depending on the location and sophistication of charging technology and the price signals offered to consumers through time-of-use tariffs. In scenarios with high electric vehicle adoption rates, smart charging technology will be required to limit increases in overall system peak demand. The potential impacts of higher system peaks and the assumed charging profiles for electric vehicles are discussed in Section 6.5.

Peak demand profiles in 2030 are illustrated in Figure 14. Base demand shown aligns with Eurostat data for 2015; a year predating significant growth in other demand constituents such as large energy users, electric vehicles and heat pumps. Temperature independent load refers to new industrial load which does not vary depending on ambient temperature. Temperature dependent load refers to new residential and tertiary load, excluding heat pumps, which varies depending on ambient temperature. Battery charging and discharging patterns shown relate to batteries used for the purposes of self consumption only.

In Coordinated Action and Centralised Energy, 'smarter' charging technology shifts electric vehicle demand to times of lower electricity prices, mostly overnight. The smoothening effects of peak shifting are most pronounced in Coordinated Action resulting in better grid utilisation throughout the day and an extension of peak time by approximately one hour to 7:00pm.

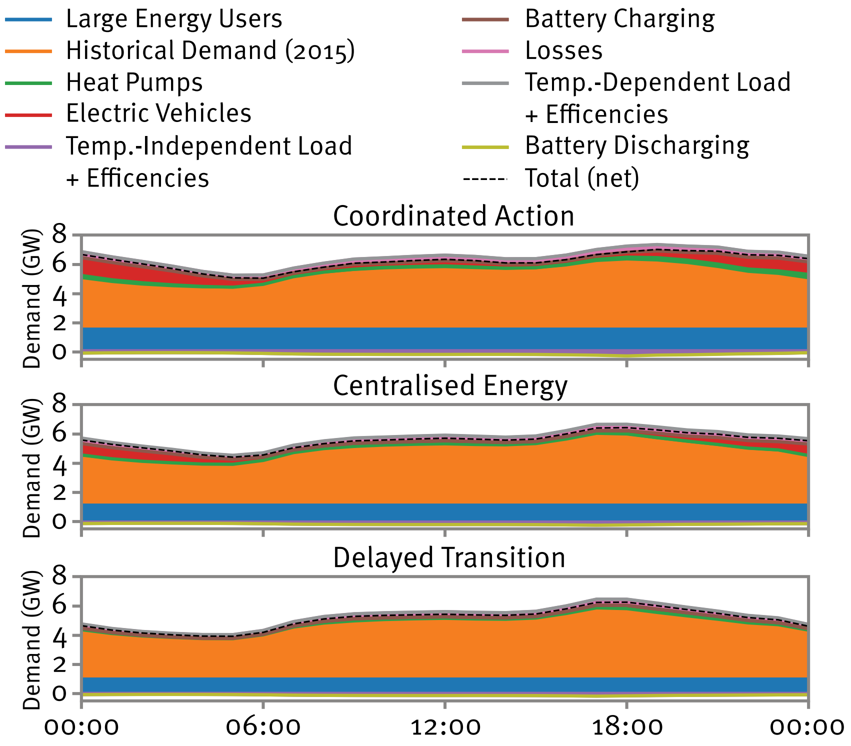


Figure 14: Peak demand profiles 2030

6.3. Energy efficiency

Energy efficiency refers to the implementation of energy saving measures, for example improvements in insulation, glazing, lighting and heating, among others[24]. Such measures can have other benefits such as improved thermal comfort, long-term energy cost savings, as well as reduced CO2 emissions and energy imports. As such, energy efficiency is a key part of the European Commission's climate and energy policy (see Section 1.4).

Table 4 shows the range of year-on-year energy efficiency gains assumed. In Coordinated Action, more of the barriers to energy efficiency implementation, such as a lack of information, sufficient incentives and access to capital, are overcome.

Table 4: Year-on-year energy efficiency gains

	Centralised Energy	**Delayed Transition**	**Coordinated Action**
Residential	**Medium**	**Low**	**High**
Electrical appliances (%)	1.0	0.8	1.2
Thermal (%)	0.6	0.5	0.8
Commercial	**Medium**	**Low**	**High**
Electrical appliances (%)	1.0	1.0	1.2
Thermal (%)	0.6	0.6	0.8
Transport	**Medium**	**Low**	**High**
EV (%)	0.9	0.9	1.0

---

[24] SEAI, Unlocking the Energy Efficiency Opportunity

6.3.1 Smart meters

Following the Commission for Regulation of Utilities (CRU) smart meter upgrade decision[25], smart meters are to be installed in households and businesses across Ireland, with a total of 2.3 million meters due by 2024. A smart meter can measure and record a building's electricity consumption. It is hoped that this information will promote better energy management and efficiency in the home. A smart meter trial, involving over 5,000 homes, showed a 2.5% reduction in overall electricity demand and a peak time demand reduction of 8.8%[26]. With time-of-use tariffs, consumers will be incentivised to move some consumption away from peak times by availing of lower electricity prices.

6.4. Residential and tertiary

Residential and tertiary 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[27]. Electric space heating comes in the form of direct electric, air source heat pumps, ground source heat pumps, and hybrid heat pumps. We focus on heat pumps, particularly air source heat pumps in the residential sector, given its forecasted strong growth, driven in part by building regulation updates, which specify nearly zero energy buildings (NZEBs)[28].

6.4.1 Heat pumps

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

The air source heat pump COP assumptions, which are fixed across scenarios, are given in Table 5.

Table 5: Air source heat pump coefficient of performance

	2020	2025	2030	2040
COP	2.31	2.43	2.54	2.77

The number of residential air source heat pumps assumed is shown in Figure 15. In Coordinated Action, we assume 400,000 existing homes are retrofitted by 2030, with the remaining 200,000 heat pump installations coming from new-builds.

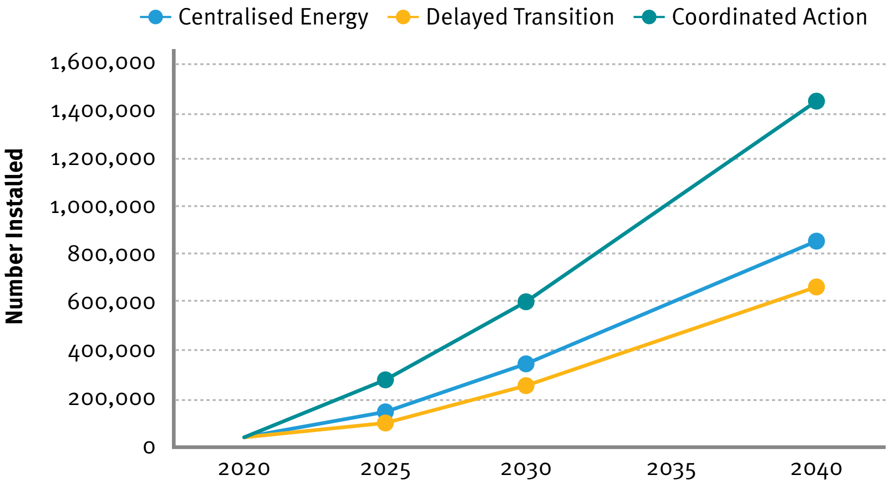


Figure 15: Residential air source heat pumps

---

[25] CRU, Customer-Led Transition to Time-of-Use
[26] CRU, Smart Metering Project - Electricity Customer Behaviour Trial
[27] European Commission, Final Energy Consumption for the Year 2012
[28] DHPLG, Building Regulations Technical Guidance Documents L

6.5. Transport

6.5.1 Electric vehicles

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

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 6 shows our consumption assumptions for electric passenger vehicles (including plug-in hybrid electric vehicles) and electric delivery vans.

Table 6: Specific consumption rates (kWh/100 km), electric passenger vehicles and delivery vans

	2020	2025	2030	2035	2040
CE	19.13	18.28	17.47	16.70	15.96
DT	19.13	18.28	17.47	16.70	15.96
CA	19.13	16.59	15.39	13.91	12.57

We assume a variation of EV uptake across scenarios to represent the range of possible rates of EV adoption, as shown in Figure 16. A higher level of uptake is promoted by falling EV costs and a ban on the sale of new non-zero emissions vehicles post-2030. Coordinated Action aligns with 2030 uptake levels targeted in the Climate Action Plan.

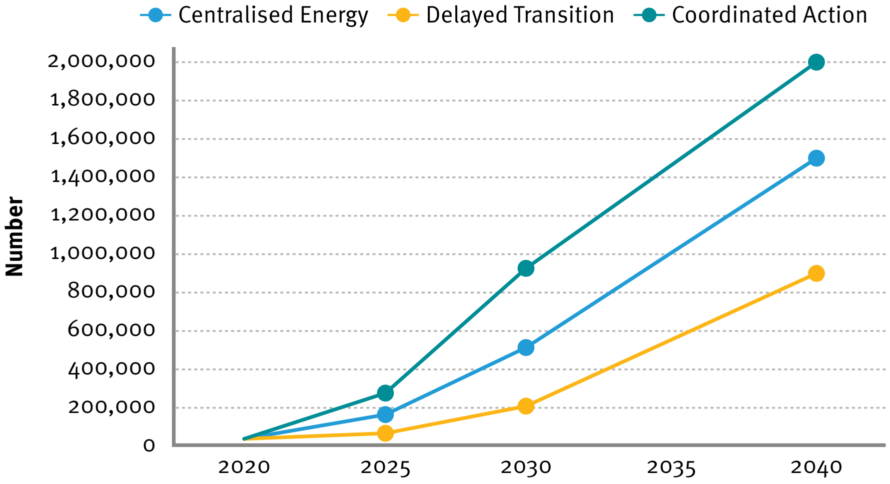


Figure 16: Number of electric passenger vehicles and delivery vans

As quantities of electric vehicles grow they will have an increasing impact on the electricity grid and on electricity markets. The scale of this impact will depend on a wide range of factors such as the quantity and types of electric vehicle, vehicle usage, types and locations of vehicle chargers and the charging patterns of vehicle owners. Vehicle charger technology has the potential to minimise the potential impact of electric vehicle demand on the electricity system, and on electricity markets.

It is assumed that charger technology will evolve over time from simple chargers and patterns that are readily available today[29], to smart chargers with features such as programmable charge start times to smarter charging technology that optimise vehicle charging in line with dynamic electricity price signals. The TES 2019 framework for electric vehicle chargers is shown in Table 7.

---

[29] National Grid SO, FES 2019

Table 7: Electric vehicle charger framework showing the most numerous charger types by vehicle type, scenario and year

	2025			2030			2040		
Type	CE	DT	CA	CE	DT	CA	CE	DT	CA
Passenger car and delivery van	Car Smart	Car Simple	Car Smart	Car Smarter	Car Simple	Car Smarter	Car Smarter		
Public bus	Bus Simple			Bus Smart	Bus Simple	Bus Smart	Bus Smart		
Train	Train Simple			Train Simple			Train Simple		
Freight (light)	Freight Simple			Freight Smart			Freight Smart		

The level of sophistication of vehicle chargers is expected to evolve from simple, to smart and to smarter. Using the simple profile as a baseline, the smart profile is developed by estimating changes to charging behaviours incentivised by time-of-use tariffs and facilitated by chargers that allow users to program charging to occur at predefined times such as overnight, when electricity prices are lower. Although some vehicle users, such as commuters, still avail of day time charging, there is a steady shift toward cost reflective charging patterns.

Smarter charging is an evolution of the smart charging profile. Algorithmic charger technologies leverage recorded vehicle usage patterns along with smart meter data and dynamic price signals to optimise charging of individual vehicles. This technology will play an important role in maximising the diversity of electric vehicle charging thereby reducing the impact on system peak demand. Weekday and weekend charging profiles are shown in Figure 17 for a range of different electric vehicle types.

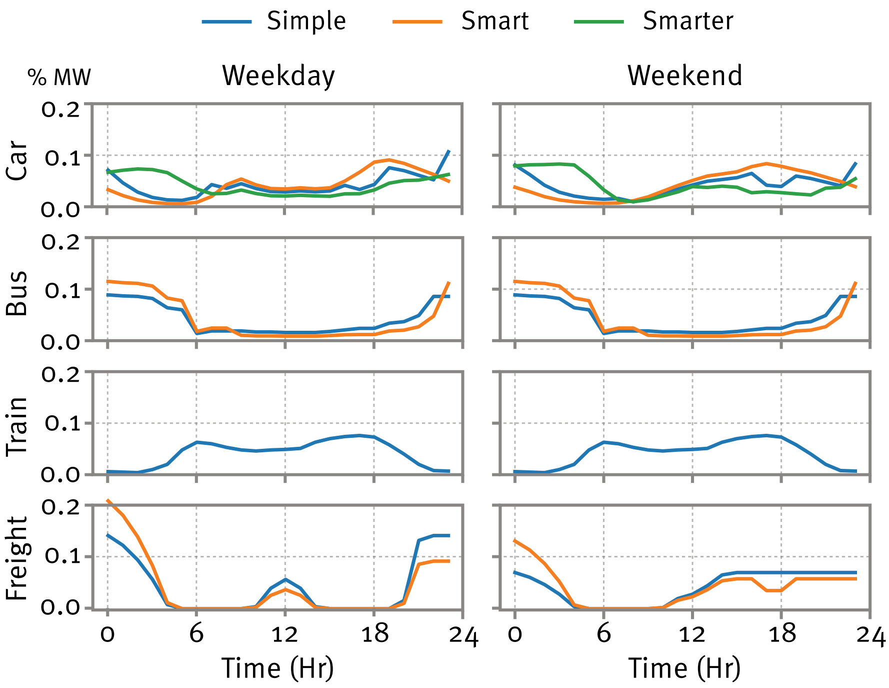


Figure 17: Charging profiles. (Delivery vans are inlcuded in cars. Train profiles are instantaneous load rather than charging load.)

In scenarios with high uptake of electric vehicles, optimisation of charging demand is required to ensure that need for grid development and additional generation capacity is minimised. Figure 18 shows the effect of vehicle charger profiles on system peak demand in Coordinated Action by 2030. The use of smart and smarter charger technologies reduces system peak demand by 0.17 GW and 0.48 GW respectively, compared to simple. The average size of CCGTs is approximately 0.35 GW. Considering this helps to frame the potential benefits associated with vehicle charging technology.

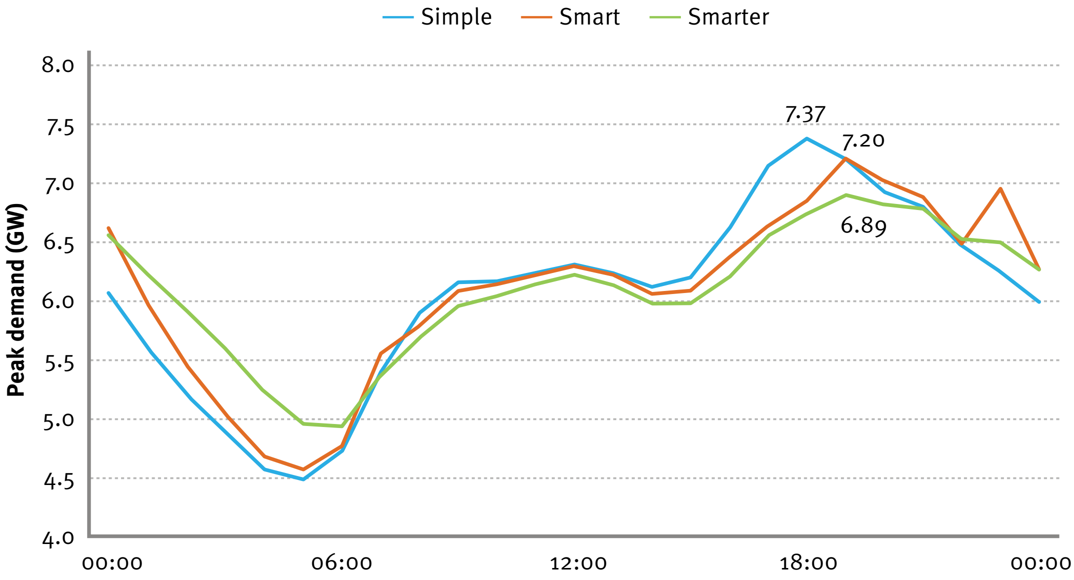


Figure 18: The impact of electric vehicle charging on the daily profile of winter peak demand in Coordinated Action by 2030

6.6. Industrial

Electricity demand from industrial sources in Ireland comes from end uses such as food and tobacco; chemicals and petrochemicals; machinery; non-ferrous metal; mining and quarrying; non-metallic minerals, e.g. 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.

Approximately 34% of the final energy demand from these industrial customers was supplied by electricity in 2015[30]. This percentage remains constant into the future, across our scenarios, excluding demand from large energy users. This is due to increases in demand balancing against reductions in demand brought away by efficiency improvement measures.

6.6.1 Large energy users

Large energy users are large demand connections, such as data centres. Large energy users have become a significant growth area in Ireland. As of today there is approximately 1,000 MVA of demand capacity contracted to large energy users in Ireland. The typical load currently drawn by these customers is approximately 35% of their contracted maximum import capacity (MIC). This is expected to rise as these customers build out to their full potential.

There are many large energy users projects in the connection process and many that have made material enquiries. As per the GCS, we have examined the status of these proposed projects and have made assumptions concerning the demand from these large energy users in the future. This has formed the differences between our low, median and high projections, as shown in Figure 19.

---

[30] Eurostat, Energy Balances

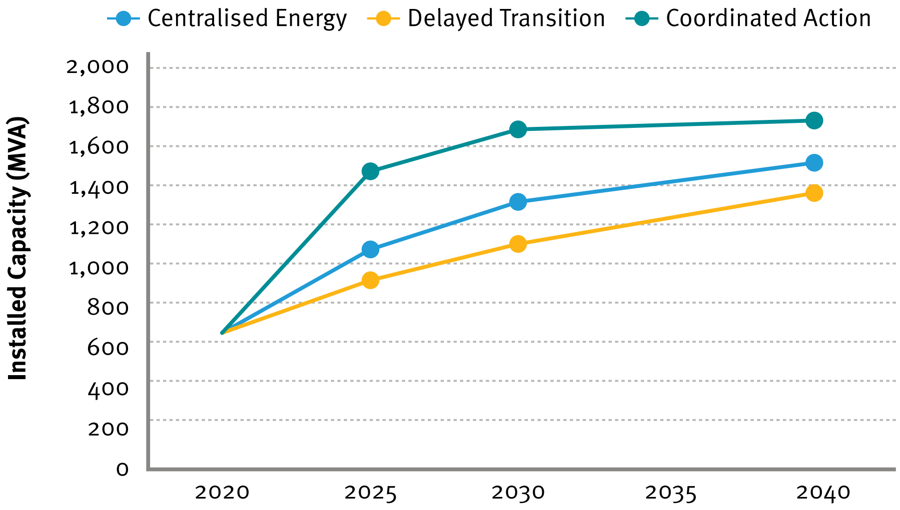


Figure 19: Large energy user maximum import capacity

7. Generation mix

7. Generation mix

The generation portfolio of the future will no doubt be different from today. The EU Clean Energy Package allows for the promotion of “renewable electricity by implementing cost-effective national support schemes subject to State aid rules”. Much of Ireland’s renewable electricity is likely to be from weather-dependent sources. This transition is also bringing changes to electricity markets, with system services and capacity markets now complementing the energy market, the latter itself having changed with the integration of the SEM into the EU Single Electricity Market. When developing assumptions regarding the envelope of installed capacities, per technology, across scenarios and study years, we consider the latest trends in the market, including the Renewable Electricity Support Scheme (RESS) High Level Design[31], the technologies successful in the latest T-4 capacity auction[32], intentions to decommission as summarised in GCS 2019, and other publically available data.

To help describe the size and scale of new generation we categorise by nominal grid voltage level:

i. high voltage transmission-connected

ii. medium voltage distribution-connected, and

iii. low voltage distribution-connected micro generation.

The latter two are categorised as decentralised generation.

Micro generation refers to generation units with a capacity less than 11 kW, including wind turbines, hydro, combined heat and power (CHP), and solar PV[33]. Rooftop solar PV is anticipated to be the most prominent form of micro generation.

The EU Clean Energy Package has established a right for renewable electricity self-consumers to sell excess renewable electricity production. It is expected that this legislation will be transposed into Irish law by June 2021.

7.1. Renewables

7.1.1 Onshore wind

Over 2.5 GW of onshore wind generation has been installed in Ireland over the past decade[34]. Onshore wind remains a highly cost competitive generation source[35]. We assume that onshore wind technologies are successful in securing support in the early RESS auctions. As shown in Figure 20, in all scenarios the rate of increase reduces after 2030, due to market share gains by other renewables. Onshore wind capacity is highest in Coordinated Action, with 8.2 GW connected by 2030.

---

[31] DDCAE, RESS High Level Design
[32] EirGrid Group, Final 2022/2023 T-4 Capacity Action Results Summary
[33] SEAI, Your Guide to Connecting Micro-Generation
[34] EirGrid Group, System and Renewable Data
[35] IRENA, Renewable Power Generation Costs in 2017

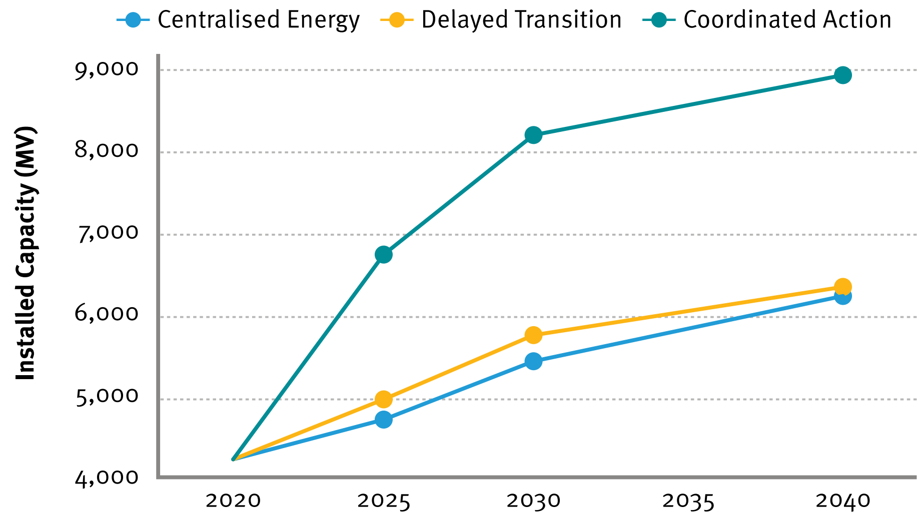


Figure 20: Onshore wind installed capacity

The decentralisation of onshore wind installed capacity is shown in Figure 21. It illustrates that new onshore wind connections to the transmission network remain high across all scenarios. Coordinated Action experiences the highest growth of distribution connections and micro generation.

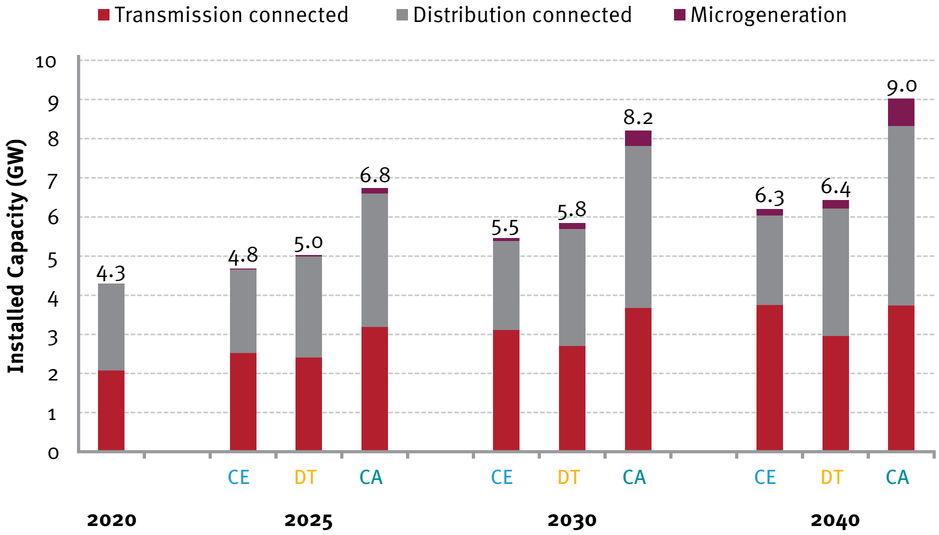


Figure 21: Onshore wind decentralisation

Ireland's earliest onshore wind generators were installed in the early 1990s and approximately 9% of the existing fleet has been in service for more than 20 years. By 2030 almost 35% of the existing installed capacity will exceed 20 years of service. Effective policy for repowering existing wind farms will be an important enabler for decarbonisation of the electricity system and is vital if targets for onshore wind, set out in the climate plan, are to be met.

Figure 22 shows the capacity weighted remaining life of onshore wind generation out to 2040, assuming a repowering age of 20 years. The impact of growth in new capacity can be seen in Coordinated Action by 2025 and in Centralised Energy and Delayed Transition by 2030. However, the average remaining life of the fleet reduces across the 2030s as fewer generators connect and existing fleet ages.

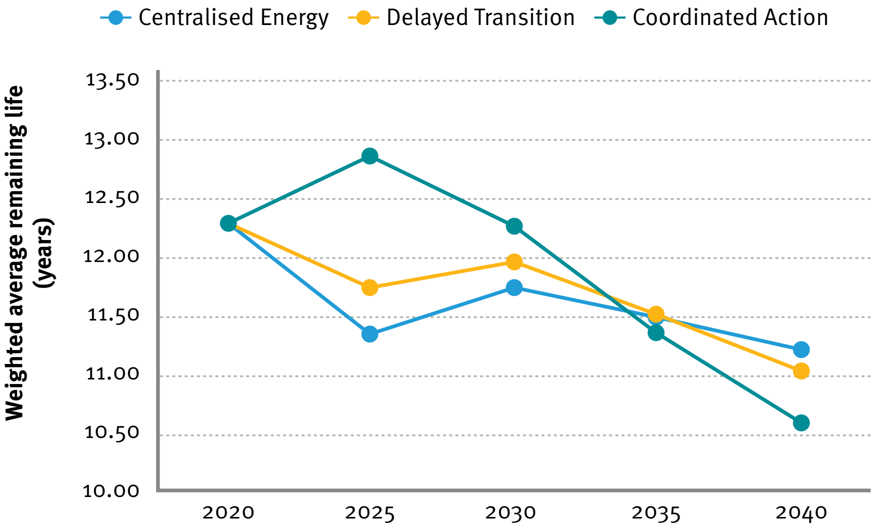


Figure 22: Remaining life of onshore wind capacity

New onshore wind generation is assumed to achieve 4% higher capacity factors compared with the existing fleet. As wind turbine technology becomes more advanced, capacity factors are expected to increase further. Average capacity factors in future scenarios will therefore depend on the age profile of the fleet. As new onshore wind capacity connects, average capacity factors will improve, as illustrated in Figure 23. Improving capacity factors increase the cost competitiveness of the onshore wind as a form of renewable generation.

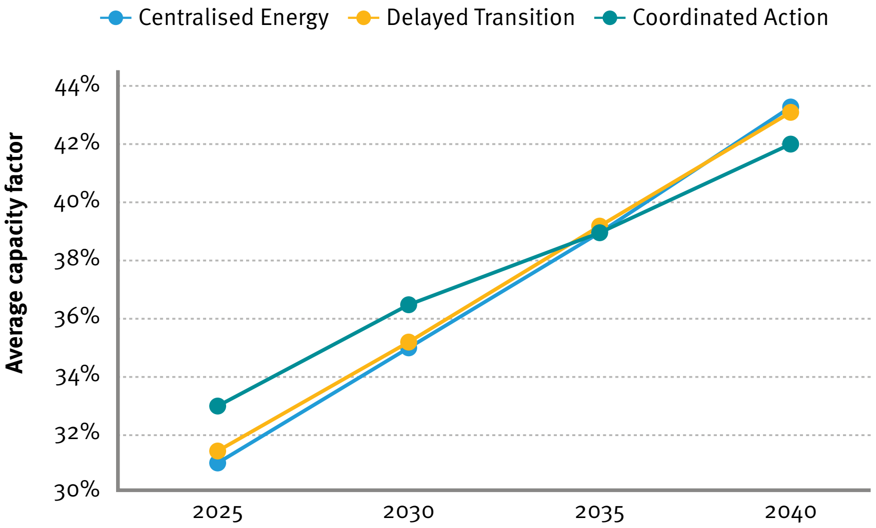


Figure 23: Average capacity factors

7.1.2 Offshore wind

As a variable resource, offshore wind has a relatively high capacity factor. As such, it is seen as playing a significant role in decarbonising electricity in Ireland. There are a number of steps required to deliver high levels of offshore wind generation by 2030[36] and we assume the main increase in offshore wind installations occurs after 2025, as shown in Figure 24.

The largest growth in offshore wind occurs in the plan-led scenario, Centralised Energy. Although a decentralised scenario, a sizeable level of offshore wind is present in Coordinated Action to meet 2030 RES-E targets due to high demand levels. All offshore wind generation is expected to connect to the transmission grid.

---

[36] DCCAE, Climate Action Plan 2019 Annex of Actions

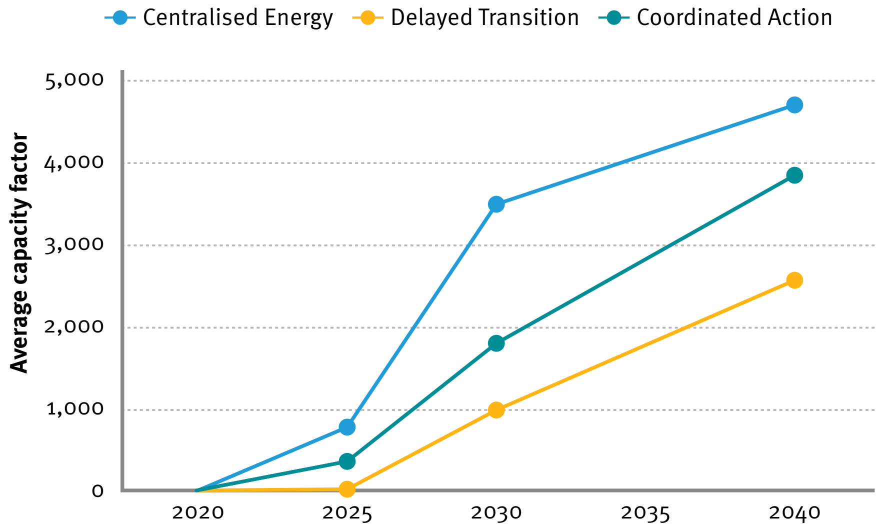


Figure 24: Offshore wind installed capacities

7.1.3 Solar photovoltaics

Over the past decade, solar PV has experienced the highest reduction in levelised cost of energy (LCOE) globally.

The total solar PV capacity, including micro generation, is shown in Figure 25. The largest growth in solar PV occurs in Coordinated Action, with approximately 150 MW of capacity connecting each year out to 2040.

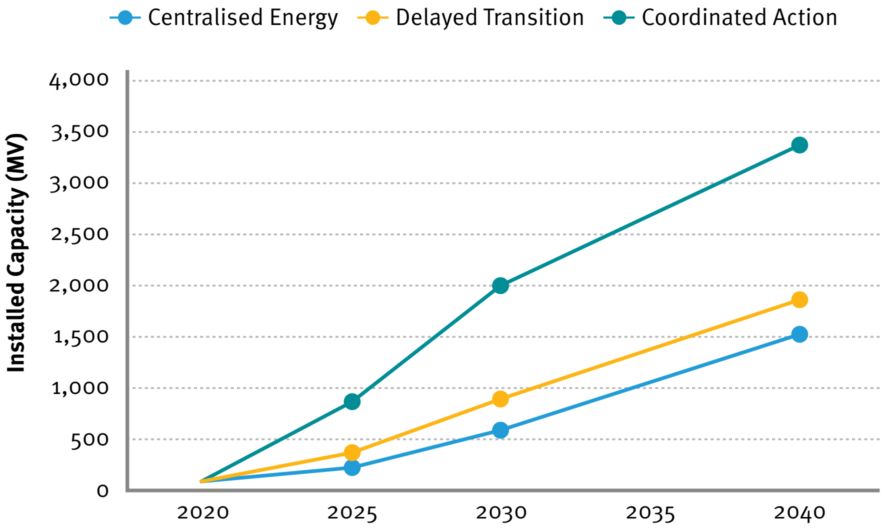


Figure 25: Solar PV installed capacity

The decentralisation of solar PV installed capacity is shown in Figure 26. The growth of solar PV connections to the distribution network, including solar PV micro generation, is highest in Coordinated Action.

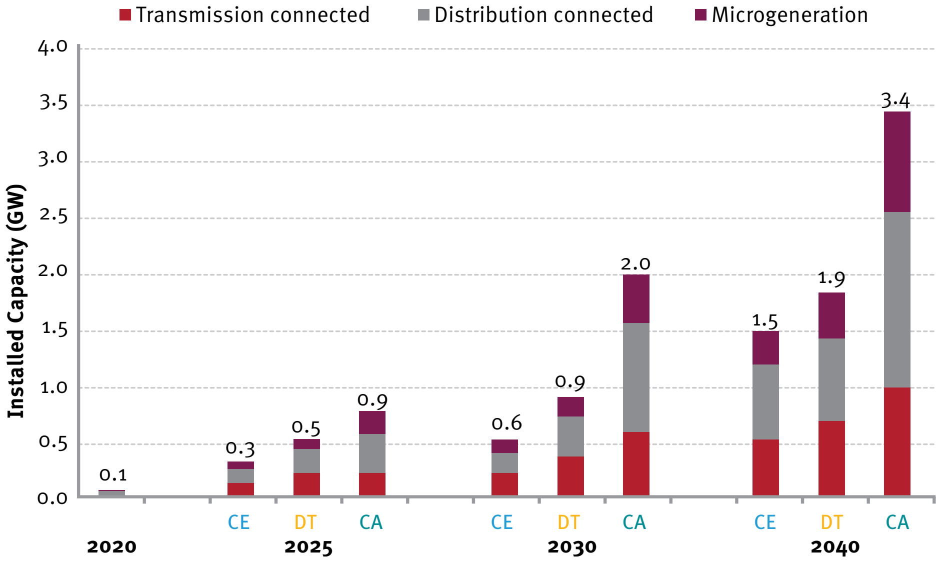


Figure 26: Solar PV decentralisation

7.1.4 Biomass and waste

REFIT 3[37] is designed to incentivise the addition of ~300 MW of renewable electricity from high efficiency combined heat and power (CHP), using both anaerobic digestion and biomass.

In Ireland, we estimate there to be currently 120 MW of generation capacity powered by biomass (excluding the co-firing in the peat stations), biogas and landfill gas as per GCS 2019. There is also 80 MW of waste. We assume a modest growth in biomass CHP across all scenarios. We have also assumed an additional 20-MW waste unit in Coordinated Action by 2030.

Figure 27 shows the cumulative installed capacity from biomass and waste.

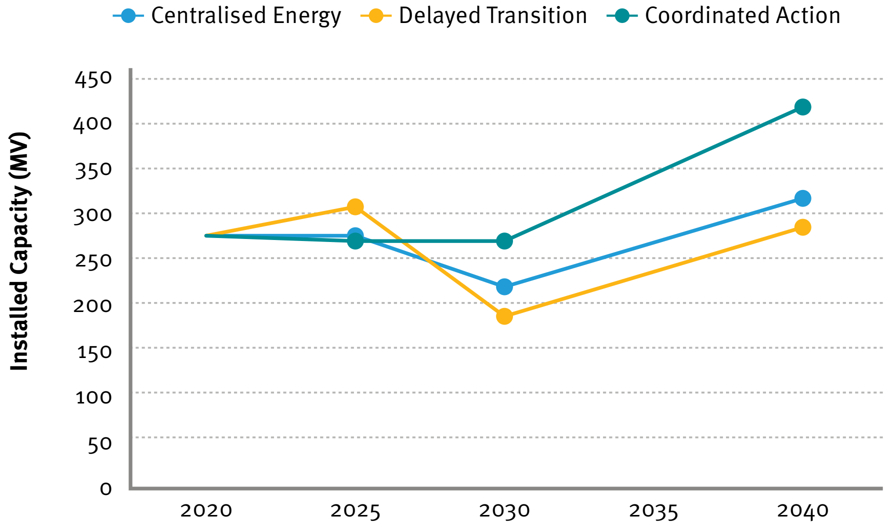


Figure 27: Biomass and waste installed capacity
(including the co-firing share from the peat stations)

---

[37] DCCAE, REFIT 3

7.1.5 Marine

Renewable marine technologies, including both wave and tidal energy devices, are still in the experimental phase, with testing facilities now developed in Ireland. We assume pilot projects are installed in Centralised Energy and Coordinated Action by 2030, and that by 2040 some coastal communities see marine renewables as a way to help meet local energy needs. Figure 28 shows the capacities assumed.

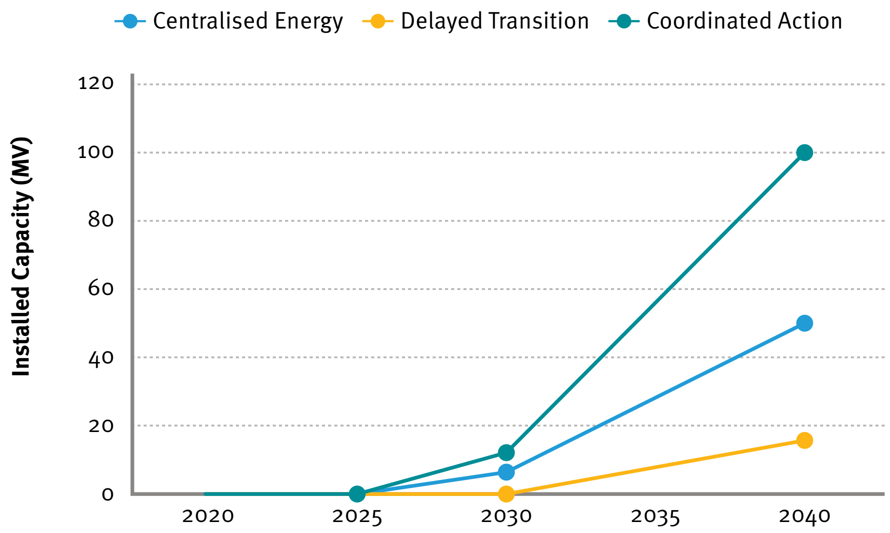


Figure 28: Marine (wave and tidal) installed capacity

We assume no further hydro generation developments in Ireland. We assume that the current hydro generation capacity (238 MW) remains constant throughout all our scenarios. This does not include pumped hydro energy storage. See Section 6.2 for the treatment of storage.

7.1.6 RES-E

RES-E is defined as consumption of electricity from renewable sources divided by consumption of electricity.

We have assumed renewable sources are:

- Renewable generation (wind, water, solar, biomass).
- Waste-to-energy generation, 50% of which is assumed to be renewable.

The capacity factors assumed are shown in Table 8. The existing onshore wind capacity factor is an average of the past five years. Future capacity factors should also reflect the average of inter-annual variations.

Figure 29 displays trends for RES-E for each scenario out to 2040.

Table 8: Average renewable source capacity factors (historical dispatch average used for biomass, waste and hydro)

Technology	Onshore wind	Offshore wind	Solar PV	Biomass & waste	Hydro	Marine (wave & tidal)
Capacity factor (%)	31-43%	45	11	85	35	26

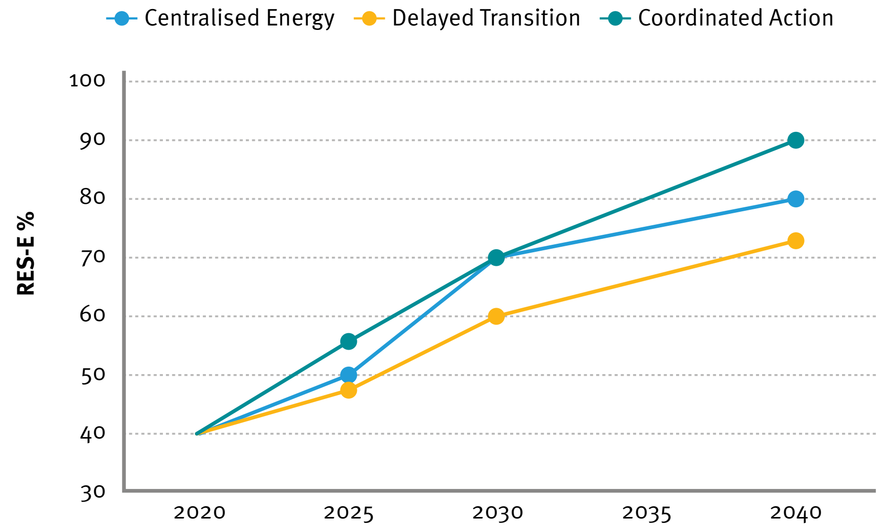


Figure 29: Electricity sourced from renewable energy sources

Achieving Ireland's RES-E targets requires a step change in growth of renewable generation capacity. This is especially true in scenarios with high demand growth, such as Coordinated Action. Figure 30 displays five year rolling averages for connection rates by scenario compared against the five year historical average. Projected connection rates in the period between 2025 and 2030 exceed the historical five year average, in all scenarios.

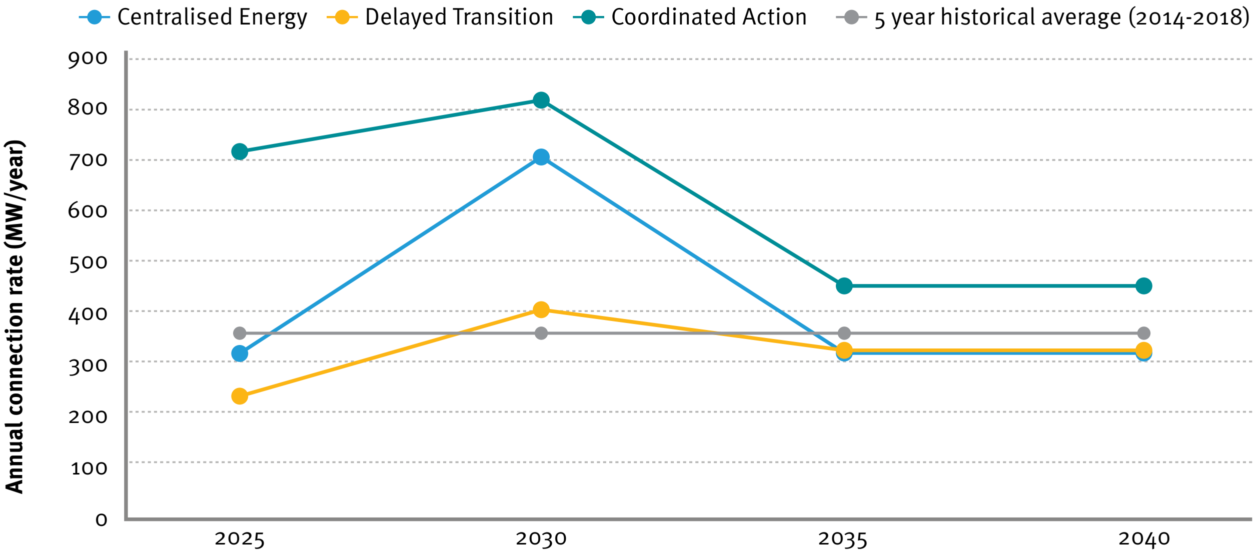


Figure 30: Annual average renewable connection rates

7.2. Fossil fuels

Capacity factors of fossil fuel generation are expected to continue to fall as more renewables are integrated into the electricity system. However, for the foreseeable future, it is likely that fossil fuel generation will continue to supply, fully dispatchable electricity as a back up to weather dependent renewables.

For the 2022/2023 T-4 capacity auction, 82% of the de-rated capacity was provided by gas and steam turbines, the remainder, in descending order, coming from demand-side units, interconnection, pumped hydro storage, hydro, other storage and wind.

7.2.1 Peat

It is expected that electricity generation from peat in Ireland will cease by 2030 at the latest. For the purposes of system needs identification, it is taken that closures occur at the start, rather than the end, of a year.

Uncertainty factors for peat include the planning permission decision for the co-firing with biomass of Shannonbridge and Lanesborough. Delayed Transition assumes that the three peat stations remain open and co-fire at moderate levels beyond 2025, despite uncertainties around planning permission and financial supports. Coordinated Action and Centralised Energy assume that the stations at Shannonbridge and Lanesborough close down before 2025.

7.2.2 Coal

It is expected that coal generation will cease operation in Ireland over the coming years[38]. For the purposes of system needs identification, it is taken that this closure occurs at the start, rather than the end, of the year. Coordinated Action and Centralised Energy assume that the units close down before 2025. Delayed Transition assumes that the three coal units at Moneypoint close after 2025.

7.2.3 Oil

It is expected, and assumed in all scenarios, that the heavy fuel oil generators at Tarbert will cease before our first study year, 2025.

Distillate oil plays two roles in today's electricity system: (i) many peaking generators are fired by distillate oil, and (ii) many generators use distillate as a secondary fuel stock[39] (heavy fuel oil also plays this role for Moneypoint). We refer to the primary fuel stock only.

Figure 31 shows the assumed trajectory for distillate oil generation across the scenarios. Centralised Energy and Coordinated Action assume that all distillate units are closed by 2030. In the case of Centralised Energy, this peaking capacity is mainly replaced by gas-fired generation, battery storage and demand side units (DSUs). Coordinated Action assumes that battery storage and consumer-side flexibility play a large role in replacing peaking generation.

Delayed Transition assumes that distillate generation continues to play a role, though are ultimately replaced.

---

[38] DPER, National Development Plan 2018-2027

[39] EirGrid, Grid Code Version 8

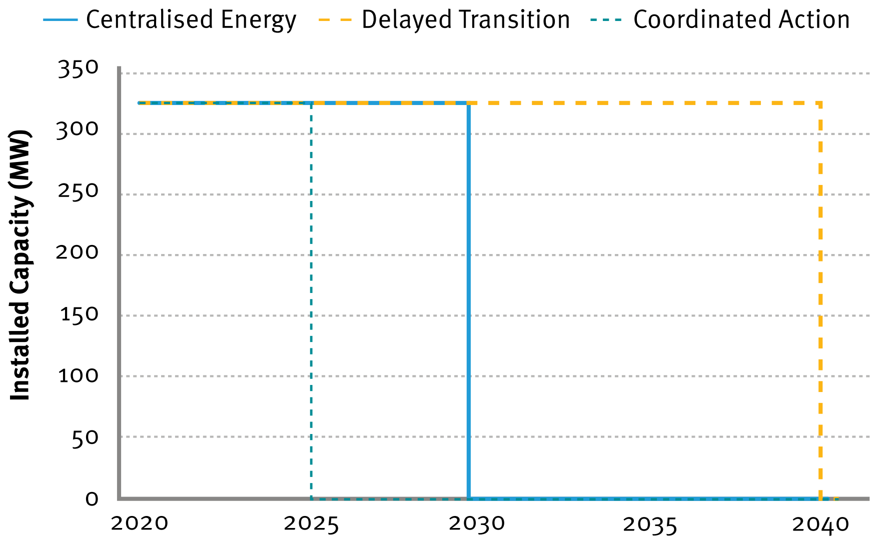


Figure 31: Distillate oil installed capacity

7.2.4 Gas

Natural Gas fuelled power stations are a lower carbon alternative to coal-fired power stations. Low carbon scenarios, such as the IEA WEO 2018 Sustainable Development Scenario[40], often employ increased carbon costs. This makes gas power generation more cost competitive than coal generation for energy production. Natural gas was the largest source of electricity generated in 2018, accounting for 52%, as per the GCS 2019. Natural gas is considered to be a transition fuel in the pathway to a low carbon economy and the decarbonisation of gas supply is a key assumption in us assuming that gas continues to have a strong role in maintaining the demand and supply balance in our scenarios out to 2040.

The composition of gas-fired generation is assumed to be CCGT, OCGT and CHP. Gas-fired generation will be vital in ensuring security of Ireland's electricity supply as integration of renewables continues and planned closures of coal, peat and oil generation stations occur.

Assumptions relating to CCGT and OCGT capacities vary by scenario. We assume the total CCGT capacity to remain constant at ~3 GW in Delayed Transition and reduces slightly in Centralised Energy.

In Coordinated Action, there is a shift toward OCGT post 2030 leading to reductions in CCGT capacity by 2040. OCGTs are a more decentralised form of fully dispatchable generation that provide greater operational flexibility compared to CCGTs.

OCGTs play an increasing role in the provision of flexibility and generation capacity in Coordinated Action over the long term. There is also growth in OCGT capacity in Centralised Energy and Delayed Transition albeit to a lesser extent. Figure 32 shows this assumed trajectory for OCGT capacity.

Gas CHP is assumed to remain constant through the scenarios and study years at the existing total capacity of 291 MW (of which 162 MW is dispatchable).

---

[40] IEA, WEO 2018

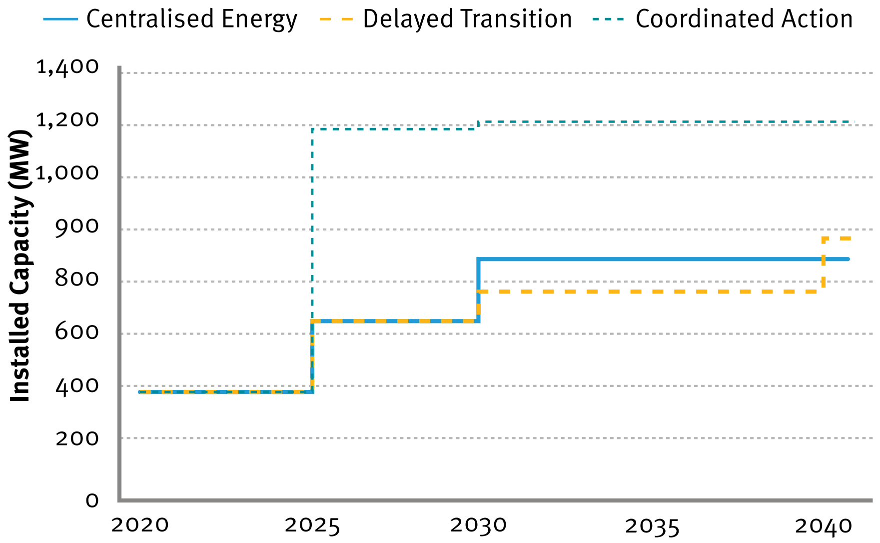


Figure 32: Gas OCGT installed capacity

7.2.5 Carbon capture utilisation and storage

CCUS is the process of capturing, transporting and storing carbon dioxide before it is released into the atmosphere. Up to ~90–99%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. CCUS is one of the seven building blocks for the European Commission's long-term vision.

In the electricity sector, it is assumed that CCUS is deployed on new or existing CCGTs[41]. As shown in Figure 33, we assume that CCUS is operational by 2031 in Centralised Energy. In Coordinated Action, we assume that CCUS comes into operation in 2040. In Delayed Transition we assume no CCUS is deployed. The delayed or non-deployment of CCUS reflects uncertainty factors including what policy, regulatory, legal and business model frameworks make CCUS commercially viable.

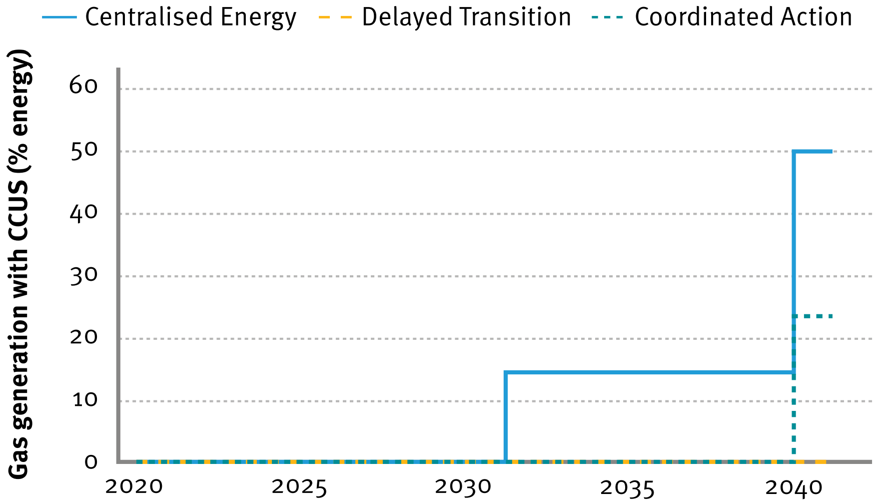


Figure 33: Percentage of gas-fired generation with CCUS

---

[41] Ervia, Carbon Capture Utilisation and Storage

8. Non-generation flexibility mix

8. Non-generation flexibility mix

8.1. Interconnection

Interconnection facilitates the transport of electricity between two transmission systems. It can provide multiple benefits, such as renewable integration (curtailment reduction), wholesale electricity price reduction, capacity adequacy improvement, as well as facilitating the sharing of reserve.

Ireland's current high voltage direct current (HVDC) interconnection is with Great Britain via the EastWest interconnector (EWIC). Ireland also has existing interconnector ties to Northern Ireland that use high voltage alternating current (HVAC). The North South Interconnector project[42], planned for 2023, would increase the total transfer capacity between Ireland and Northern Ireland to 1,100 MW.

The EU has a 2030 interconnection ambition of 15%[43], which for a given EU Member State is calculated by dividing the interconnection import capacity by the installed generation capacity[44]. To help realise this goal, the EU has the PCI process. Our scenario assumptions include three electricity interconnector projects that have PCI status: North South, Celtic and Greenlink. The Celtic and Greenlink projects use HVDC, while North South uses HVAC. In all scenarios we assume North South is commissioned as per project time lines (2023).

Figure 34 illustrates the HVDC interconnection assumptions with France and Great Britain. Centralised Energy assumes that Celtic[45] and Greenlink[46] are built as per project times (2023 for Greenlink, 2026 for Celtic), and that one additional interconnector to Great Britain is built by 2040. Coordinated Action also assumes Celtic and Greenlink are built on time, with two additional interconnectors built by 2040 in order to facilitate higher RES-E levels. Delayed Transition assumes there is a delay in interconnection with Great Britain, with no additional interconnection beyond Greenlink.

When considering the HVAC and HVDC interconnection assumptions, our scenarios meet the 15% ambition for 2030.

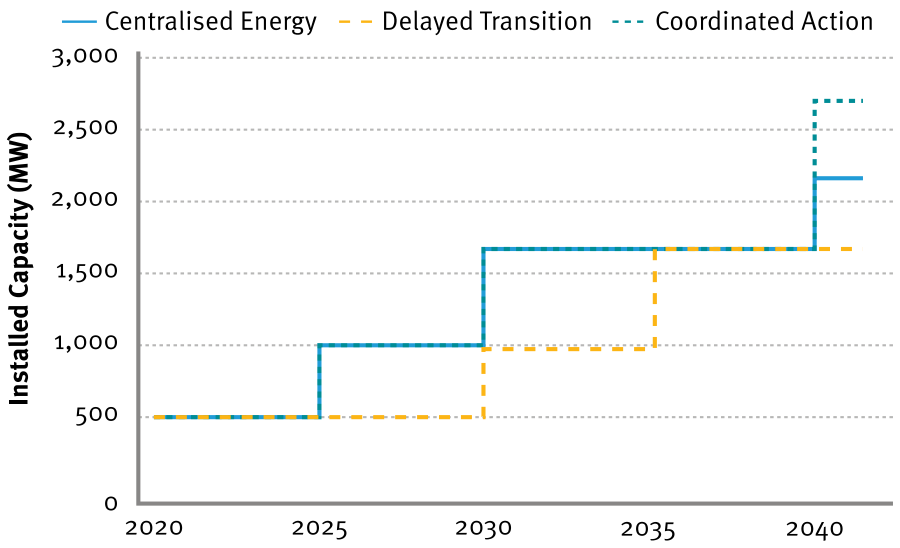


Figure 34: HVDC interconnection capacity with France and Great Britain

---

[42] EirGrid Group, North South 400 kV Interconnection Development
[43] European Commission Expert Group on Electricity Interconnection Targets, Report
[44] European Commission Expert Group on Electricity Interconnection Targets, Report
[45] EirGrid, Celtic Interconnector Project Update Step 3 Consultation
[46] Greenlink Development Ltd, Greenlink Interconnector website

8.2. Storage and Demand Side Management

Sources of flexibility, over multiple time horizons, are required to ensure variable renewables are integrated into the electricity system in a secure and efficient manner.

For TES, storage and demand side management (DSM) volumes are informed by analysing capacity adequacy, flexibility and reserve requirements, all of which are appraised on an all-island basis. Thus, in this regard, TES 2019 Ireland and TES 2019 Northern Ireland should both be consulted together.

Capacity adequacy is evaluated using an 8-hour loss of load expectation (LOLE) standard, as per the GCS. Upward reserve capacity is evaluated based on the largest single infeed. Flexibility is evaluated based on the potential ramps associated with output of the total variable renewable installed capacity.

As well as DSM and battery energy storage, other sources of upward reserve include interconnection when exporting or at zero, interconnection with headroom when importing, Pumped Hydro Energy Storage (PHES), and conventional generation when part-loaded. Other sources of offline flexibility include quick-starting generation.

Figure 35 shows the capacities assumed for battery energy storage (BES), DSM, and power to gas.

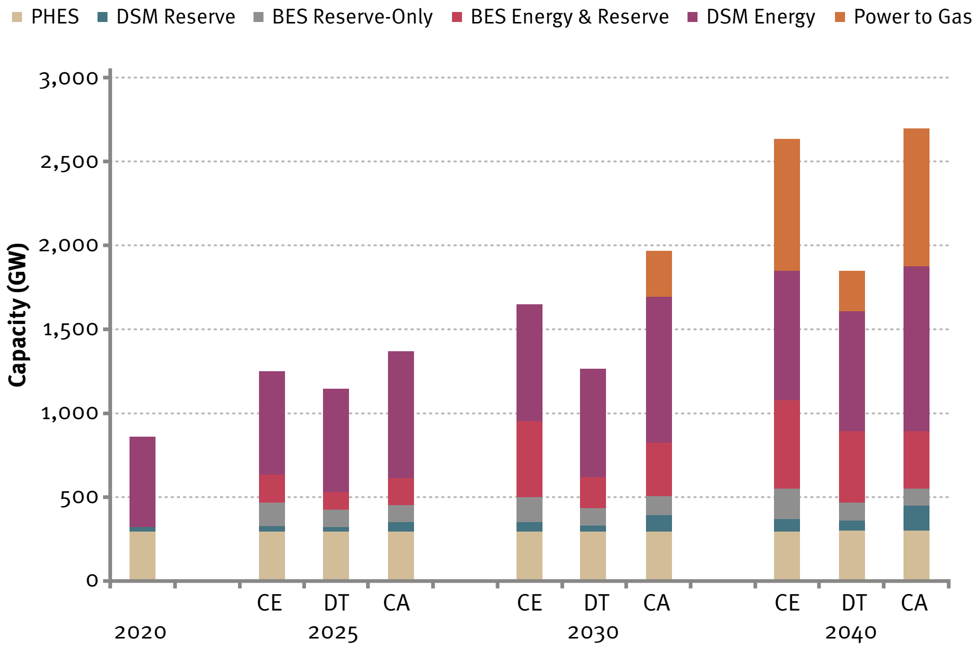


Figure 35: Storage, DSM and Power to Gas installed capacity

We assume that the capacity and availability of DSM reserve provision increases over time in all scenarios, but in particular in Coordinated Action as artificial intelligence and smart meters allow for residential loads to be offered as reserve without loss of customer comfort.

We also assume that DSM fully decarbonises over time. This could mean that on-site/back-up generation switches to a zero-carbon fuel source and/or that sources of demand reduction are available for dispatch.

With respect to battery energy storage, it is assumed that the reserve-only capacity (0.5 hours energy-to-power ratio) saturates at 2025. We assume that batteries connecting post 2025 are capable of providing capacity, flexibility and reserve. These batteries have energy-to-power ratios of 2, 3 and 4 hours if installed for 2025, 2030 and 2040, respectively. This means that the flexible (not reserve-only) battery capacity fleet's average energy-to-power ratio approximately increases from 2 hours to 2.67 hours to 3.33 hours between study years.

Power to gas is an enabler of sector-coupling and experiences growth in scenarios with high demand for renewable gas, such as Coordinated Action. As seen from the electricity system, power to gas is a load increase. Such a form of flexibility becomes beneficial during times when variable renewable curtailment would otherwise occur, thereby increasing realised renewable energy capacity factors.

9. Locations

9. Locations

This section outlines the assumptions regarding where various demand technologies, generation technologies and HVDC interconnection may connect in the future. Modelling future locations enables us to identify potential areas of stress on the network which require further investigation.

9.1. Ireland's regions

EirGrid uses regions to help communicate the development of the transmission system in Ireland. These eight regions[47] are illustrated in Figure 36. These regions are used to display locations assumptions for different technologies.

Figure 36: Ireland's regions as per the Nomenclature of Territorial Units for Statistics (NUTS) 3 classification. The three Assembly regions, Northern and Western; Eastern and Midlands; and Southern, are groupings of these NUTS 3 regions.

9.2. Generation locations

Future generation locations are modelled using a number of information sources which vary depending on generation technology type, as shown in Table 11. Data contained within these sources are used to estimate potential future generation connection patterns and locations on the grid.

Future generation connection patterns are linked to the generation location storylines:

---

[47] Ordnance Survey Ireland, NUTS 3

Centralised Energy: This plan-led scenario is influenced by the National Planning Framework and the objective to develop RES in state owned land. Onshore wind locations are mostly informed by project pipeline information. There is also opportunity based development with offshore wind generation connecting to areas of the transmission grid with available capacity. Available capacity is identified based on the results of the East Coast Generation Opportunity Assessment. Population growth projections have been used to determine potential locations for micro generation, particularly solar PV.

Delayed Transition: The pattern of RES connections is expected to follow those observed in recent years with locations mostly chosen by developers. Planning applications provide insight in the potential locations of future grid connections. Decentralisation does not change significantly in this scenario as the proportions of distribution and transmission connected generation stays consistent over time.

Coordinated Action: Although high rates of generator connections to the transmission network continue, there is an increase in connections to the distribution network, supported by community led components of the RESS and growth in micro-generation. Potential locations for community projects and microgeneration are influenced by existing RES locations and population growth projections. Onshore wind locations are informed by project pipeline information.

Table 11: Generation location information sources

Technology	Source
Onshore wind	• Project pipeline data[48] • Grid connection applications • Historical nodal electricity demand
Offshore wind	• Grid connection applications • *East Coast Generation Opportunity Assessment*[49] • *Offshore Renewable Energy Development Plan*[50]
Solar PV	• Grid connection applications • Historical nodal electricity demand • Regional population projections[51]

9.2.1 Onshore wind

The regional distribution of onshore wind installed capacity is shown in Table 12 for each scenario and year.

---

[48] IWEA, Project Pipeline Summary
[49] EirGrid, East Coast Generation Opportunity Assessment
[50] DCCAE, Offshore Renewable Energy Development Plan
[51] CSO, Population Projections 2017–2051

Table 12: Onshore wind capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	994	1,030	1,347	1,120	1,175	1,604	1,201	1,276	1,718
Dublin	1	1	1	1	1	1	1	1	1
Mid-East	104	117	231	152	170	338	182	205	429
Midland	331	385	862	465	520	1,074	569	624	1,160
Mid-West	776	801	1,028	874	917	1,242	935	995	1,354
South-East	343	357	478	396	419	598	429	460	672
South-West	1,417	1,446	1,695	1,554	1,616	2,020	1,630	1,725	2,190
West	834	862	1,108	937	982	1,324	1,001	1,064	1,426
Total	**4,800**	**5,000**	**6,750**	**5,500**	**5,800**	**8,200**	**5,950**	**6,350**	**8,950**

It is expected that some onshore wind farms will repower in the future as existing assets reach end-of-life[52]. Future repowered sites have been assumed using installed dates and an average expected life of 20 years. Repowering assumptions are constant for all scenarios, with the regional distribution displayed in Table 13.

Table 13: Onshore wind repowered locations (MW)

Region	**2025**	**2030**	**2040**
Border	135	270	245
Dublin	-	-	-
Mid-East	25	-	50
Midland	-	-	105
Mid-West	35	90	535
South-East	40	120	105
South-West	30	400	780
West	90	20	395
Total	**355**	**900**	**2,215**

---

[52] IWEA, Repowering report

9.2.2 Offshore wind

The regional distribution of offshore wind installed capacity is shown in Table 14 for each scenario and year.

Table 14: Offshore wind capacity locations (MW)

	2025			2030			2040		
Region	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
Border	-	-	-	130	73	67	515	186	143
Dublin	406	-	160	1,248	181	637	1,175	459	1,373
Mid-East	444	25	190	1,778	553	920	1,676	1,365	1,954
Midland	-	-	-	-	-	-	-	-	-
Mid-West	-	-	-	208	117	106	365	297	229
South-East	-	-	-	-	-	-	337	-	-
South-West	-	-	-	-	-	-	281	-	-
West	-	-	-	136	76	70	353	194	150
Total	**850**	**25**	**350**	**3,500**	**1,000**	**1,800**	**4,700**	**2,500**	**3,850**

The Offshore Renewable Energy Development Plan identified considerable potential for floating offshore wind energy development off the south, west and north coasts of Ireland. Up to 3.3 GW of installed capacity is currently in early project development phases. It is assumed that plan-led connections of floating offshore wind farms will occur from 2031 as part of Centralised Energy. A regional distribution of floating wind farm installed capacity in 2040 is provided in Table 15.

Table 15: Floating offshore wind installed capacity, Centralised Energy (MW)

Region	**2040**
Border	393
Dublin	-
Mid-East	-
Midland	-
Mid-West	168
South-East	337
South-West	281
West	224
Total	**1,403**

9.2.3 Solar PV

The regional distribution of solar PV installed capacity is shown in Table 16 for each scenario and year.

Table 16: Solar PV capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	8	12	18	17	25	49	42	51	77
Dublin	24	38	87	45	74	170	148	176	995
Mid-East	69	104	176	138	207	436	346	427	427
Midland	53	79	132	107	159	336	254	316	267
Mid-West	15	23	57	31	46	119	77	95	229
South-East	79	117	234	159	236	546	380	472	590
South-West	32	48	102	63	95	226	159	196	427
West	19	29	45	39	58	118	94	116	102
Total	**300**	**450**	**850**	**600**	**900**	**2,000**	**1,500**	**1,850**	**3,400**

9.2.4 Gas generation

The regional distribution of dispatchable gas generation installed capacity is shown in Table 17 for each scenario and year.

Table 17: Dispatchable gas generation locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	-	-	-	-	-	-	-	-	-
Dublin	2,061	2,061	2,626	1,941	2,301	1,924	1,941	2,401	1,924
Mid-East	-	-	-	-	-	-	-	-	-
Midland	-	-	-	100	-	100	100	100	100
Mid-West	162	162	162	162	162	162	162	162	162
South-East	431	431	431	431	431	431	431	431	431
South-West	1,055	1,055	1,055	875	965	875	875	975	875
West	400	400	400	400	400	400	400	400	400
Total	**4,109**	**4,109**	**4,674**	**3,909**	**4,259**	**3,892**	**3,909**	**4,469**	**3,892**

9.3. Demand locations

Future electricity demand locations are influenced by the electrification of heat and transport and increasing levels of digitalisation. Some of the information sources used to project future demand locations are shown in Table 18. Patterns of future demand growth, and their locations, are linked to the demand location storylines:

Centralised Energy: The National Planning Framework objective of promoting regional growth in Ireland influences the demand locations in this scenario. A Government statement[53] on data centres discusses their role in meeting regional policy objectives and the intention to adopt a plan-led approach to data centre development ensuring suitable locations are promoted for investment minimising the need for deep reinforcement of the electricity grid.

Delayed Transition: Data centre connection patterns follow those observed in recent times with demand growth mostly occurring in Dublin and the Mid-East. This developer led growth primarily reflects locations detailed in grid connection applications. Future locations of heat pumps are established using regional projections for population growth as a proxy for new housing development.

Coordinated Action: Decentralisation of demand is highest in this scenario mainly driven by growth in smaller scale 'edge' data centres which are expected to connect mostly in urban areas. Electric vehicle growth is highest in this scenario – the locations of the associated electricity demand is expected to increase pro rata based on underlying residential and tertiary electricity demand.

Table 18: Demand location information sources

Technology	Source
Data centres	• Grid connection applications • *National Planning Framework*
Electric vehicles	• Regional population projections • Historical nodal electricity demand
Heat pumps	• Regional population projections • Historical nodal electricity demand

9.3.1 Large energy users

The regional distribution of large energy user import capacity is shown in Table 19 for each scenario and year.

Table 19: Large energy user maximum import capacity locations (MVA)

	2025			2030			2040		
Region	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
Border	-	-	-	72	-	82	83	-	85
Dublin	864	713	1,074	892	888	1,113	1,022	1,113	1,150
Mid-East	196	213	406	223	213	318	256	267	328
Midland	-	-	-	-	-	-	-	-	-
Mid-West	-	-	-	43	-	49	49	-	51
South-East	-	-	-	11	-	-	12	-	-
South-West	-	-	-	54	-	70	62	-	73
West	-	-	-	14	-	47	16	-	48
Total	**1,060**	**925**	**1,480**	**1,310**	**1,100**	**1,680**	**1,500**	**1,380**	**1,735**

---

[53] DBEI, The Role of Data Centres in Ireland's Enterprise Strategy

9.3.2 Electric vehicles

The regional distribution of EV energy demand is shown in Table 20 for each scenario and year. This includes passenger vehicles (battery and plug-in hybrid), delivery vans, light trucks and buses.

Table 20: EV annual energy demand locations (TWh)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	0.07	0.03	0.19	0.29	0.10	0.46	0.67	0.39	0.67
Dublin	0.20	0.08	0.49	0.76	0.26	1.22	1.78	1.04	1.79
Mid-East	0.09	0.04	0.22	0.33	0.11	0.53	0.78	0.46	0.78
Midland	0.05	0.02	0.11	0.18	0.06	0.28	0.41	0.24	0.41
Mid-West	0.05	0.02	0.13	0.21	0.07	0.33	0.48	0.28	0.48
South-East	0.08	0.03	0.19	0.29	0.10	0.47	0.68	0.40	0.69
South-West	0.10	0.04	0.25	0.39	0.13	0.62	0.91	0.53	0.91
West	0.06	0.03	0.16	0.24	0.08	0.38	0.56	0.33	0.56
Total	**0.69**	**0.29**	**1.74**	**2.68**	**0.90**	**4.30**	**6.27**	**3.68**	**6.29**

9.3.3 Heat pumps

The regional distribution of residential air source heat pump energy demand is shown in Table 21 for each scenario and year.

Table 21: Residential air source heat pump annual energy demand locations (TWh)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	0.09	0.07	0.14	0.12	0.09	0.20	0.25	0.20	0.39
Dublin	0.43	0.33	0.71	0.59	0.45	0.95	1.20	0.96	1.92
Mid-East	0.20	0.15	0.33	0.29	0.22	0.47	0.59	0.47	0.94
Midland	0.11	0.08	0.17	0.16	0.12	0.26	0.32	0.26	0.51
Mid-West	0.04	0.03	0.06	0.04	0.03	0.07	0.09	0.07	0.14
South-East	0.12	0.09	0.20	0.17	0.13	0.27	0.34	0.27	0.55
South-West	0.17	0.13	0.28	0.24	0.18	0.38	0.48	0.38	0.77
West	0.04	0.03	0.07	0.05	0.04	0.08	0.10	0.08	0.15
Total	**1.19**	**0.91**	**1.96**	**1.65**	**1.27**	**2.67**	**3.38**	**2.68**	**5.37**

9.4. Interconnection locations

The regional distribution of HVDC interconnection is shown in Table 22 for each scenario and year.

Table 22: HVDC capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	-	-	-	-	-	-	-	-	-
Dublin	500	500	500	500	500	500	500	500	500
Mid-East	-	-	-	-	-	-	500	-	500
Midland	-	-	-	-	-	-	-	-	-
Mid-West	-	-	-	-	-	-	-	-	-
South-East	500	-	500	500	-	500	500	500	1000
South-West	-	-	-	700	700	700	700	700	700
West	-	-	-	-	-	-	-	-	-
Total	**1,000**	**500**	**1,000**	**1,700**	**1,200**	**1,700**	**2,200**	**1,700**	**2,700**

10. Dispatch modelling results

10. Dispatch modelling results

As TSO, EirGrid has obligations with regard to the process of scheduling and dispatching (‘dispatch’) resources to meet electricity demand[54]. This includes ensuring operational security, the efficient operation of the SEM and providing transparency via reporting and monitoring.

As part of this process, we employ operational constraints, also referred to as transmission constraint groups (TCGs). These are rule sets that ensure that a dispatch produced is technically feasible, within safe and secure operating boundaries, and flexible enough for operators to respond to forecast errors and real time events. These rule sets can result in reducing the output of generation, including renewable energy sources, an action referred to as dispatch down.

Dispatch down, as outlined in our Annual Renewable Constraint and Curtailment Report[55], is categorised in two forms: ‘curtailment’, which is related to system-level aspects, e.g. reserve, and ‘constraint’, which is related to local-level aspects, e.g. grid capacity in a particular area. In TES, no dispatch down due to local constraint is modelled: the dispatch-down levels reported are solely curtailment. However, the *TES System Needs Assessment* will identify locations where constraint may occur in the future.

In order to achieve the 70% RES-E target by 2030, as outlined in the Climate Action Plan 2019, changes to how we ensure operational security during the dispatch process are required. For example, the TCGs may need to be adapted over time. There are a myriad of ways this could potentially be achieved. For example a TCG could be satisfied by new resources and/or by retrofitting existing assets, or the TCG itself could be removed by installing new technologies in appropriate network locations.

A programme of work, replacing DS3[56], will be undertaken in the future to identify the operational change required in order to achieve RES-E and CO2 reduction targets. While *TES* does not in any way outline the preferred or optimal path for TCGs, assumptions are made in order to achieve RES-E and CO2 reduction targets.

An overview of the assumptions taken in dispatch modelling is outlined in Table 23. Note that for 2040 no TCGs are included. Also note that the reductions in limits associated with some existing TCGs, in addition to an enhanced future portfolio, are related to the delivery of the North South Interconnector and new tools in the National Control Centre, among others.

It is assumed that the SNSP limit increases over time and that the inertia limit lowers over time. Across all scenarios, it assumed that the operational RoCoF limit increases to 1 Hz/s. In Centralised Energy and Coordinated Action, synchronous condensers are included in the RoCoF constraint, helping to reduce curtailment associated with inertial requirements.

---

[54] EirGrid Group, TSO Scheduling
[55] EirGrid Group, Annual constraint and curtailment report 2018
[56] EirGrid Group, DS3

It is also assumed that conventional plant continue to lower their minimum generation level, which helps reduce curtailment associated with the minimum number of conventional units online. Across all scenarios it is taken that the minimum number of conventional units required online reduces significantly from today. There is also no limit on the reserve allowed from non-synchronous technologies such as battery energy storage, DSM and interconnection, which helps reduce the curtailment associated with reserve requirements.

Table 23: TES dispatch modelling assumptions

	CE2025	**DT2025**	**CA2025**	**CE2030**	**DT2030**	**CA2030**
SNSP upper limit (%)	80	75	80	95	80	95
Inertia lower limit (MWs)	15,000	17,500	15,000	None	15,000	None
RoCoF upper limit (Hz/s)	1	1	1	1	1	1
Limit on reserve from non-synchronous sources (e.g. batteries, DSM, interconnection, etc.)	No	No	No	No	No	No
Reductions from today in the minimum generation output of large generating units	Yes	Yes	Yes	Yes	Yes	Yes
Inertia provision from non-generation resources (e.g. synchronous condensers, etc.)	No	No	No	Yes	No	Yes
Jurisdictional reserve requirements	No	No	No	No	No	No
Minimum number of conventional units, Ireland	3	3	3	2	2	2
Minimum number of conventional units, Northern Ireland	2	2	2	2	2	2

10.1. RES-E and CO2 emissions

The RES-E results from the dispatch modelling are shown in Figure 37. With high growth in large energy user demand between 2020 and 2025, RES-E levels in Centralised Energy and Community Action are less than 55%, which is the mid-way point assuming linear interpolation between the 2020 and 2030 RES-E targets. Note that in order to facilitate an annual 70% RES-E target, the electricity system may need to be able to facilitate hourly RES-E levels in excess of double the annual figure.

As well as the energy demand provided by renewables, interconnector flows have an impact on the RES-E level attained. If there are net imports to Ireland from neighbouring jurisdictions, the RES-E level achieved is lower than that if there are net exports from Ireland (all else being equal). As interconnection increases, how future portfolio changes in neighbouring systems affect interconnector flows and hence the RES-E level will be a topic of growing importance.

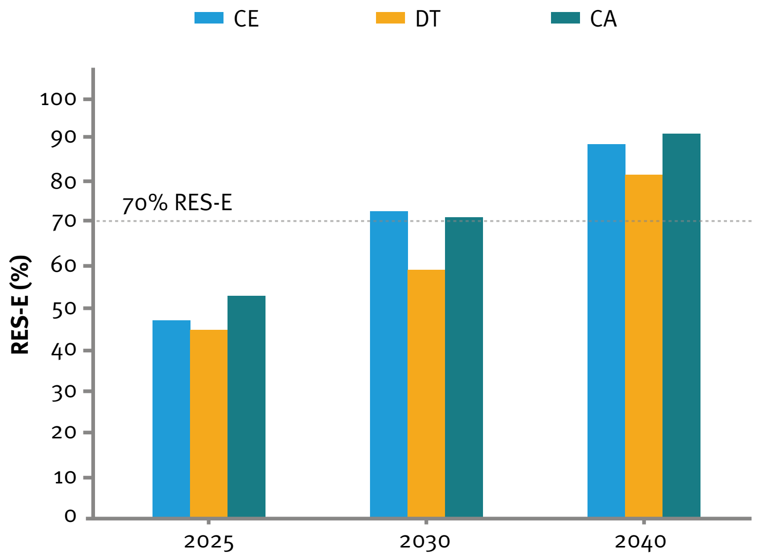


Figure 37: Annual RES-E level

CO2

The CO2 results, shown in Figure 38, are presented in two metrics: (a) CO2 emissions from electricity generation in Ireland and (b) the intensity of that CO2 emission.

While all scenarios reach a similar CO2 emission level in 2030, the cumulative emissions between 2020 and 2030 for Centralised Energy and Coordinated Action is lower than Delayed Transition, due to earlier closure of peat and coal generation.

With significantly lower demand in Delayed Transition, it achieves a similar level of CO2 reduction in comparison to Centralised Energy and Coordinated Action. However, with significantly higher levels of heat and transport electrification in the latter two scenarios, the electricity system has helped facilitate the decarbonisation of heat and transport.

The flat-lining of CO2 emissions between 2030 and 2040 in Delayed Transition highlights the need for decarbonising back-fill generation. If decarbonisation of the gas supply and post-combustion capture technology do not occur at the required pace and scale, other forms of zero-carbon dispatchable capacity will be required for deep decarbonisation of the electricity system.

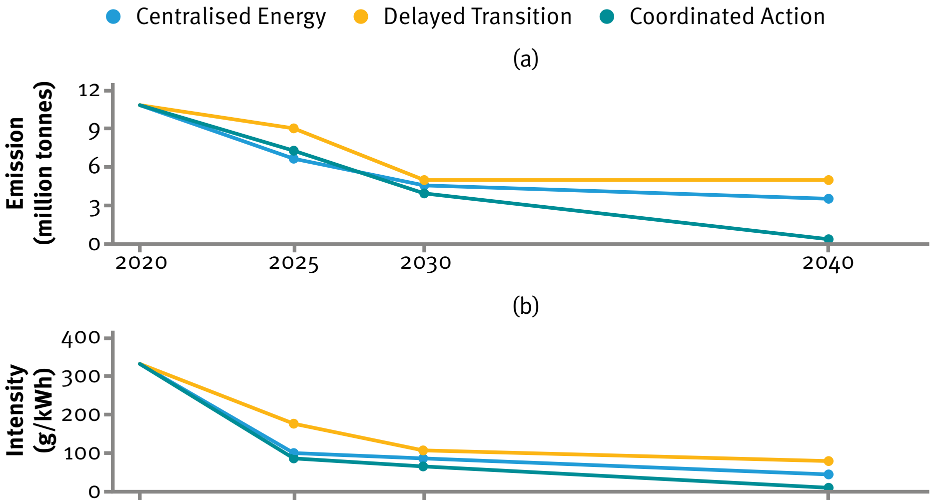


Figure 38: Annual CO2 (i) emission and (ii) intensity

Curtailment

Figure 39 presents the curtailment levels seen in the scenarios. In broad terms, curtailment follows installed variable renewable capacity. Solar PV experiences the lowest level of curtailment due to the lower correlation between its availability and wind.

Albeit reaching only 60% RES-E, Delayed Transition has a curtailment level close to Centralised Energy and Coordinated Action due to less interconnection and less development on relaxing TCGs.

Curtailment levels fall or nearly-saturate between 2030 and 2040 due to deployment of power to gas, the increase in interconnection to neighbouring systems and due to the removal of TCGs in the 2040 study year.

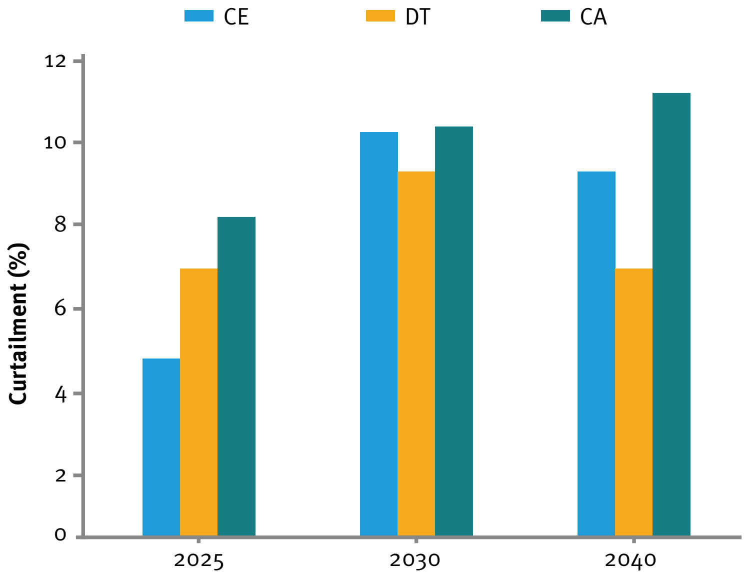


Figure 39: Annual variable renewable curtailment

Production

A summary of the schedule, on an annual energy basis, per fuel-type, is shown in Figure 40. Other Renewables includes hydro and marine, storage includes pumped hydro and batteries.

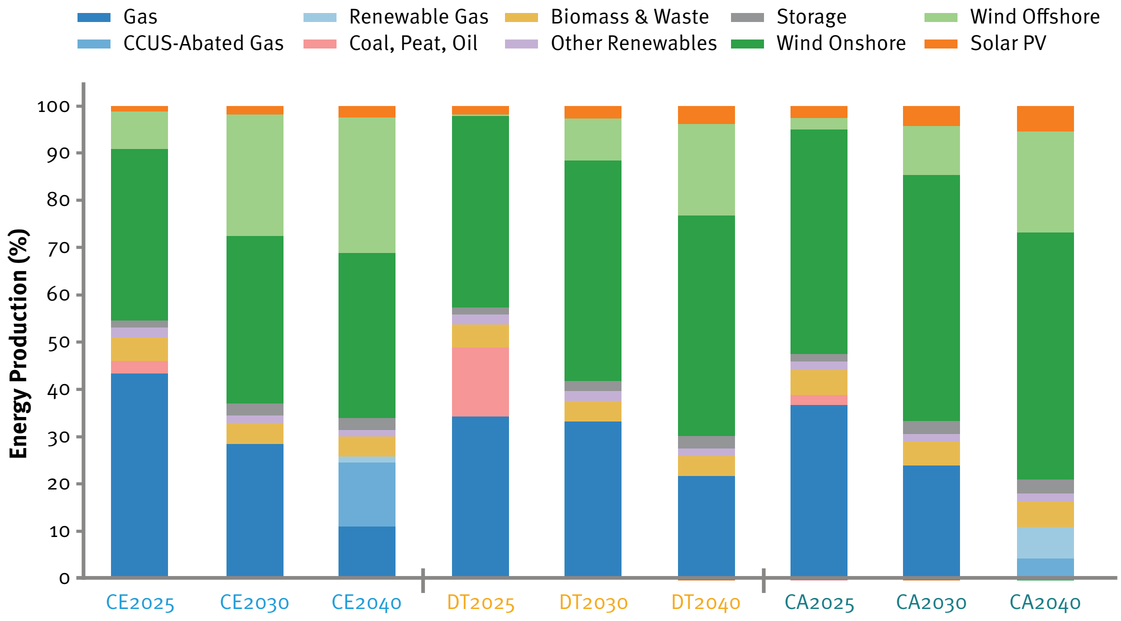


Figure 40: Annual electrical energy production shares

11. Next steps

11. Next steps

We will now use the final scenarios, detailed in this report, to conduct a number of different power system studies for each scenario out to 2040. These studies will help us identify any future needs on the transmission system brought about by changes in electricity generation, electricity demand, electricity storage or interconnection.

The results will be presented in TES 2019 System Needs Assessment report which will be published in December 2019. This report will conclude the current scenario development cycle.

Our biennial scenario development cycle will begin again in 2021 as work begins on TES 2021. We look forwarding to engaging with our stakeholders as part of TES 2021 scenario development.

For more information on TES, please visit our Energy Future website. Alternatively, you can email your views on TES to scenarios@eirgrid.com and one of our team will be in touch.

12. Appendix

12. Appendix

The following tables summarise some of the key generation and demand components of TES 2019.

Table A-1: Generation mix summary (MW)

	2025			2030			2040		
Technology/Fuel	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
OCGT (gas)	650	650	1,200	900	800	1,200	900	1,000	1,200
Distillate oil	300	300	0	0	300	0	0	0	0
CCGT	3,300	3,300	3,300	2,850	3,300	2,500	2,850	3,300	2,500
Steam turbine*	75	1100	100	40	40	50	40	40	50
CHP*	350	350	350	350	350	350	350	350	350
Coal	0	850	0	0	0	0	0	0	0
Peat	35	220	60	0	0	0	0	0	0
Waste*	40	40	40	40	40	50	40	40	50
Renewables	6,460	6,045	8,460	9,660	8,130	12,520	12,755	11,245	16,935
Total (MW)	**11,135**	**11,745**	**13,410**	**13,800**	**12,920**	**16,620**	**16,895**	**15,935**	**21,035**

*Fossil fuel or non-renewable component.

Table A-2: Renewable generation mix summary (MW)

	2025			2030			2040		
Renewables	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
Onshore wind	4,800	5,000	6,750	5,500	5,800	8,200	5,950	6,350	8,950
Offshore wind	850	50	50	3,500	1,000	1,800	4,700	2,500	3,850
Solar	300	450	850	600	900	2,000	1,500	1,850	3,400
Biomass*	270	305	270	215	190	270	315	290	395
Hydro**	240	240	240	240	240	240	240	240	240
Marine***	0	0	0	5	0	10	50	15	100
Total (MW)	**6,460**	**6,045**	**8,460**	**10,060**	**8,130**	**12,520**	**12,755**	**11,245**	**16,935**

*Including renewable waste, biogas, landfill gas, co-firing in the peat stations.
**Not including pumped hydroelectric storage. ***Wave and tidal.

Table A-3: Demand mix summary (TWh)

	2025			2030			2040		
TER*	CE	DT	CA	CE	DT	CA	CE	DT	CA
Transport	0.7	0.3	1.7	2.7	0.9	4.3	6.3	3.7	6.3
Residential	8.8	8.5	9.0	9.0	8.6	9.1	10.3	10.0	11.8
Industry	17.9	16.9	20.8	19.5	17.9	22.0	20.5	19.6	21.8
Tertiary	7.3	7.2	7.2	7.4	7.2	7.2	6.9	6.9	6.4
Losses	2.5	2.4	2.7	2.7	2.5	2.9	3.1	2.8	3.2
Total (TWh)	**37.2**	**35.3**	**41.4**	**41.3**	**37.2**	**45.5**	**47.1**	**43.0**	**49.5**

*TER: total electricity requirement.

Table A-4: Storage, DSM and Power to Gas mix summary (MW)

	2025			2030			2040		
Storage & DSM Data	CE	DT	CA	CE	DT	CA	CE	DT	CA
DSM Energy	620.0	620.0	700.0	750.0	620.0	900.0	800.0	750.0	1,000.0
BES Energy & Reserve	160.0	100.0	200.0	450.0	200.0	300.0	500.0	400.0	300.0
DSM Reserve	26.4	23.1	50.0	50.0	36.0	100.2	90.0	60.0	150.0
BES Reserve-Only	150.0	110.0	110.0	150.0	110.0	110.0	150.0	110.0	110.0
Power to Gas	0.0	0.0	0.0	0.0	0.0	280.0	800.0	220.0	860.0
PHES	292.0	292.0	292.0	292.0	292.0	292.0	292.0	292.0	292.0
Total (MW)	**1,248.4**	**1,145.1**	**1,352**	**1,692**	**1,258**	**1,982.2**	**2,632**	**1,832**	**2,712**

EIRGRID

The Oval, 160 Shelbourne Road, Ballsbridge, Dublin D04 FW28 • Telephone: 01 677 1700 • www.eirgrid.com

Printed on recycled paper