Tomorrow's Energy Scenarios 2019 Consultation Ireland

Planning our Energy Future

EIRGRID

The current. The future.

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Table of contents

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

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

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

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

Decarbonisation
The level of 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 and which 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.

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 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.

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.

1. Introduction

1. Introduction

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.

1.1. What are the Tomorrow's Energy Scenarios?

Our Tomorrow's Energy Scenarios (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 our TES 2017 publications on our Energy Future webpage. For the 2019 series, scenario development has been expanded to cover Ireland and Northern Ireland. We will be consulting on TES 2019 Northern Ireland later in the year. When the TES 2019 scenarios are finalised, we will test the performance of the electricity transmission grid under our scenarios and publish the results in the *TES 2019 System Needs Assessment*.

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

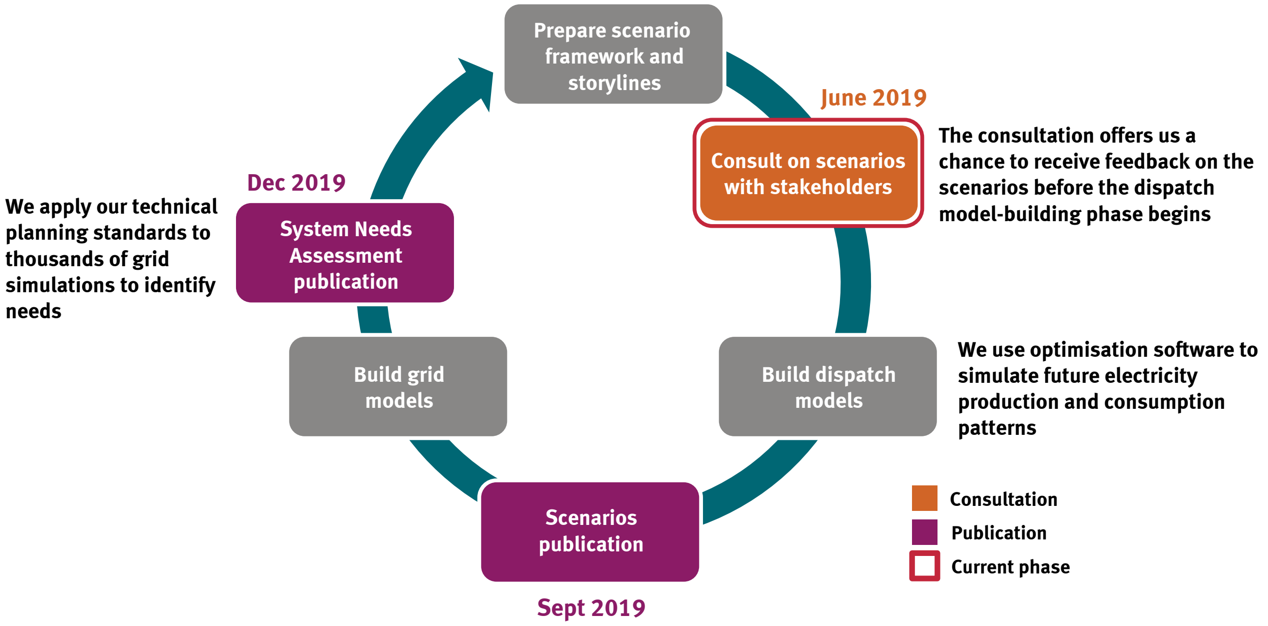


Figure 1: TES 2019 Ireland development cycle

Stakeholder engagement is critical to the development of our scenarios. **This consultation is an invitation to our stakeholders to contribute their insights to help improve the scenarios.** We value the feedback provided by our stakeholders and welcome the submission of evidence to support any insights and commentary. Involving our stakeholders in the development cycle helps us to ensure the continuous improvement of our scenarios. For information on our commitment to public consultation, see our *Reviewing and Improving Our Consultation Process*[1].

Details of the consultation process and how to respond are outlined in Section 8.

1.2. 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.

Our long-term approach to the development of Ireland's electricity infrastructure is set out in our *Grid Development Strategy*[2]. It assists us to meet projected demand levels, to meet Government policy objectives, and to ensure a long-term sustainable and competitive energy future for Ireland.

Have Your Say[3] details our six-step consultation and engagement process, 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 and interconnection;
- 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*[4]. 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.

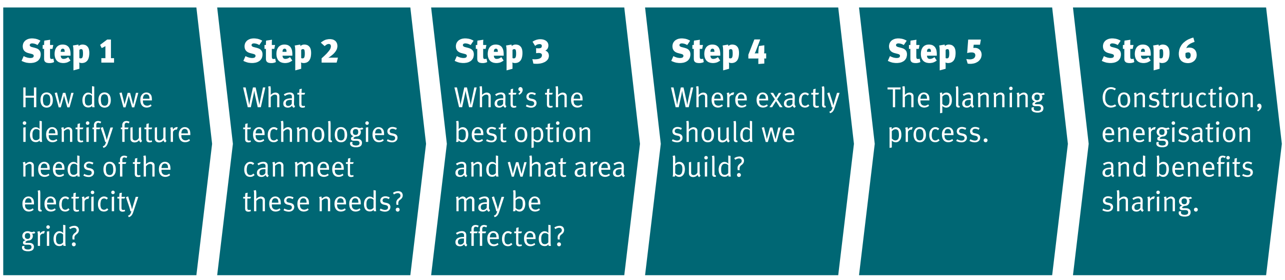


Figure 2: Grid development process

1 EirGrid, Reviewing and Improving Our Consultation Process
2 EirGrid, Grid Development Strategy
3 EirGrid, Have Your Say
4 EirGrid, TES 2017 System Needs Assessment

1.3. Related EirGrid publications

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

They alongside TES 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)*[5] 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.

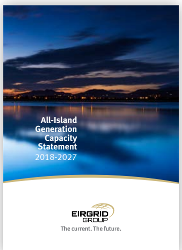
The *Ten Year Transmission Forecast Statement (TYTFS)*[6] provides detailed data by transmission network node, which provides the basis for the existing electricity grid model used in the *TES System Needs Assessment*.

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

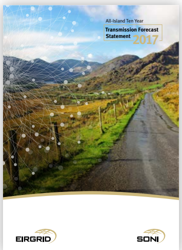
The *Transmission Development Plan (TDP)*[7] outlines development plans for the transmission network over a ten year period. This report shares an important relationship with the *TES System Needs Assessment* report. Long-term development needs, identified in the *TES System Needs Assessment* report, 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.

The Ten Year Network Development Plan (TYNDP) process[8,9] of the European Network of Transmission System Operators (ENTSOs) for Electricity and Gas is an important reference for TES. It provides guidance on the European-wide energy transition, and is central to understanding projects of common interest (PCIs)[10].

Ten-year-horizon planning publications



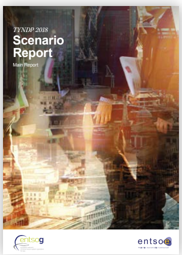
All Island Generation Capacity Statement
Ten year electricity demand forecast.



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

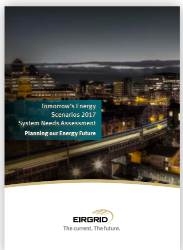
Transmission Development Plan
Ten year network and interconnection development plan.

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

5 EirGrid Group, GCS 2018–2027
6 EirGrid Group, TYTFS 2017
7 EirGrid, TDP 2017–2027
8 ENTSOs, TYNDP 2018 Scenario Report
9 ENTSOs, TYNDP 2020 Scenarios Consultation
10 European Commission, Projects of Common Interest

1.4. Energy and climate policy

Energy policy action is needed to bridge between today's policies and those required to ensure climate neutrality[11], i.e. net-zero greenhouse gas (GHG) emissions. To that end, many parties, including the European Union (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[12].

The EU's commitment is to reduce GHG emissions by at least 40% by 2030 compared to 1990, via its Clean Energy Package[13]. 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[14]).
- At least 32% renewable energy share (RES) (Ireland in 2017 was at 10.6%[15]).
- 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[16] last year. The final NECP will incorporate aspects of the *Climate Action Plan 2019*[17].

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, which are open for consultation, act as a forum for debating sensible and credible pathways for Ireland's electricity sector.

1.4.1 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[15].

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[15]. 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.

11 European Commission, European Long-Term Vision
12 UN, Paris Agreement
13 EU, Clean Energy Package
14 EPA, Ireland's Provisional GHG Emissions 1990–2017
15 SEAI, Energy in Ireland 2018
16 DCCAE, Draft NECP 2021–2030
17 DCCAE, Climate Action Plan 2019

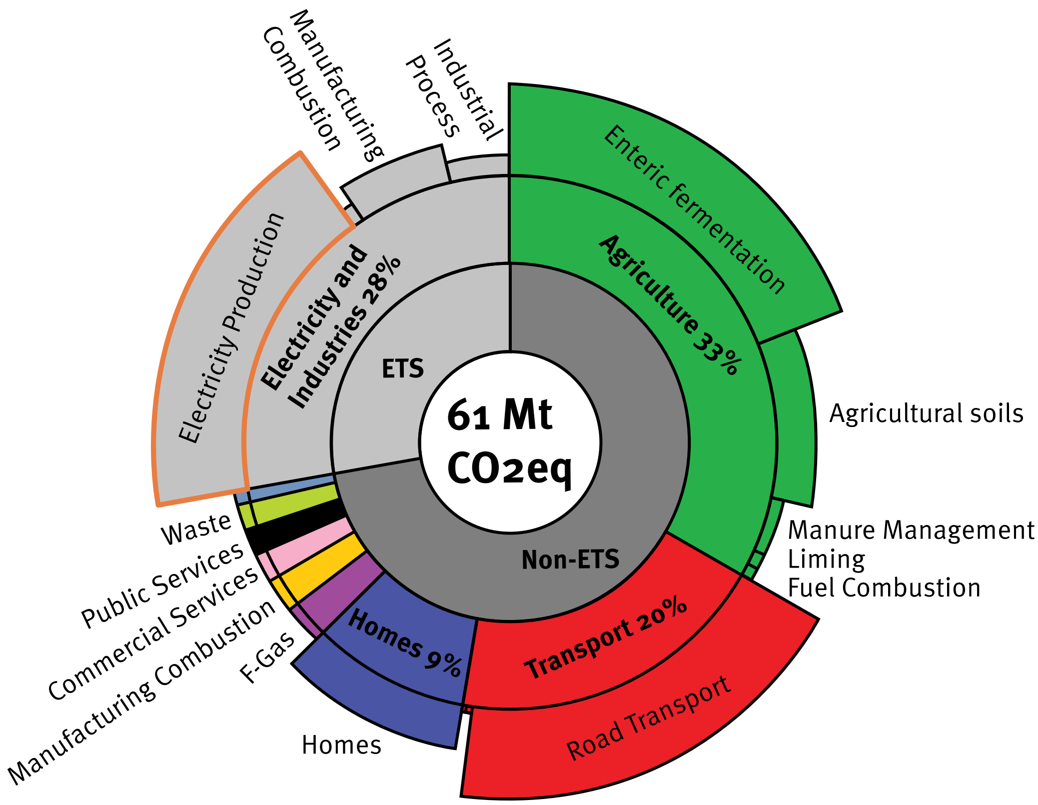


Figure 4: Ireland's GHG emissions, 2017
(reprinted with permission from the Environmental Research Institute, ERI, UCC)

2. Scenario storylines

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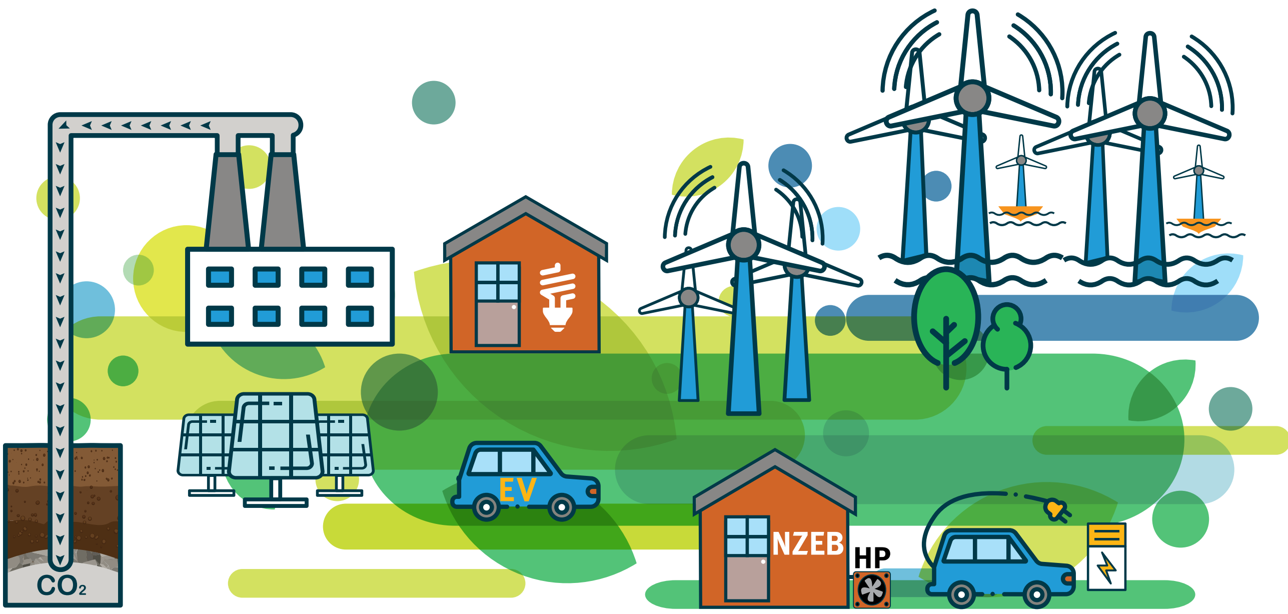
Centralised Energy

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 5 years for electric vehicles. Electrification of the existing housing stock 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 technologies are slower than required. This diminishes the benefits of sector coupling. Data centre growth, albeit sizeable, is lower than the median forecast.

Community Action

Community Action is a world where sustainability and economic circularity are core to future decisions. Citizens recognise climate change as a risk and take appropriate action.

Policy measures are targeted at and embraced by energy consumers and communities, leading to a more decentralised electricity system. Centralised decarbonisation solutions play an important role in moving toward energy and climate targets.

Consumer adoption, the Internet of Things and artificial intelligence help realise a change in current 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.

3. Scenario evolution

3. Scenario evolution

3.1. 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 5 shows the high-level relationship between TES 2017 and TES 2019.

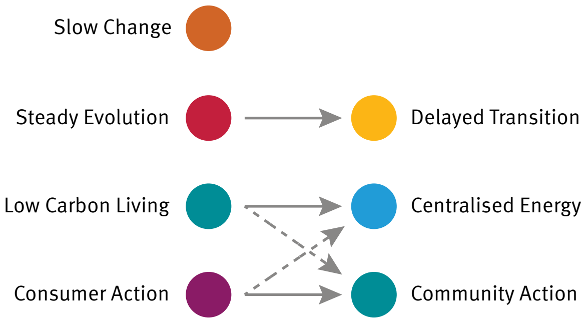


Figure 5: Illustrative similarity between TES 2017 and TES 2019. A solid line indicates a stronger relationship between old and new scenarios in comparison to a dotted line.

3.2. Scenario framework

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 defining design characteristics.

The evolution of scenarios across study years is shown in Figure 5. The number of scenarios is constant with time. The increasing 'distance' between the scenario nodes further into the study horizon represents the growing difference between the scenarios over time, as the level of uncertainty regarding the composition of the energy system increases into the future.

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

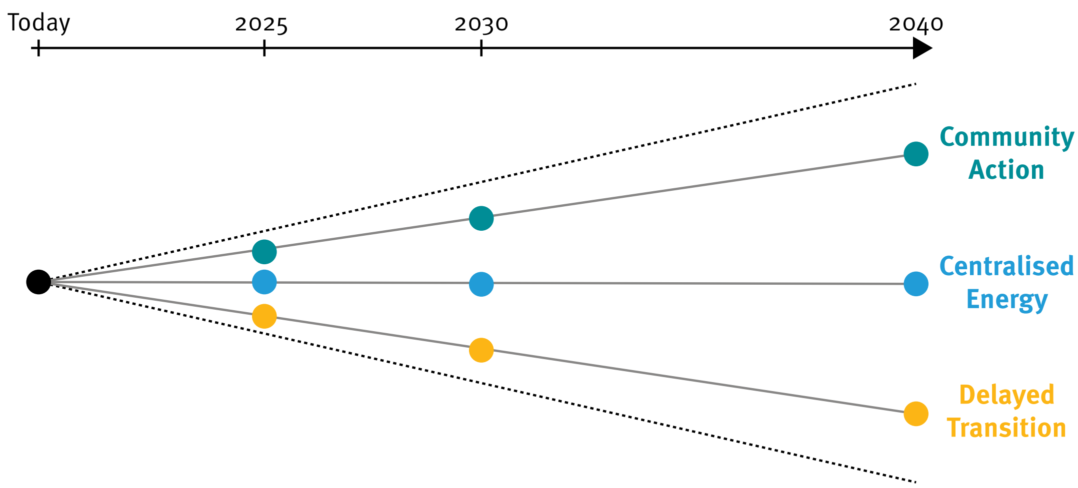


Figure 6: TES 2019 scenario evolution

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.

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 carbon capture and storage (CCS), and energy efficiency measures.

In order for the electricity sector to support Ireland equitably contributing to the Paris Agreement, the electricity sector would need to be CO_2 neutral by 2040[20].

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.

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.

The high-level interaction between the scenario design characteristics is shown in Figure 7.

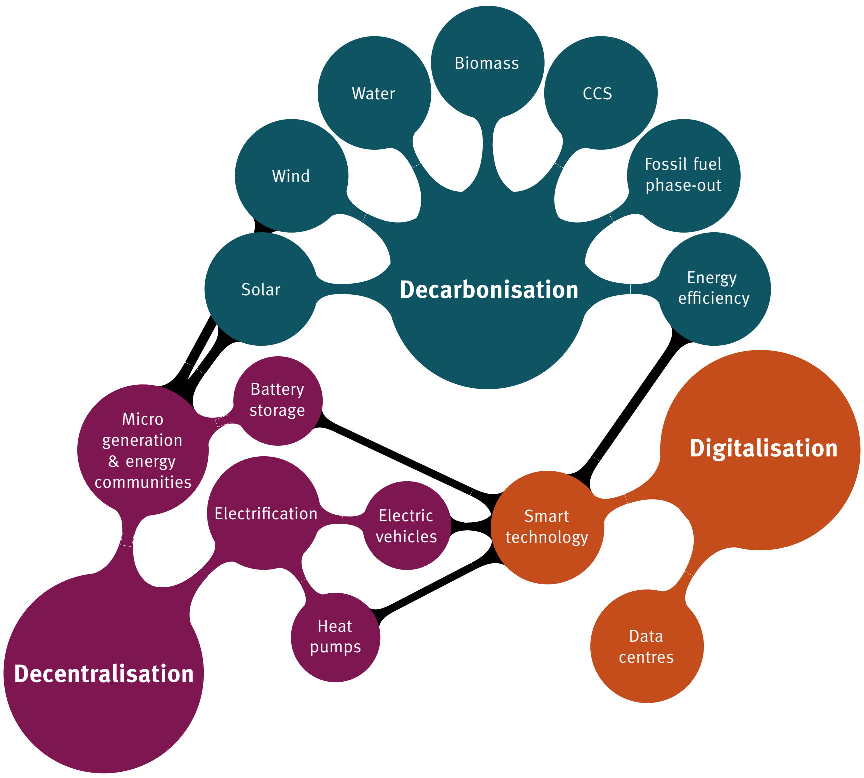


Figure 7: Scenario design characteristics

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

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

Table 1: Scenario design characteristic matrix

	Centralised Energy	Delayed Transition	Community Action
Decarbonisation	**High**	**Low**	**High**
Toward a CO_2-neutral electricity system* in 2050	Yes	No	Yes
Meets 70% RES-E 2030 target	Yes	No	Yes
Coal and peat generation phase-out	Timely	Late	Timely
Carbon capture and storage	Yes (by 2030)	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 CO_2 emissions in the electricity sector.

Translating the scenario design decisions into scenario storylines occurs via the use of political, economic, social and technological (PEST) analysis[21], which provides a mechanism to explore the enablers of a scenario.

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.

21 National Grid SO, FES 2017

4. Demand mix

4. Demand mix

Electricity demand is forecasted to significantly increase over the next couple of decades. The forecasted median electricity growth over the next decade is approaching 10 TWh, which is approximately a 32% increase from today.

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

The economic growth assumptions used are shown in Table 2.

Table 2: Economic growth assumptions

		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%
Community 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 add (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*.

4.1. Energy efficiency

Energy efficiency refers to the implementation of energy saving measures, for example improvements in insulation, glazing, lighting and heating, among others[22]. Such measures can have other co-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 3 shows the range of year-on-year energy efficiency gains assumed. In Community Action, more of the barriers to energy efficiency implementation, such as a lack of information, sufficient incentives and access to capital, are overcome.

Table 3: Year-on-year energy efficiency gains

	Centralised Energy	Delayed Transition	Community 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

22 SEAI, Unlocking the Energy Efficiency Opportunity

4.1.1 Smart meters

Following the Commission for Regulation of Utilities (CRU) smart meter upgrade decision[23], 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%[24]. With time of use tariffs, consumers will be incentivised to move some consumption away from peak times by availing of lower electricity prices.

For the final TES 2019 publication we will create different net residential demand curves (time of day, week, and season), consistent with the storylines. For example, more engaged energy citizens in Community Action will participate in demand shifting than in Delayed Transition.

4.2. 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[25]. Electric space heating comes in the form of direct electric, air source heat pump, ground source heat pump, and hybrid heat pumps. We focus on 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)[26].

4.2.1 Heat pumps

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

The air source heat pump COP assumptions, which are fixed across scenarios, are given in Table 4.

Table 4: 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 8. In Centralised Energy, we assume 400,000 existing homes are retrofitted by 2030, with the remaining 200,000 heat pump installation in that year coming from new-builds.

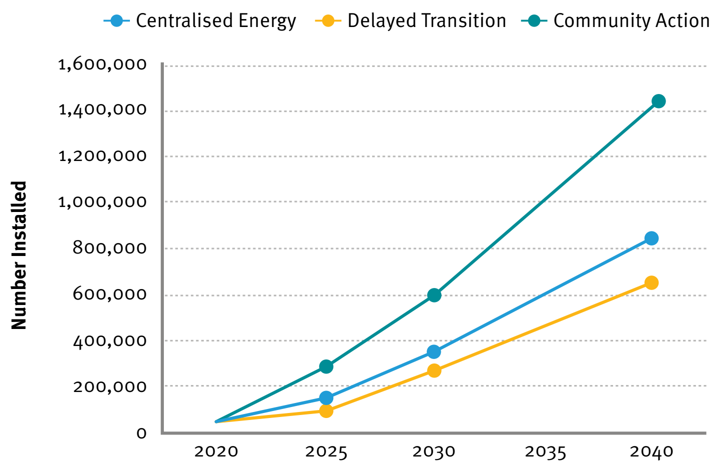


Figure 8: Residential air source heat pumps

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

4.3. Transport

4.3.1 Electric vehicles

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

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

Table 5: 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 9. Higher levels of uptake is promoted by falling EV costs and a ban on the sale of new non-zero emissions vehicles post-2030.

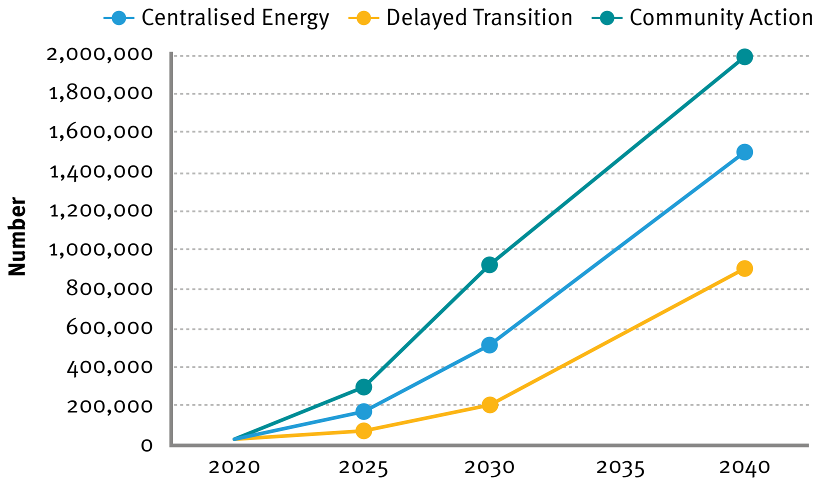


Figure 9: Number of electric passenger vehicles and delivery vans

4.4. 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[27]. We have assumed that this percentage remains constant into the future, across our scenarios.

4.4.1 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*[5], 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 10.

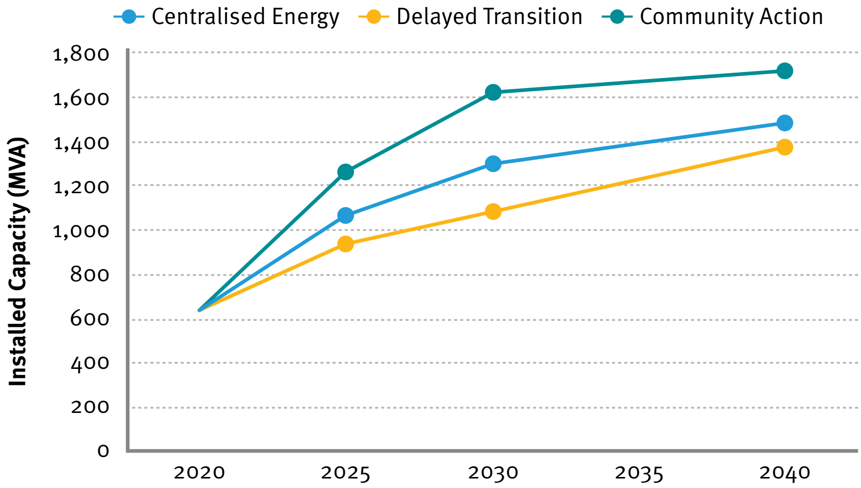


Figure 10: Large energy user maximum import capacity

27 Eurostat, Energy Balances

4.5. Total electricity requirement

Taking the electricity demand from each sector, including energy efficiency measures, and incorporating losses of 8% (2% transmission and 6% distribution), yields the total electricity requirement. As shown in Figure 11, the initial increase in demand is predominantly due to large energy user growth. Demand growth from 2030 is primarily driven by the electrification of heat and transport.

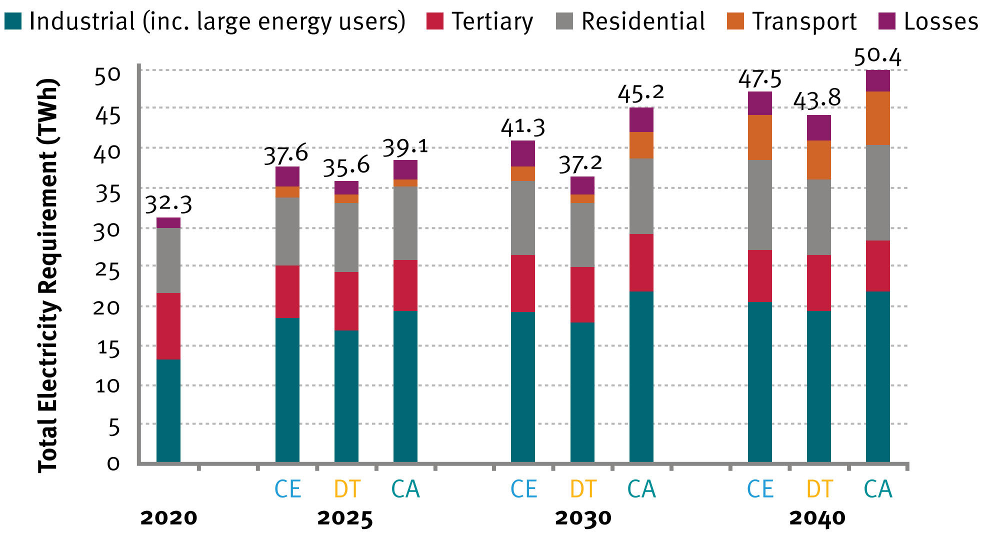


Figure 11: Annual total electricity requirement

5. Generation mix

5. Generation mix

The generation portfolio of the future will no doubt be different from today. The EU Clean Energy Package[13] 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 implementation of the Integrated 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*[28], the technologies successful in the latest capacity auction[29], intentions to decommission as summarised in the *GCS 2018–2027*[5], 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[30]. Rooftop solar PV is anticipated to be the most prominent form of micro generation.

The EU Clean Energy Package[13] 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.

5.1. Renewables

5.1.1 Onshore wind

Over 2.5 GW of onshore wind generation has been installed in Ireland over the past decade[31]. Onshore wind remains a highly cost competitive generation source[32]. We assume that onshore wind technologies are successful in securing support in in the early RESS auctions. As shown in Figure 12, in all scenarios the rate of increase reduces after 2030, due to market share gains by other renewables. Onshore wind capacity is highest in Community Action, with significant increases in distribution grid connections and community based projects.

28 DCCAE, RESS High Level Design
29 EirGrid Group, Final 2022/2023 T-4 Capacity Action Results Summary
30 SEAI, Your Guide to Connecting Micro-Generation
31 EirGrid Group, System and Renewable Data
32 IRENA, Renewable Power Generation Costs in 2017

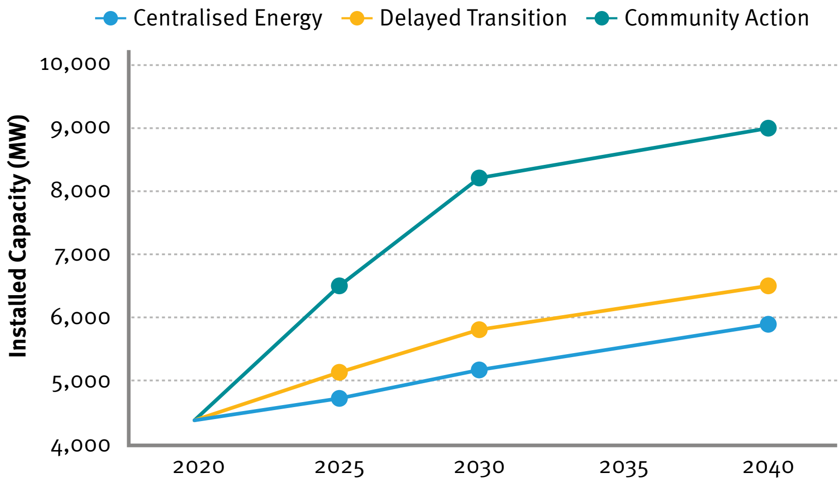


Figure 12: Onshore wind installed capacity

The decentralisation of onshore wind installed capacity is shown in Figure 13. It illustrates that new onshore wind connections to the transmission network remain high across all scenarios. Community Action experiences the highest growth of distribution connections and micro generation.

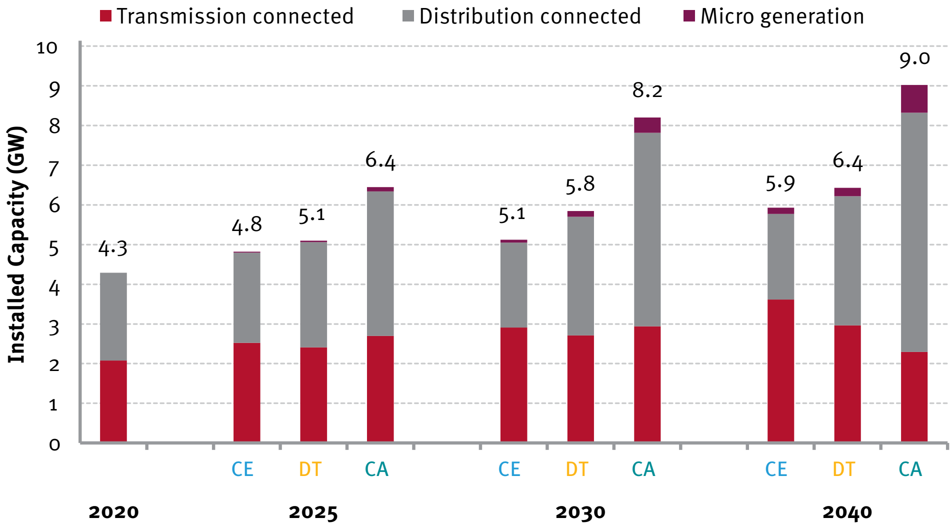


Figure 13: Onshore wind decentralisation

5.1.2 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[33], we assume the main increase in offshore wind installations occurs after 2025, as shown in Figure 14.

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 Community Action to meet 2030 RES-E targets due to high demand levels. All offshore wind generation is expected to connect to the transmission grid.

33 DCCAE, Climate Action Plan 2019 Annex of Actions

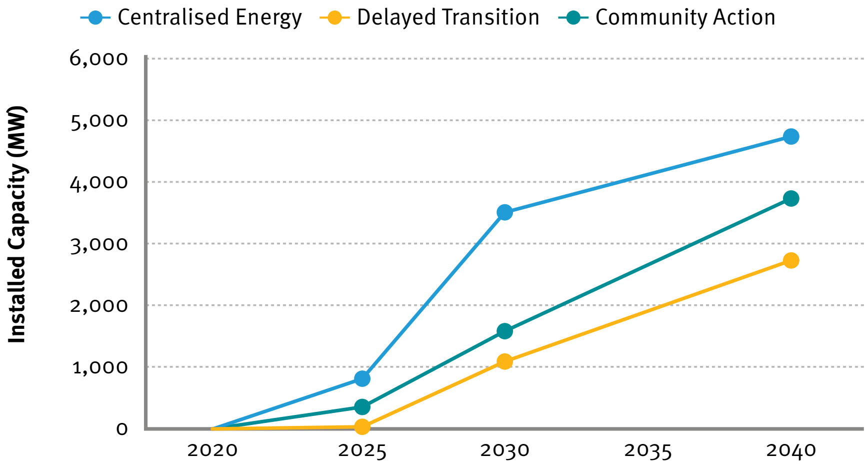


Figure 14: Offshore wind installed capacity

5.1.3 Solar photovoltaics

Over the past decade, solar PV has experienced the highest reduction in levelised cost of energy (LCOE) globally[32].

The total solar PV capacity, including micro generation, is shown in Figure 15. The largest growth in solar PV occurs in the Community Action, with approximately 150 MW of capacity connecting each year out to 2040.

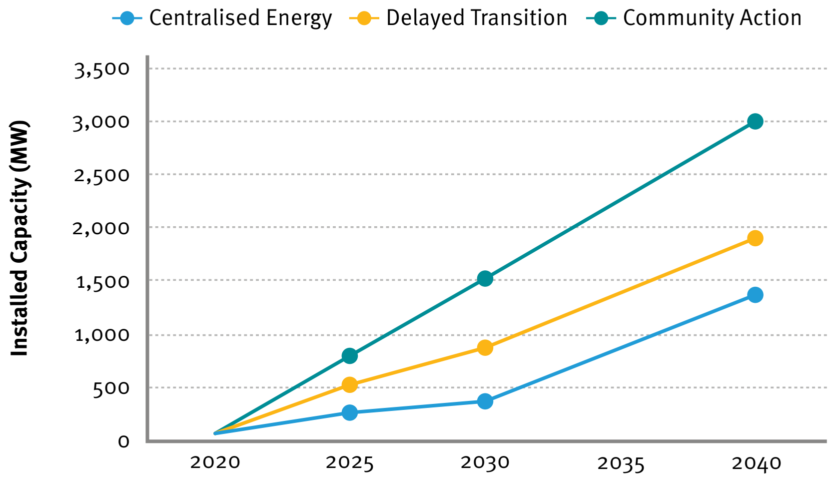


Figure 15: Solar PV installed capacity

The decentralisation of solar PV installed capacity is shown in Figure 16. The growth of solar PV connections to the distribution network, including solar PV micro generation, is highest in Community Action.

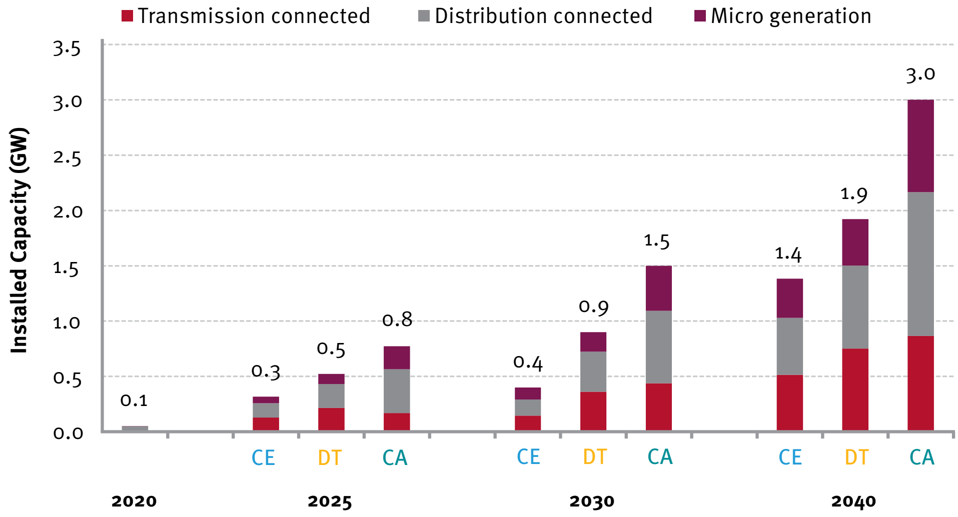


Figure 16 - Solar PV decentralisation

5.1.4 Biomass and waste

REFIT 3[34] 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. There is also 80 MW of waste[5]. We assume a modest growth in biomass CHP across all scenarios. We have also assumed an additional 20-MW waste unit in Community Action by 2030.

Figure 17 shows the cumulative installed capacity from biomass and waste (see Figure 20 for our assumptions on peat co-firing with biomass).

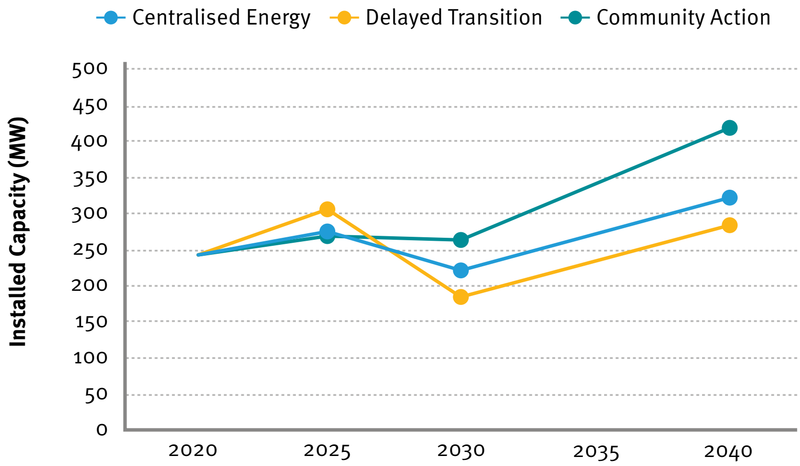


Figure 17: Biomass and waste installed capacity (including the co-firing share from the peat stations)

34 DCCAE, REFIT 3

5.1.5 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 Community Action by 2030, and that by 2040 some coastal communities see marine renewables as a way to help meet local energy needs. Figure 18 shows the capacities assumed.

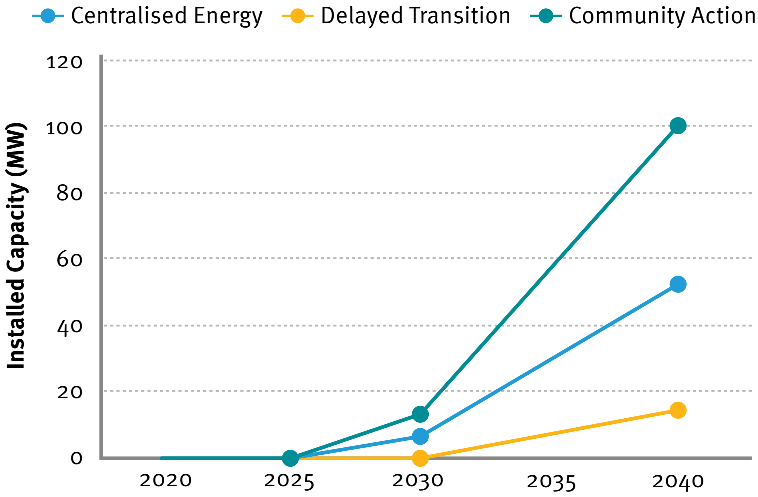


Figure 18: Marine (wave and tidal) installed capacity

5.1.6 Hydro

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.

5.1.7 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 6. 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 19 displays trends for RES-E for each scenario out to 2040.

Table 6: Average renewable source capacity factors
(historical dispatch average used for biomass, waste and hydro)

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

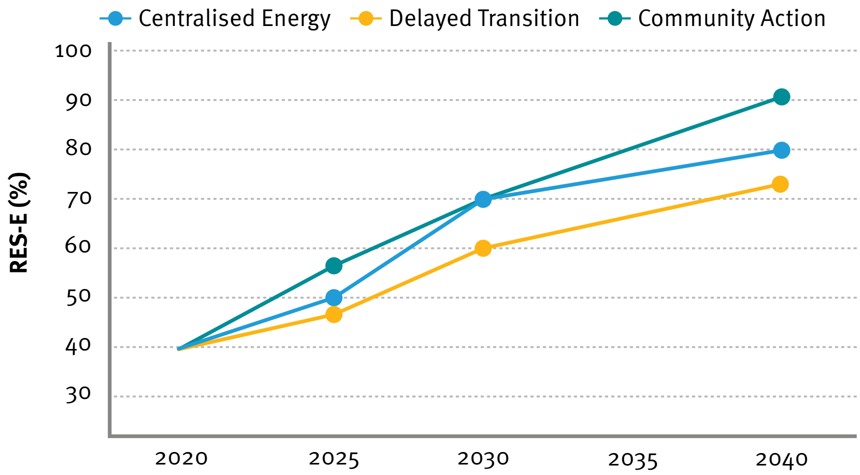


Figure 19: Electricity sourced from renewable energy sources

5.2. 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 firm, 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.

5.2.1 Peat

It is expected that electricity generation from peat in Ireland will cease by 2030 at the latest[35]. For the purposes of system needs identification, it is taken that closures occurs 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. The assumed fuel type composition of the three peat stations capacity is shown in Figure 20. Delayed Transition assumes that the three peat stations remain open and co-fire at moderate levels beyond 2025, closing some time before 2030. Community Action and Centralised Energy assume that the stations at Shannonbridge and Lanesborough close down before 2025.

35 DPER, National Development Plan 2018–2027

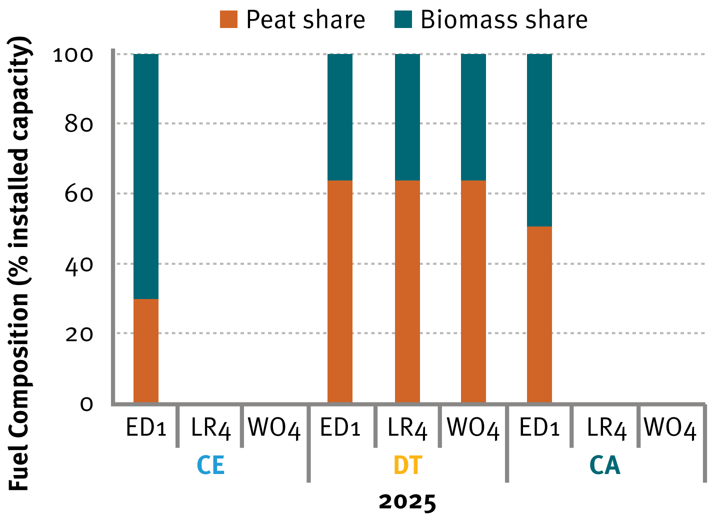


Figure 20: Percentage of installed capacity fueled by peat and biomass at the Edenderry (ED1, 118 MW), West Offaly (WO4, 137 MW) and Lough Ree (LR4, 91 MW) power stations in 2025. The stations are assumed to be decommissioned before 2030

5.2.2 Coal

It is expected that coal generation in Ireland will cease by 2025[35]. For the purposes of system needs identification, it is taken that this closure occurs at the start, rather than the end, of the year. Community 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.

5.2.3 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[36] (heavy fuel oil also plays this role for Moneypoint). We refer to the primary fuel stock only.

Figure 21 shows the assumed trajectory for distillate oil generation across the scenarios. Centralised Energy and Community Action assume that all distillate units are closed by 2030. In the case of Centralised Energy, this peaking capacity is mainly replaced by open cycle gas turbines (OCGTs), battery storage and demand side units (DSUs). Community Action assumes that battery storage and consumer-side flexibility play a large role in replacing peaking generation.

Delayed Transition assumes that distillate plant continue to play a role, though are ultimately replaced.

36 EirGrid, Grid Code version 7

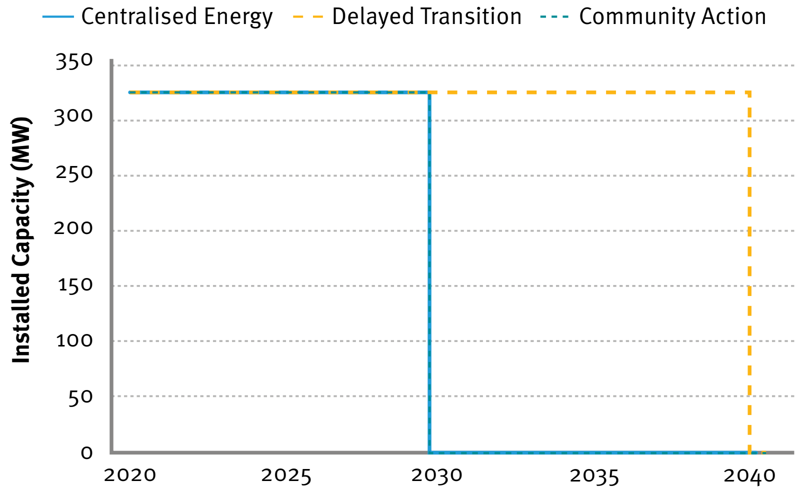


Figure 21: Distillate oil OCGT installed capacities

5.2.4 Gas

Natural gas was the largest source of electricity generated in 2018, accounting for 51%[31].

The composition of gas-fired generation is assumed to be combined cycle gas turbine (CCGT), OCGT and CHP.

For CCGTs, we assume the total capacity to remain constant at ~3 GW. We assume gas CHP to remain constant through the scenarios and study years at the existing total capacity of 291 MW (of which 162 MW is dispatchable).

For OCGTs, we assume new capacity is installed by 2025, with older capacity eventually retiring. Figure 22 shows this assumed trajectory for OCGT capacity.

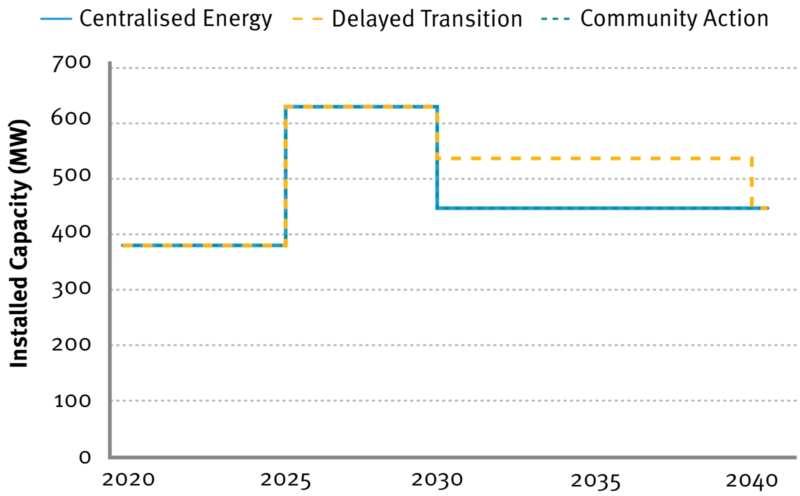


Figure 22: Gas OCGT installed capacity

5.2.5 Carbon capture and storage

CCS 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. CCS is one of the seven building blocks for the European Commission's long-term vision[11].

In the electricity sector, it is assumed that CCS is deployed on new or existing CCGTs[37]. As shown in Figure 23, we assume that CCS is operational by 2030 in Centralised Energy. In Community Action, we assume that CCS is delayed a decade, coming into implementation in 2040. In Delayed Transition we assume no CCS is deployed. The delayed or non-deployment of CCS reflects uncertainty factors including what policy, regulatory, legal and business model frameworks make CCS commercially viable.

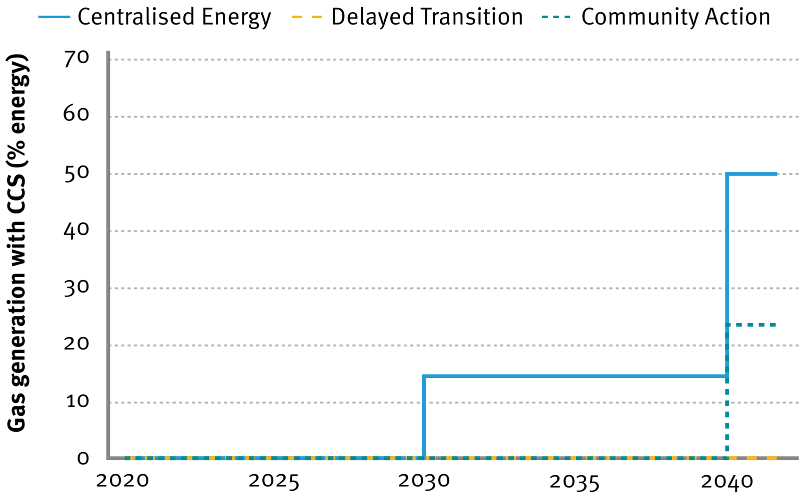


Figure 23: Percentage of gas-fired generation with CCS

37 Ervia, Carbon Capture and Storage

6. Non-generation flexibility mix

6. Non-generation flexibility mix

6.1. Interconnection with neighbouring systems

Interconnection allows 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 facilitate the sharing of reserve.

Ireland's current high voltage direct current (HVDC) interconnection is with Great Britain via the East-West interconnector (EWIC). Ireland also has existing interconnector ties to Northern Ireland that use high voltage alternating current (HVAC). The North South Interconnector project[38], 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%, which for a given EU Member State is calculated by dividing the interconnection import capacity by the installed generation capacity[39]. 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[40] and Greenlink[41]. The Celtic and Greenlink projects use HVDC, while North South uses HVAC.

Figure 24 illustrates the HVDC interconnection assumptions with France and Great Britain. Centralised Energy assumes that Celtic and Greenlink are built as per project times (2023 for Greenlink, 2026 for Celtic), and that one additional interconnector to Great Britain is built by 2040. Community Action also assumes Celtic and Greenlink are built on time, with two additional interconnectors built by 2040 in order to facilitate the higher RES-E level. 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.

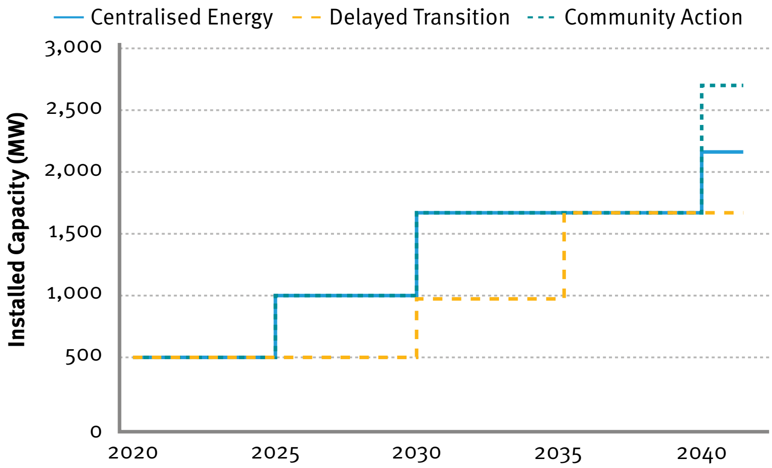


Figure 24: HVDC interconnection capacity with France and Great Britain

38 EirGrid Group, North South 400 kV Interconnection Development
39 European Commission Expert Group on Electricity Interconnection Targets, Report
40 EirGrid, Celtic Interconnector Project Update Step 3 Consultation
41 Greenlink Development Ltd, Greenlink Interconnector website

6.2. Storage

A sizeable range of storage technologies exists. For the purposes of TES 2019, storage is categorised in a generalised manner, placing the focus on the uses of the storage mix, as outlined in Table 7.

The exact breakdown of storage installed capacity (MW) and energy storage volume (MWh) will be determined from the dispatch modelling to be conducted before the final publication of TES 2019.

Table 7: Storage uses

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

6.2.1 Seasonal storage

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

Power to gas (PtG) is the process of using renewable electricity to produce hydrogen, or in a consecutive step, using the hydrogen with CO_2 to produce methane. Such developments may allow for the seasonal storage of gas produced with renewable electricity.

The share of methane (CH4) and hydrogen (H2) sourced from PtG is given in Figure 25. Community Action has the highest shares of PtG due to a higher consumer demand for renewable gas for heating and transport.

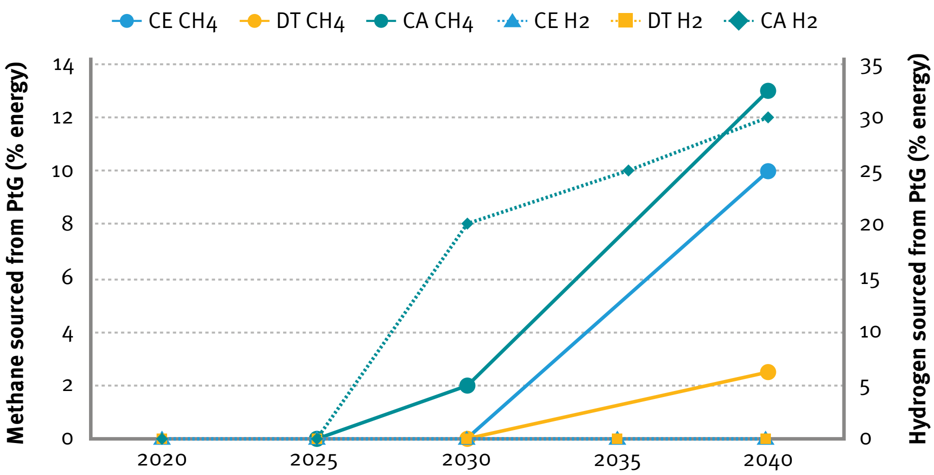


Figure 25: Proportion of methane (solid lines) and hydrogen (dashed lines) demand supplied by power to gas

6.3. Demand side management

As with energy storage, there are a range of technologies which can deliver demand side management (DSM), for a number of uses. For DSM, two categories are proposed, as shown in Table 8. The exact breakdown of DSM installed capacity will be determined from the dispatch modelling to be conducted before the final publication of TES 2019.

Table 8: DSM categories

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

7. Locations

7. 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.

7.1. Ireland's regions

EirGrid uses regions to help communicate the development of the transmission system in Ireland. These eight regions[42] are illustrated in Figure 26. These regions are used to display locations assumptions for different technologies.

Figure 26: 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

7.2. Generation locations

Future generation locations are modelled using a number of information sources which vary depending on generation technology type, as shown in Table 9. 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:

42 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. 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.

Community Action: Although connections to the transmission network continue, there is a significant increase in connections to the distribution network. This decentralised generation is driven by community projects supported by the *RESS High Level Design*. Potential locations for community projects and microgeneration are influenced by existing RES locations and population growth projections.

Table 9: Generation location information sources

Technology	Source
Onshore wind	• Grid connection applications • *National Planning Framework*[43] • Historical nodal electricity demand
Offshore wind	• Grid connection applications • *East Coast Generation Opportunity Assessment*[44] • *Offshore Renewable Energy Development Plan*[45]
Solar PV	• Grid connection applications • Historical nodal electricity demand • Regional population projections[46]

7.2.1 Onshore wind

The regional distribution of onshore wind installed capacity is shown in Table 10 for each scenario and year.

43 DHPLG, National Planning Framework
44 EirGrid, East Coast Generation Opportunity Assessment
45 DCCAE, Offshore Renewable Energy Development Plan
46 CSO, Population Projections 2017–2051

Table 10: Onshore wind capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	917	1,047	1,327	951	1,194	1,654	982	1,298	1,788
Dublin	1	1	2	1	1	2	1	1	3
Mid-East	81	122	139	95	175	235	114	210	325
Midland	424	374	277	500	488	356	805	580	407
Mid-West	722	793	1,096	753	898	1,395	783	969	1,532
South-East	315	380	478	332	453	627	350	504	712
South-West	1,360	1,468	2,058	1,414	1,646	2,600	1,465	1,763	2,833
West	985	874	1,069	1,080	995	1,330	1,401	1,079	1,446
Total	**4,805**	**5,060**	**6,445**	**5,125**	**5,850**	**8,200**	**5,900**	**6,405**	**9,045**

It is expected that some onshore wind farms will repower in the future as existing assets reach end-of-life. Future repowered sites have been assumed using installed dates and an average expected life of 25 years. The same repowering assumptions are used for all three scenarios, with the regional distribution displayed in Table 11.

Table 11: Onshore wind repowered locations (MW)

Region	**2025**	**2030**	**2040**
Border	20	145	280
Dublin	-	-	-
Mid-East	-	25	-
Midland	-	-	85
Mid-West	-	35	335
South-East	-	50	180
South-West	30	30	605
West	10	90	100
Total	**60**	**375**	**1,585**

7.2.2 Offshore wind

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

Table 12: Offshore wind capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	-	-	-	130	80	57	406	197	144
Dublin	413	-	148	1,248	198	542	1,357	486	1,377
Mid-East	452	25	177	1,778	604	787	1,931	1,446	1,959
Midland	-	-	-	-	-	-	-	-	-
Mid-West	-	-	-	208	128	91	340	315	230
South-East	-	-	-	-	-	-	227	-	-
South-West	-	-	-	-	-	-	189	-	-
West	-	-	-	136	84	59	299	206	150
Total	**865**	**25**	**325**	**3,500**	**1,095**	**1,535**	**4,750**	**2,650**	**3,860**

The *Offshore Renewable Energy Development Plan* identified considerable potential for floating offshore wind energy development off the south, west and north coasts of Ireland. It is assumed that plan-led connections of floating offshore wind farms will occur post 2030 as part of Centralised Energy scenario only. A regional distribution of floating wind farm installed capacity in 2040 is provided in Table 13.

Table 13: Floating offshore wind installed capacity, Centralised Energy (MW)

Region	**2040**
Border	265
Dublin	-
Mid-East	-
Midland	-
Mid-West	113
South-East	227
South-West	189
West	151
Total	**945**

7.2.3 Solar PV

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

Table 14: Solar PV capacity locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	8	14	17	11	25	37	37	52	70
Dublin	24	38	87	45	74	170	148	176	905
Mid-East	70	115	160	92	207	329	310	433	641
Midland	54	89	117	66	159	236	222	323	234
Mid-West	16	26	51	21	46	88	69	96	203
South-East	80	132	207	98	236	385	333	482	517
South-West	32	53	92	43	95	170	143	200	380
West	20	33	40	24	58	84	82	119	90
Total	**305**	**500**	**770**	**400**	**900**	**1,500**	**1,345**	**1,880**	**3,040**

7.2.4 Gas generation

The regional distribution of dispatchable gas generation installed capacity is shown in Table 15 for each scenario and year.

Table 15: Dispatchable gas generation locations (MW)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	-	-	-	-	-	-	-	-	-
Dublin	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060
Mid-East	-	-	-	-	-	-	-	-	-
Midland	-	-	-	-	-	-	-	-	-
Mid-West	160	160	160	160	160	160	160	160	160
South-East	430	430	430	430	430	430	430	430	430
South-West	1,055	1,055	1,055	875	965	875	875	875	875
West	400	400	400	400	400	400	400	400	400
Total	**4,105**	**4,105**	**4,105**	**3,925**	**4,015**	**3,925**	**3,925**	**3,925**	**3,925**

7.3. 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 16. 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[47] 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.

47 DBEI, The Role of Data Centres in Ireland's Enterprise Strategy

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.

Community 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 16: 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

7.3.1 Large energy users

The regional distribution of large energy user import capacity is shown in Table 17 for each scenario and year.

Table 17: Large energy user maximum import capacity locations (MVA)

	2025			2030			2040		
Region	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
Border	-	-	-	72	-	75	83	-	80
Dublin	864	713	959	892	888	1,094	1,022	1,113	1,164
Mid-East	196	213	291	223	213	309	256	267	329
Midland	-	-	-	-	-	-	-	-	-
Mid-West	-	-	-	43	-	45	49	-	48
South-East	-	-	-	11	-	-	12	-	-
South-West	-	-	-	54	-	64	62	-	68
West	-	-	-	14	-	43	16	-	46
Total	**1,060**	**925**	**1,250**	**1,310**	**1,100**	**1,630**	**1,500**	**1,380**	**1,735**

7.3.2 Electric vehicles

The regional distribution of EV energy demand is shown in Table 18 for each scenario and year. This includes passenger vehicles (battery and plug-in hybrid), delivery vans, light trucks and buses.

Table 18: EV annual energy demand locations (TWh)

	2025			2030			2040		
Region	CE	DT	CA	CE	DT	CA	CE	DT	CA
Border	0.07	0.03	0.11	0.29	0.10	0.44	0.67	0.41	0.75
Dublin	0.20	0.09	0.29	0.76	0.26	1.16	1.78	1.10	1.98
Mid-East	0.09	0.04	0.13	0.33	0.11	0.51	0.78	0.48	0.87
Midland	0.05	0.02	0.07	0.18	0.18	0.27	0.41	0.25	0.46
Mid-West	0.05	0.02	0.08	0.21	0.07	0.31	0.48	0.30	0.53
South-East	0.08	0.03	0.11	0.29	0.10	0.45	0.68	0.42	0.76
South-West	0.10	0.04	0.15	0.39	0.13	0.59	0.91	0.56	1.01
West	0.06	0.03	0.09	0.24	0.08	0.37	0.56	0.34	0.62
Total	**0.69**	**0.30**	**1.02**	**2.68**	**0.90**	**4.10**	**6.27**	**3.87**	**6.99**

7.3.3 Heat pumps

The regional distribution of residential air source heat pump energy demand is shown in Table 19 for each scenario and year.

Table 19: 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**

7.4. Interconnection locations

The regional distribution of HVDC interconnection is shown in Table 20 for each scenario and year.

Table 20: 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	**1000**	**500**	**1000**	**1700**	**1200**	**1700**	**2200**	**1700**	**2700**

8. Next steps

8. Next steps

We look forward to receiving your feedback on the *Tomorrow's Energy Scenarios 2019 Consultation*. Feedback received will be used when developing the final *Tomorrow's Energy Scenarios 2019* publication and the associated dispatch modelling. See Figure 1 for the TES 2019 Ireland development cycle.

8.1. Dispatch assumptions

The proposed dispatch-modelling approach for operational constraints[48] in TES is to determine what set of constraints facilitate the RES-E levels presented (see Section 5.1.7 for RES-E assumptions). While these constraints may not be those that ultimately transpire in future years, this method aims to provide a sign-post and facilitate discussion regarding the innovation required to integrate high shares of renewable electricity and decarbonise the electricity sector.

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

8.2. How to respond to the consultation

To respond to the consultation, please use the consultation response form, following the guidelines provided therein.

We look forward to engaging with you as part of TES 2019, and thank those who have provided their insight to date.

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.

48 http://www.eirgridgroup.com/site-files/library/EirGrid/Operational-Constraints-Update-Feb-2019.pdf

Appendix

Appendix

The following tables summarise some of the key generation and demand components of this consultation.

Table A-1: Generation mix summary (MW)

	2025			2030			2040		
Technology/Fuel	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**	**CE**	**DT**	**CA**
OCGT (gas)	626	626	626	446	536	446	446	446	446
OCGT (DO)*	324	324	324	0	324	0	0	0	0
CCGT	3321	3321	3321	3321	3321	3321	3321	3321	3321
Steam turbine**	74	1119	98	39	39	50	39	39	50
CHP**	300	300	300	302	302	302	302	302	302
Coal	0	855	0	0	0	0	0	0	0
Peat	35	225	59	0	0	0	0	0	0
Waste**	39	39	39	39	39	50	39	39	50
Renewables	6541	6187	8047	9492	8271	11742	12730	11610	16553
Total (MW)	**11261**	**12996**	**12814**	**13639**	**12832**	**15911**	**16877**	**15757**	**20722**

*Distillate oil. **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	4820	5097	6446	5124	5848	8200	5930	6429	9025
Offshore wind	895	25	323	3500	1095	1535	4803	2717	3800
Solar	316	523	772	400	901	1500	1384	1922	3001
Biomass*	272	305	268	225	189	259	325	289	390
Hydro**	238	238	238	238	238	238	238	238	238
Marine***	0	0	0	5	0	10	50	15	100
Total (MW)	**6541**	**6187**	**8047**	**9492**	**8271**	**11742**	**12730**	**11610**	**16553**

*Including renewable waste, biogas, landfill gas, co-firing in the peat stations.
**Not including pumped hydro electric 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	1.0	0.6	1.0	2.7	0.9	4.1	6.7	4.4	6.6
Residential	8.8	8.5	9.0	9.0	8.6	9.1	10.3	10.0	11.8
Industry	17.9	16.9	19.3	19.5	17.9	21.9	20.5	19.6	22.2
Tertiary	7.3	7.2	7.2	7.4	7.2	7.2	6.9	6.9	6.4
Losses	2.4	2.3	2.5	2.6	2.4	2.8	3.0	2.8	3.1
Total (TWh)	**37.6**	**35.6**	**39.1**	**41.3**	**37.2**	**45.2**	**47.5**	**43.8**	**50.4**

*TER: total electricity requirement.

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