# All-Island Resource Adequacy Assessment

## 2025-2034 Inputs & Assumptions for Ireland

EirGrid

# Contents

# 1. Introduction

EirGrid as the Transmission System Operators (TSO) for Ireland have a responsibility to operate the electricity transmission system every minute of every day, whilst also planning the future of the transmission grid. To achieve this, EirGrid must balance supply and demand now and forecast how to do so in the future.

EirGrid, is required to publish forecast information about the power system, as set out in Section 38 of the Electricity Regulation Act 1999[1] and Part 10 of S.I. No. 60 of 2005 European Communities (Internal Market in Electricity) Regulations[2].

Under this reporting requirement, EirGrid forecasts the projected level of electricity demand and the expected resources available to supply this demand. The demand and generation forecasts for Ireland are modelled along with relevant operational requirements to evaluate power system reliability in reference to the relevant reliability standard. This process is referred to as a resource adequacy assessment where the reliability standard is specified for Ireland using Loss of Load Expectation (LOLE).

As European policy direction and regulations have evolved, the approach for assessing resource adequacy has also evolved to appropriately represent the transforming power system i.e. transitioning away from aging fossil fuelled conventional generation plant and towards a power system increasingly dependent on variable renewables, interconnection, demand side response, long duration energy storage and other renewable gas ready dispatch power plants. Through the Shaping Our Electricity Future Roadmap[3], EirGrid identifies the need to enhance our reliability assessments to suitably dimension the possible risks to resource adequacy and align with European Union regulation.

The All-Island Resource Adequacy Assessment (AIRAA) will evolve the existing Generation Capacity Statement (GCS) methodology for EirGrid's annual publications, to align with EU Regulation 2019/943 Article 24(1) and overall improve the approach to assessing the reliability of the evolving power systems in Ireland.

Assessments conducted using the new methodology will support signalling future system outlook and requirements to the energy market as well as to policy makers, regulators, industry, TSOs, Distribution System Operators (DSOs), electricity consumers, and the general public.

## 1.1. European Regulatory Framework

The 'Clean Energy for all Europeans' package adopted in 2019 set out a new framework for the transition away from fossil fuels to cleaner sources of energy which included the Regulation on the internal market for electricity (EU/2019/943)[4] herein referred to as 'the Regulation'. Chapter IV (Articles 20-27) of the Regulation is focussed on resource adequacy.

Article 23 of the Regulation mandates the European Network for Transmission System Operators for Electricity (ENTSO-E) to conduct annual resource adequacy assessments based on projected supply and demand for electricity across the EU to identify resource adequacy concerns for Member States. ENTSO-E's obligations under Article 23 of the Regulation are fulfilled through the European Resource Adequacy Assessment[5] (ERAA), which was approved by the European Union Agency for Cooperation of Energy Regulators (ACER) on 2nd October 2020. ACER also has responsibility for approving the annual implementation of the ERAA methodology conducted by ENTSO-E.

Article 20(1) of the Regulation states that Member States may also carry out national adequacy assessments where necessary. Article 24 of the Regulation states that the national adequacy assessment should be based on the ERAA methodology, and capture market specific characteristics or risks that the European assessment

[1] https://www.irishstatutebook.ie/eli/1999/act/23/section/38/enacted/en/html
[2] https://www.irishstatutebook.ie/eli/2005/si/60/made/en/print#partx-article28
[3] https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping-Our-Electricity-Future-Roadmap_Version-1.1_07.23.pdf
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN
[5] https://www.acer.europa.eu/Individual%20Decisions_annex/ACER%20Decision%2024-2020%20on%20ERAA%20-%20Annex%20I_1.pdf

may not capture in detail. Effectively, the national adequacy assessment provides the scope to run studies that are relevant on a national level but may not be relevant at a pan-EU level.

The development of an implementation plan for the NRAA methodology has been a component of the Security of Supply Programme in Ireland, led by the Commission for Regulation of Utilities (CRU). Engagements on the implementation of the NRAA methodology have been ongoing with the Regulatory Authorities from early 2023.

## 1.2. Data Freeze Date

To obtain the most relevant information, EirGrid engaged with a range of stakeholders including market participants, distribution operators and other industry organisations to gather information and data to support deriving the annual demand and generation forecasts. When developing the forecasts in this report, the respective TSOs have endeavoured to use the most up-to-date information available at the time of the data freeze, which was 30$^{th}$ April 2024 for the demand data and 8$^{th}$ May 2024 for the generation data used in this report.

There was a possibility of additional information relating to input data or assumptions arising between the time of the data freeze date and the publication of the final report. Such developments were not included in the core modelling assessments however best efforts were made to identify any developments and where possible provided a high-level assessment of any possible impact.

## 1.3. Structure of the Paper

This paper is structured as follows:

- **Section 2** specifies data sources and assumptions for the median demand forecast.
- **Section 3** specifies data sources and assumptions for relevant generation inputs as listed in the methodology.
- **Section 4** specifies data sources and assumptions for the configuration of the adequacy model.

# 2. Total Electricity Requirement - Demand Assumptions

The assumptions shared below are for input to inform the median demand forecast of Total Electricity Requirement. Total Electricity Requirement is the amount of electricity required to meet final use electricity including behind the meter generation (such as solar PV) and the amount of energy that is required to meet transmission and distribution grid losses.

The median Total Electricity Requirement[6] demand forecast is EirGrid's best estimate of how demand will change in the future to meet government targets for energy policy and climate action. The Total Electricity Requirement demand forecast is dependent on a significant number of economic, social and policy factors, therefore low and high forecasts are also defined in the Scenarios section of this paper. The low and high demand scenarios capture estimates above and below the median forecast that are realistically plausible given current trends and policies.

## 2.1. Electric Vehicles

### 2.1.1. Electric Vehicles Annual Electricity Demand

| Category | Ireland Data Source / Assumption |
|---|---|
| Types of Electric Vehicles Modelled | • Passenger Battery Electric Vehicles (BEV).<br>• Passenger Plug in Hybrid Electric Vehicles (PHEV).<br>• Battery Electric Large Goods Vehicles (LGV).<br>• Battery Electric Busses. |
| Historic Number of Electric Vehicles | • Irish Bulletin of Vehicle and Driver Statistics (including draft 2023 data)[7]. |
| Forecast Number of Electric Vehicles | • Climate Action Plan 2024 (CAP24) Targets[8].<br>• Assume passenger BEV/PHEV proportion 60% BEV in 2025, 75% BEV in 2030 and continuing to increase beyond 2030 based on current trend to date.<br>• Assume Low emissions LGV 50% BEV in 2025, 85% BEV in 2030.<br>• Interpolated projection of new EVs through latest historical figures, and CAP24 targets, limited to 165,000 passenger vehicles per year based on historic average[9].<br>• Post 2030 assume all new passenger vehicles are EVs (165,000 per year), LGV and bus growth forecast to continue growth.<br>• Assume vehicles are scrapped at 15 years of age. |
| Distance Travelled / Year | • Central Statistics Office Transport historic data[10] [11].<br>• Forecast to 2025 based on 10-year average of historic data.<br>• Forecast 2025-2030 assumes 20% mileage reduction (CAP24 target) applied to passenger and light goods vehicles.<br>• PHEVs assumed 47% of distance travelled in EV mode based on European study of real-world driving[12]. |

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[6] Equivalent to SEAI's final electricity consumption plus transmission losses. https://www.seai.ie/data-and-insights/seai-statistics/key-publications/national-energy-balance/#:~:text=The%20provisional%20RES%20values1,RES%2DT)%20was%205.5%25
[7] https://www.gov.ie/en/publication/f392d-bulletin-of-vehicle-and-driver-statistics/#
[8] https://www.gov.ie/pdf/?file=https://assets.gov.ie/279555/25df7bb5-1488-4ba1-9711-e058d578371b.pdf#page=null
[9] https://data.cso.ie/table/TEA25
[10] https://www.cso.ie/en/statistics/transport/transportomnibus/
[11] Vehicle Kilometres Road Traffic Volumes Transport Hub - Central Statistics Office
[12] https://theicct.org/publication/real-world-phev-use-jun22/

| | |
|---|---|
| Electric Vehicle Efficiency | • Current efficiency assumes 0.169 kWh/km for passenger BEV, 0.263 kWh/km for LGV, and 1.39 kWh/km for bus, aligned to Tomorrows Energy Scenarios (TES) 2023[13].<br>• Efficiency projections aligned with Tomorrows Energy Scenarios (0.9% improvement per year for passenger vehicles, 0.5% improvement per year for commercial vehicles).<br>• PHEVs assumed to be 49% less efficient than BEV equivalent[14]. |

*Table 1 - Electric Vehicles Annual Electricity Demand*

### 2.1.2. Electric Vehicles Demand Shape

| Category | Ireland Data Source / Assumption |
|---|---|
| Vehicle Usage Pattern | • 48.1% of annual usage in summer, 51.9% of annual usage in winter based on national weekly car volumes for 2022[15].<br>• 14.68% usage on weekdays, 13.30% usage on weekend day based on 2022 traffic count analysis[16]. |
| Charging Profiles | • Aligned to weekday and weekend charging profiles for cars, freight, and busses first published in TES 2019[17].<br>• Simple and smarter[18] profiles used to reflect flexibility through incentives to avoid charging during peak times. |
| Proportion of Users on Charging Profiles | • Simple / Smarter proportion assumes 26% of people currently charge using a smarter profile. Based on proportion of residential properties on time of use tariffs (information from ESB).<br>• Assume this grows to 90% by 2030 and stays at 90% beyond 2030. |

*Table 2 - Electric Vehicles Demand Shape*

## 2.2. Heat Pumps

### 2.2.1. Heat Pump Annual Energy Demand

| Category | Ireland Data Source / Assumption |
|---|---|
| Historic Number of Heat Pumps | • SEAI Data from BER Database analysis for residential properties[19]<br>• McKinsey Study on supporting CAP23 for commercial heat pumps[20] |
| Forecast Number of Heat Pumps | • Climate Action Plan 2024 (CAP24) Targets[21].<br>• Polynomial projection of growth through latest historical figures, and CAP24 targets.<br>• Linear increase post 2030 based on growth from 2029 - 2030. |
| Heating Demand | • Assume residential heat pumps only fitted to efficient homes, SEAI grant only offered to homes that have a BER of B2 and above.<br>• Annual space and hot water heating demand for BER of A1-B2 is 7.909 MWh/yr/property[22].<br>• Commercial Heat Demand based on proportional attribution of commercial and public heat demand from SEAI national heat study[23] (58.354 MWh/yr/property). |

[13] https://www.eirgrid.ie/industry/tomorrows-energy-scenarios-tes
[14] https://evstatistics.com/2022/04/bev-batteries-average-83-kwh-versus-15-kwh-for-phevs/#:~:text=Using%20the%20median%20numbers%2C%20BEVs,mile%20per%20kWh%20for%20PHEVs
[15] https://www.cso.ie/en/releasesandpublications/rp/fp-ttftcd/trafficcountanalysisusingtiidata/data/
[16] https://www.cso.ie/en/releasesandpublications/rp/fp-ttftcd/trafficcountanalysisusingtiidata/data/
[17] https://www.eirgrid.ie/site-files/library/EirGrid/EirGrid-TES-2019-Report.pdf
[18] https://2022.entsos-tyndp-scenarios.eu/wp-content/uploads/2022/04/TYNDP_2022_Scenario_Building_Guidelines_Version_April_2022.pdf
[19] https://ndber.seai.ie/BERResearchTool/ber/search.aspx
[20] https://www.gov.ie/pdf/?file=https://assets.gov.ie/245173/39588f58-81ed-4631-82fc-11d6d6d55dea.pdf#page=null
[21] https://www.gov.ie/pdf/?file=https://assets.gov.ie/279555/25df7bb5-1488-4ba1-9711-e058d578371b.pdf#page=null
[22] https://www.seai.ie/data-and-insights/national-heat-study/heating-and-cooling-in-ir/
[23] https://www.seai.ie/data-and-insights/national-heat-study/heating-and-cooling-in-ir/

| | |
|---|---|
| | • Climatic variability factored into annual heating demand using when2heat study of heating demand from 2008-2022[24]. The ENTSO-E Demand forecasting tool ensures the average heating demand across 35 historic Pan-European Climatic Database (PECD) simulated climate years is equivalent annual estimate, but captures the variability brought about by temperature. |
| Heat Pump Efficiency | • Based on SEAI low-carbon heating study giving 2020 efficiency and projecting out to 2050[25].<br>• The impact of temperature on the heat pump coefficient of performance (COP) is based on the when2heat study[26] and is factored in by the ENTSO-E Demand forecasting tool when converting heat demand to electricity demand. |
| Heat Pump Type | • Informed by TES 2023 analysis, 66% air source heat pump and 34% ground source heat pump. |

*Table 3 - Heat Pump Annual Energy Demand*

### 2.2.2. Heat Pump Demand Shape

| Category | Ireland Data Source / Assumption |
|---|---|
| Climate Dependency | • Hourly heat demand based on when2heat study, and hourly climate data from PECD 35 historic years. |
| Heat Pump Usage | • Usage of heat pumps aligned to Loughborough University Study[27] showing 28% of homes have a daytime usage, 8% have a bimodal usage, and 64% have continuous usage. |

*Table 4 - Heat Pump Demand Shape*

## 2.3. Data Centres and New Technology Load

This sector considers large scale data centres and technology loads that have dedicated connections to the high voltage network. This includes all dedicated connections to the TSO operated 110 kV, 220 kV network and the DSO operated 110 kV network in Dublin. Customers with connection voltages less than 110 kV are captured as part of the commercial and industrial demand.

### 2.3.1. Data Centre and New Technology Load Annual Energy Demand

| Category | Ireland Data Source / Assumption |
|---|---|
| Annual Demand | • The forecasted growth rates for individual sites are compared to sites from the same customer, and sites of a comparable size to verify if they are reasonable. Adjustments are made if required.<br>• Final utilisation of contracted capacity is assumed on a site-by-site basis, considering current utilisation and typical utilisation for a particular customer or site size.<br>• Demand is assumed to grow linearly across the year, from the previous year's forecast peak in December, to the subsequent years peak in December. This is based on historic trends. |

*Table 5 - Data Centre and New Technology Load Annual Energy Demand*

### 2.3.2. Data Centre and New Technology Load Demand Shape

| Category | Ireland Data Source / Assumption |
|---|---|
| Hourly Demand Shape | • Demand is assumed to be flat throughout the day on the basis of analysis of consumption patterns. |
| Daily Demand Shape | • Demand is assumed to be consistent across weekdays and weekends on the basis of analysis of consumption patterns. |

*Table 6 - Data Centre and New Technology Load Demand Shape*

24 https://data.open-power-system-data.org/when2heat/
25 https://www.seai.ie/data-and-insights/national-heat-study/low-carbon-heating-and-co/
26 https://data.open-power-system-data.org/when2heat/
27 https://www.sciencedirect.com/science/article/pii/S037877882100061X?via%3Dihub

## 2.4. Conventional Demand

This section analyses the conventional demand. For the purposes of this paper, we are defining "conventional demand" as that from the residential, commercial and industrial sector, excluding the impact of electric vehicles, heat pumps and data centres and new technology loads.

### 2.4.1. Conventional Demand Annual Energy Demand

| Category | Ireland Data Source / Assumption |
|---|---|
| Historic End User Demand | • Residential Demand includes domestic electricity sales (ESB), and an assumed level of self-consumption from rooftop solar panels (detailed below).<br>• Commercial and Industrial Demand includes the DSO non-domestic energy sales (ESB), transmission connected energy sales (EirGrid), and self-consumption from Combined Heat and Power electricity generation (SEAI) Small Scale Generation (SEAI), and rooftop solar panels.<br>• Installed capacity of residential solar panels based on ESB data from NC6 forms.<br>• Installed capacity of commercial and industrial solar panels based on ESB data from NC7 and NC8 forms.<br>• Solar panel capacity factor of 11% assumed[28].<br>• Current assumption that behind the meter (micro, mini and small-scale generation) solar generation energy is consumed on site.<br>• Assumed historic demand from electric vehicles, heat pumps and data centres and new tech loads is detracted to view the underlying conventional demand from residential, commercial and industrial sectors. |
| Historic Temperature Correction | • Temperature correction applied to residential demand which is most sensitive to temperature.<br>• Daily Historic climate data from Met Eireann using a population weighting of temperatures at Dublin Airport, Knock Airport, Cork Airport, Shannon Airport.<br>• Number of degree days (15.5°C Base) for winter of each year compared to average to provide a metric of mild and cold winters[29].<br>• Delta to average number of degree days multiplied by temperature correction factor to calculate a correction to the total energy demand.<br>• Temperature correction factor calculated as factor which gives strongest correlation between temperature corrected demand and economic performance. |
| Historic Economic Performance | • Historic residential demand correlated to historic personal consumption figures from the CSO.<br>• Periods around the global financial crisis (2008-2014) and COVID-19 (2020-2021) excluded to avoid turbulent periods masking trends that are apparent in steady growth which is forecast.<br>• Historic commercial and industrial demand correlated to historic Modified GNI* figures from the CSO. |
| Forecast Economic Performance | • Forecast economic growth for personal consumption based on ESRI private consumer expenditure forecast[30].<br>• Forecast economic growth for Modified GNI* based on ESRI Modified Domestic Demand forecast[31]. |
| Smart Meter Effects | • Number of installed smart meters based on ESB press release[32]. |

[28] https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1004&context=dubencon2
[29] https://www.sustainabilityexchange.ac.uk/files/degree_days_for_energy_management_carbon_trust.pdf
[30] QUARTERLY ECONOMIC COMMENTARY, Winter 2023 (esri.ie)
[31] QUARTERLY ECONOMIC COMMENTARY, Winter 2023 (esri.ie)
[32] https://esb.ie/media-centre-news/press-releases/article/2023/11/21/esb-networks-installs-1.5-million-smart-meters-nationwide-as-part-of-the-national-smart-metering-programme

| | |
|---|---|
| | • 90% of currently installed smart meters assumed to be in residential buildings (90/10 split in number of residential/commercial buildings).<br>• Forecast rollout of smart meters assumes all domestic properties by end of 2024.<br>• Current uptake of smart tariffs based on ESB energy sales.<br>• Projected 100% of residential properties using smart tariffs by 2030.<br>• Assume that a smart tariff reduces annual residential demand by 2% based on CRU study[33].<br>• Assume that smart meters have no statistically significant impact on commercial or industrial demand based on CRU study[34]. |
| Efficiency Improvements | • Residential, Commercial, and Industrial efficiency improvements based on EU Energy Directive[35], after accounting for inherent efficiency gains in historic load.<br>• Historic efficiency improvements inherent in historic industrial and commercial demand assumed to continue. |

*Table 7 - Conventional Demand Annual Energy Demand*

### 2.4.2. Conventional Demand Shape

Conventional demand shape is forecast within the ENTSO-E Demand Forecasting Tool on the basis of historical correlation between demand and a number of factors that are then forecasted into the future.

| Category | Ireland Data Source / Assumption |
|---|---|
| Correlation Data | • Historic hourly demand measured by EirGrid at the transmission level from 2012 – 2018 used to train model, with historic data from 2019 used to verify correlation.<br>• Historic calendar used to draw correlation between time of day, day of week and day of year for demand trends.<br>• Special days identified and categorised to identify common trends where demand may be different to normal. Categories used include Public Holidays, Christmas Day, Boxing / St Stephen's Day, Good Friday, Easter Weekend, Short week after Easter and St Patrick's Day, Days around Christmas and New Year.<br>• Hourly climatic data for each jurisdiction based on the Pan European Climatic Database (PECD). Data includes wind speed, irradiance, and population weighted temperature. |
| Forecast Data | • Future calendar including same categories of special days for study horizon.<br>• Historic 35 climate years of PECD v3.1 data from 1982-2016 used to forecast climatic variability and historic extremes of wind speed, irradiance and population weighted temperature.<br>• Future small scale (rooftop) solar incorporated into demand shape. |

*Table 8 - Conventional Demand Shape*

33 https://cruie-live-96ca64acab2247eca8a850a7e54b-5b34f62.divio-media.com/documents/cer11080.pdf
34 cer11080.pdf (divio-media.com)
35 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

## 2.5. Network Losses

Network losses are included in the forecast of Total Electricity Requirement and are included in Table 9.

| Category | Ireland Data Source / Assumption |
|---|---|
| Forecast Network Losses | • Historic Losses are calculated using the difference between metered generation (net of interconnection and storage) and metered demand. This data is historically recorded by the TSO and DSO.<br>• Forecast losses are based on a 14-year average of historic network losses.<br>• Network losses are estimated as 7.2% for the duration of the study. |

*Table 9 - Network Losses*

## 2.6. Flexibility

Demand flexibility is contributed to by multiple different sectors included in the demand and generation assumptions. The table below shows the assumed contribution to demand flexibility based on the data sources listed.

| Category | Ireland Data Source / Assumption |
|---|---|
| Storage | • Storage contribution to flexibility captured to battery storage and pumped storage in Section 3.<br>• This storage is able to charge and discharge providing flexibility. |
| DSUs | • Aligned to Demand Side Units in Section 3. |
| Electric Vehicles | • Electric vehicle contribution to peak shifting flexibility accounted for on the basis of charging profiles as described in Section 2.1. |
| Residential Demand | • 8.8% reduction in residential demand during peak period (17:00-19:00) assumed[36].<br>• Based on the uptake of smart tariffs as described in Section 2.4.<br>• Reduction in residential demand assumed to be spread evenly throughout the remainder of the day. |

*Table 10 - Flexibility*

[36] cer11080.pdf (divio-media.com)

# 3. Adequacy Resources

This section specifies data sources and assumptions sources for relevant inputs as listed in the methodology.

## 3.1. Conventional Generation

Table 11 below outlines data input sources and assumptions related to conventional generation.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| Existing Plant Annual Operating Capacity | • Connection Agreements.<br>• Operational data from Electronic Dispatch Instruction Logger (EDIL) declarations for information related to enduring capacity changes.<br>• Closure notices submitted under the EirGrid Grid Codes[37].<br>• Directive 2010/75/EU[38] of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED).<br>• REMIT Urgent Market Messaging (REMIT UMM)[39]. | • In the instance where information differs between data sources, the most conservative value will be taken as the input e.g. a unit has declared unavailability through REMIT for a given year it will be excluded even if it still holds a valid Connection Agreement. |
| New plant capacity & deliverability | • Projects with awarded capacity in published capacity market auction results. Data for successful projects will be obtained from capacity market qualification data forms submitted to the capacity market team when seeking to qualify for a capacity auction.<br>• Capacity market termination notices. | • Enhanced Monitoring programme in Ireland comprising the TSO, Regulatory Authority, and DECC. The programme tracks new plant deliverability and assesses likely connection dates based on a range of factors including planning, grid connection, gas connection.<br>• At the freeze date, the TSO will risk adjust each project to an expected delivery date aligned with best available information. |
| Heat Rate | • ENTSO-E Market Modelling Database[40] Thermal Properties tab. | • Thermal operating characteristics based on standard values (e.g. efficiency) consistent with the ERAA modelling framework. |
| Plant Performance | • EirGrid and SONI monthly availability reports from 2019 – 2023 (five years of statistics). | • Forced outages are represented as an annual % that capacity is expected to be forced unavailable.<br>• Ambient availability is represented as a weekly profile, applied to gas fired generation and reflects reduced capacity availability during summer months when conditions are warmer.<br>• Scheduled outages are represented as an annual number of hours that capacity is expected to be on an agreed outage. |

[37] https://cms.eirgrid.ie/sites/default/files/publications/Grid-Code-Version-13_0.pdf
[38] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010L0075&from=EN
[39] Nord Pool - REMIT UMM (nordpoolgroup.com)
[40] https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/sdc-documents/ERAA/2023/ERAA2023%20PEMMDB%20Generation.xlsx

| | | |
|---|---|---|
| | | • Stats are calculated on an all-island basis i.e. not on a jurisdictional level.<br>• Units that have retired or are known to be retiring within the study horizon are excluded from the calculation of outage statistics. Rationale: Such units do not represent the performance of the fleet expected to be operational over the study horizon.<br>• Stats are applied to new and existing units i.e. no assumptions made regarding the performance of new units joining the system over the coming years.<br>• Stats are fixed across the study horizon i.e. performance is not modelled as improving or declining over time.<br>• Assumed 24 hours for a plant to return to operation when forced offline.<br>• Assumed each unit undertakes a single scheduled outage pear year.<br>• No distinguishment made to differentiate minor from major planned outages. |
| Run Hour Limitations | • Best Available Techniques[41] (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants.<br>• Environmental Protection Agency (EPA) guidance.<br>• Data or information received from market participants or project developers.<br>• Generator Survey.<br>• Planning permission.<br>• Fuel scarcity considerations. | • In the instance where information differs between data sources, the most conservative value will be taken as the input.<br>• Run Hour Limits will restrict the availability of plant to a limited number of operating hours per year.<br>• The information pertaining to Hydrogenated Vegetable Oil (HVO) as a primary fuel type is evolving however it is expected there may be emissions legislation and possibly fuel supply challenges which could limit the operating hours of these units. The assessment assumes capacity operating on HVO as a primary fuel source are restricted to a 500 hours per year operating hour restriction. |

*Table 11 - Conventional Generation Input Sources and Assumptions*

[41] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021D2326

## 3.2. Interconnection

Table 12 below outlines data input sources and assumptions related to interconnection including HVDC and HVAC interconnection.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| SEM to GB and France HVDC Interconnection | • Connection Agreements.<br>• European Ten-Year Network Development Plan.<br>• European Commission Project of Common Interest (PCI) status.<br>• EirGrid Transmission Development Plans. | • In the instance where information differs between data sources, the most conservative value will be taken as the input. |
| Ireland to Northern Ireland HVAC Interconnection | • EirGrid Transmission Development Plans for delivery dates of new North-South interconnector.<br>• ERAA 2022[42] for Net Transfer Capacity. | • The existing North South consists of two bi-directional lines having a combined NTC of +/- 300 MW. The new North South Interconnector will increase this NTC by +900/-950 giving a total NTC of 1200 N → S and 1250 S → N.<br>• The Net Transfer Capacity increase from the new North South Interconnector was determined through Grid Transfer Capacity Studies for TYNDP studies in 2016.<br>• No outage statistics applied to HVAC. |
| Pan European model | • The model used for the European Resource Adequacy Assessment 2023[43]. | • Model used to derive fixed import/export flows for non-explicitly modelled regions (regions beyond GB and France). |
| HVDC Interconnection Availability | • SEM Interconnectors: Regulatory Authority approved outage statistics received through capacity auction process for interconnection to the SEM.<br>• Non-SEM Interconnectors: European Resource Adequacy Assessment 2023. | • Implemented as forced outage only.<br>• Availability statistics for SEM interconnectors are available in the accompanying data workbook. |

*Table 12 - Interconnection Input Sources and Assumptions*

## 3.3. Variable Generation

Table 13 below outlines data input sources and assumptions related to variable generation including wind, solar and hydro resources.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| Variable Renewable Capacity | • Renewable Electricity Support Scheme (RESS) deliverability monitoring of successful projects.<br>• Offshore Renewable Electricity Support Scheme (ORESS).<br>• Connection policy including Gate 3, Non-GPA and ECP.<br>• Climate Action Plan 2024[44].<br>• Connection offer process figures. | • SEAI expert elicitation was selected for the median scenario.<br>• Sensitivities were implemented on different renewable trajectories using the SEAI expert elicitation and Climate Action Plan. |

[42] https://eepublicdownloads.azureedge.net/clean-documents/sdc-documents/ERAA/2022/data-for-publication/Net%20Transfer%20Capacities.zip *Note: The ERAA23 published data contains an error, therefore ERAA2022 is used instead. ENTSO-E are aware of this and the data will be corrected for ERAA24.*
[43] https://www.entsoe.eu/outlooks/eraa/2023/
[44] https://assets.gov.ie/284675/70922dc5-1480-4c2e-830e-295afd0b5356.pdf

| | | |
|---|---|---|
| | • Shaping Our Electricity Future Roadmap v1.1[45].<br>• EirGrid / ESBN publications of renewable connections.<br>• SEAI Expert Elicitation[46]. | |
| Ireland Hourly Renewable Rating Factor (%) | • ERAA PECD 3.1[47] database profiles. | • The PECD profiles include significantly high-capacity factors beyond what has been observed in actual recorded wind availability. Overestimating wind availability could present underrepresent risks to resource adequacy and therefore scaling factors are proposed to adjust the PECD onshore and offshore profiles (detailed further below).<br>• Onshore profile scaled on an hourly basis by a 0.9 scaling factor. Rationale: Comparison of PECD profiles against recorded historic availability profiles provides the basis for scaling down PECD profiles. The average scaled capacity factor of PECD onshore profiles is 30% in 2030.<br>• Offshore profile scaled on an hourly basis by a 0.75 scaling factor. Rationale: Comparison of PECD profiles against profiles used in the ECP[48] modelling process provides the basis for scaling down PECD offshore profiles. The average scaled capacity factor of PECD offshore profiles is 45% in 2030.<br>• Performance of renewable generators is considered to be consistent across the study horizon. Considerations for degrading performance of renewable generators towards the end of operational life, plant retirements, or repowering to more efficient turbines are outside of the scope of this methodology.<br>• Assume that any technological efficiency improvements are captured in the PECD profiles which show increase capacity factor of technologies across the study horizon.<br>• Assuming same profile for rooftop solar as with large scale onshore. |
| France and Great Britain Hourly Renewable Rating Factor (%) | • ERAA PECD 3.1[49] database profiles. | • Profiles used for GB and France are consistent with ERAA. |

*Table 13 - Variable Generation Input Sources and Assumptions*

## 3.4. Battery Storage

Table 14 below outlines data input sources and assumptions related to battery storage.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|

[45] https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping-Our-Electricity-Future-Roadmap_Version-1.1_07.23.pdf
[46] https://www.seai.ie/renewable-energy/decarbonised-electricity-system-study
[47] https://www.entsoe.eu/outlooks/eraa/2023/eraa-downloads/
[48] https://cms.eirgrid.ie/sites/default/files/publications/ECP-2.3-Wind-and-Solar-Profiles-Excel-Format.xlsx
[49] https://www.entsoe.eu/outlooks/eraa/2023/eraa-downloads/

| | | |
|---|---|---|
| Battery Storage Capacity | • Capacity market auction qualification data for MW and storage duration information.<br>• Operational data from Electronic Dispatch Instruction Logger (EDIL) declarations.<br>• Capacity market termination notices. | • In the instance where information differs between data sources, the most conservative value will be taken as the input. |
| Battery Storage Deliverability | • Projects with awarded capacity in published capacity market auction results will be considered as part of the input generation portfolio when also considering the latest risk assessment of project delivery. Data for successful projects will be obtained from capacity market qualification data forms submitted to the capacity market team when seeking to qualify for a capacity auction. | • Enhanced Monitoring programme in Ireland comprising EirGrid, CRU, and DECC. The programme tracks new plant deliverability and assesses likely connection dates based on a range of factors including planning, grid connection, gas connection. |
| Technical Characteristics | • ERAA 2023 methodology[50].<br>• 3$^{rd}$ party independent review of battery storage technologies. | • Round Trip Efficiency: 80%.<br>• Max State of Charge: 90%.<br>• Min State of Charge: 10%.<br>• It is assumed that performance does not decline over time as units are cycled more frequently or chemical storage erodes. The parameters above are a balanced approach as opposed to purely representing units at the start of end of life. |
| Pump Load | • Connection offers and agreements. | • Maximum Import Capacity (MIC) set to 50% of Maximum Export Capacity for Ireland existing and new battery units. |
| Storage Performance | • ERAA 2023 methodology. | • There is insufficient data to appropriately dimension outage statistics for battery storage, given the relatively recent introduction of this technology. In the absence of appropriate data, outages will not be modelled for batteries at this time. |

*Table 14 - Battery Storage Input Sources and Assumptions*

## 3.5. Demand Side Units

Table 15 below outlines data input sources and assumptions related to demand side units.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| Demand Side Units Capacity | • Capacity market auctions successful projects information.<br>• Capacity market termination notices. | • In the instance where information differs between data sources, the most conservative value will be taken as the input. |
| Rating Factor | • EirGrid and SONI monthly availability reports from 2019 – 2023 (five years of statistics). | • Applied as a rating factor in the model to restrict capacity available to the economic dispatch rather than model using forced and scheduled outages which are less representative of DSU availability. |
| Daily Run Hour Limits | • Run hour limits based on capacity market data. | • Run Hour Limits are applied on a daily basis. They do not change throughout the day or across the |

[50] https://www.entsoe.eu/outlooks/eraa/2023/report/ERAA_2023_Annex_2_Methodology.pdf

| | | |
|---|---|---|
| | | year i.e. depending on what loads may be available for response.<br>• Annual Run Hour Limits associated with Individual Demand Sites are not considered. This is assumed to be reflected in overall DSU performance captured in the Rating Factor. |

*Table 15 - Demand Side Units Input Sources and Assumptions*

## 3.6. Pumped Storage

Table 16 below outlines data input sources and assumptions related to pumped storage.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| Import/Export Capacity | • Connection agreement.<br>• Operational data from Electronic Dispatch Instruction Logger (EDIL) declarations. | • Assumed to be fixed across study horizon. |
| Pumped Storage Reservoir Volume | • Operational policy and procedures. | • Assumed to be fixed across study horizon. |
| Performance | • EirGrid and SONI monthly availability reports from 2019 – 2023 (five years of statistics). | • Five-year capacity weighted average statistics. Same calculation as conventional generators.<br>• The same assumptions apply as per conventional generators i.e. not considering future performance will improve or decline. |
| Pumped Storage Efficiency | • Operational policy and procedures. | • Efficiency is assumed to be fixed i.e. does not vary depending on pumping or generating load. |

*Table 16 - Pumped Storage Input Sources and Assumptions*

## 3.7. Other RES / Other Non-RES

Table 17 below outlines data input sources and assumptions related to other RES and other non-RES.

| Input Category | Input Source(s) | Input Assumption(s) |
|---|---|---|
| Capacity | • DSO data (ESBN)<br>• SEAI | • Assumed to be fixed across study horizon. |

*Table 17 – Other RES / Non-RES Input Sources and Assumptions*

# 4. Modelling

Table 18 below specifies modelling input(s) sources and assumption(s).

| Category | Input Source(s) | Assumption(s) |
|---|---|---|
| Ireland Loss of Load Expectation Standard | • Engagement with CRU and DECC. | • The CRU have confirmed, following engagement with DECC, the LOLE standard for Ireland is 3 hours. |
| Modelling application | • N/A | • Energy Exemplar's Plexos application will be utilised for stochastic modelling of resource adequacy. |
| Modelling resolution | • N/A | • Hourly |
| Monte Carlo samples | • Internal convergence analysis. | • The Stochastic Class within Plexos will create 20 samples for the LOLE and EENS calculation, where each sample has a random forced and scheduled outage. Additional detail on the generation of scheduled outage patterns is provided below for the Maintenance Factor. Note this is increased to 40 samples for the MW calculation.<br>• Assessing the variation of sample results for a single climate year and target year to ensure with a 95% confidence that results are ±50MW within each other. This represents a reasonable balance between the time taken to run stochastic simulations and convergence analysis of results. |
| Maintenance Factor | • Generator outage schedules from previous 5 years. | • The maintenance factor is an hourly profile representing the average historic scheduled outages pattern. This profile is used by Plexos to generate maintenance patterns for future years which on average reflect the typical scheduled outage pattern observed historically.<br>• Single maintenance factor profile used in both Northern Ireland and Ireland. Rationale: The pattern of outages in either jurisdiction is not observed to be significantly different from the other in terms of when maintenance may occur as such generating different maintenance factor profiles for Ireland and Northern Ireland does not have significant impact results. |
| Reserve | • Operational constraints policy (example[51]).<br>• System Operator GuideLines[52] (SOGL). | • LSI pre-2027: 500 MW.<br>• LSI from 2027: 700 MW.<br>• Reserve is fixed across each hour of the model optimisation i.e. does not vary dynamically over time. |
| Transmission Outage Planning | • Analysis of transmission outages on operation of plant. | • From 2025 EirGrid account for a 350 MW transmission outage planning requirement in Ireland. Given the constrained nature of the transmission network, contingencies or planned outages can result in restricted power flows on the network. Whilst the network is not explicitly modelled in the Plexos model, this adjustment is included to facilitate outages needed to connect new generation and infrastructure. |
| Fuel and carbon prices | • ERAA 2024 Preliminary Input Data[53]. | • ENTSO-E have issued a call for evidence on input data for ERAA 2024. NRAA will use the fuel and carbon price forecasts for adequacy modelling. Note that as NRAA 2024 is not doing an Economic Viability Assessment fuel and carbon prices are less relevant as they have negligible impact on resource adequacy. |
| Climate Years | • European Resource Adequacy Assessment 2023. | • There are 35 historic climate years available from PECD database. The core adequacy analysis will model 35 of these climate years. |

*Table 18 - Modelling Input Sources and Assumptions*

[51] Wk06_2024_Weekly_Operational_Constraints_Update_Rev2.pdf (sem-o.com)
[52] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R1485
[53] https://consultations.entsoe.eu/system-development/eraa2024-call-for-evidence-preliminary-dat/

# 5. Scenarios

## 5.1. High and Low Demand Scenarios

Given the high number of variables in the demand forecast that are highly dependent on external factors, low and high demand scenarios are modelled as an expected upper and lower band of where EirGrid believe demand could realistically fall. These are not deemed as extreme scenarios, but realistic forecasts. Table 19 below details the assumptions are the assumptions which are altered in comparison to the median demand forecast described in Section 3 for deriving high and low demand forecasts. Whilst this does not adjust all parameters within the forecast, each sector has a factor adjusted to provide a projection built on the same foundation. Unless stated below, all other assumptions remain the same as the median forecast.

| Sector | Ireland | |
|---|---|---|
| | Low forecast | High Forecast |
| Electric Vehicles | Growth in number of electric vehicles 25% lower than median demand. | Growth in number of electric vehicles 10% higher than median demand. |
| Heat Pumps | Growth in heat pump installations 25% lower than median demand. | Growth in heat pump installations 10% higher than median demand. |
| Data Centres & New Technology Loads | Growth rate and contract utilisation are more conservative. The assumptions are applied on a site-by-site basis, considering historic examples of lower and higher growth and contract utilisation by particular customers or sites of a similar size. | Growth rate and contract utilisation are more aggressive. The assumptions are applied on a site-by-site basis, considering historic examples of lower and higher growth and contract utilisation by particular customers or sites of a similar size. |
| Conventional Demand | Economic growth forecast 25% lower than ESRI forecast. | Economic growth forecast 10% higher than ESRI forecast. |

*Table 19 - Low and High Demand Forecast Assumptions in Ireland*

## 5.2. Modelling Scenarios

| Scenario | Description |
|---|---|
| Base | The Base scenario analyses the adequacy position in line with the European Resource Adequacy Assessment (ERAA). |
| Secure | Secure scenario analyses the system considering Low Imports, Annual Run Hour Limits (ARHL) and transmission outage planning. Low Imports are modelled through restricting the maximum imports to 70% for each interconnector to the SEM. |

*Table 20 – Adequacy Scenarios*

## 5.3. Other Sensitivities

| Scenario | Description |
|---|---|
| Demand | Assessing the impact of a lower or higher demand trajectory. |
| Flexibility | Assessing the impact of varying levels of flexibility. |
| Renewable Deployment | Assessing the impact of varying levels of renewable deployment. |
| Annual Run Hour Limits (ARHL) | Assessing the impact of Annual Run Hour Limits on some new units. |
| Storage | Assessing the impact of varying levels of storage deployment. |

| | |
|---|---|
| Capacity Market Delivery | Assessing the impact of all capacity which has been awarded a capacity contract that has not yet been terminated, delivering on time for the year in which its contract was due to commence. |
| Interconnection | Assessing the impact of lower dependence on interconnection, either through limited imports or low generation availability in neighbouring regions. |

*Table 21 - Adequacy Analysis*

# 6. Glossary

| | |
|---|---|
| **ACER** | The European Union Agency for Cooperation of Energy Regulators |
| **AHC** | Advanced Hybrid Coupling |
| **ATC** | Available Transmission Capacity |
| **BESS** | Battery Energy Storage System |
| **BEV** | Battery Electric Vehicles |
| **CCS** | Carbon Capture & Storage |
| **CHP** | Combined Heat & Power |
| **CO2** | Carbon Dioxide |
| **CONE** | Cost Of New Entry |
| **COP** | Coefficient Of Performance |
| **DFT** | Demand Forecasting Tool |
| **DSU** | Demand Side Units |
| **EENS** | Expected Energy Not Served |
| **ENS** | Energy Not Served |
| **ENTSO-E** | European Network of Transmission System Operators for Electricity |
| **ERAA** | European Resource Adequacy Assessment |
| **EU** | European Union |
| **EV** | Electric Vehicles |
| **EVA** | Economic Viability Assessment |
| **FBMC** | Flow Based Market Coupling |
| **FCR** | Frequency Containment Reserve |
| **FOR** | Forced Outage Rate |
| **FR** | France |
| **FRR** | Frequency Restoration Reserves |
| **GB** | Great Britain |
| **GCS** | Generation Capacity Statement |
| **GJ** | Gigajoules |
| **GW** | Gigawatts |
| **LOLD** | Loss Of Load Duration |
| **LOLE** | Loss Of Load Expectation |
| **LOLP** | Loss Of Load Probability |
| **LSI** | Largest Single Infeed |
| **MW** | Megawatt |
| **NCV** | Net Calorific Value |
| **NRAA** | National Resource Adequacy Assessment |
| **NTC** | Net Transfer Capacities |
| **P2X** | Power-to-X |
| **PEMMDB** | Pan-European Market Database |
| **PHEV** | Plug-in Hybrid Electric Vehicles |
| **PTDF** | Power Transfer Distribution Factor |
| **PV** | Photovoltaics |
| **RES** | Renewable Energy Sources |
| **ROCOF** | Rate-of-Change-of-Frequency |
| **RR** | Replacement Reserves |
| **SEM** | Single Electricity Market |
| **SNSP** | System Non-Synchronous Penetration |
| **SONI** | System Operator for Northern Ireland |
| **SRMC** | Short-Run Marginal Cost |
| **SY** | Submission Year |
| **TSO** | Transmission System Operator |
| **VO&M** | Variable Operations & Maintenance |
| **VOLL** | Value of Lost Load |
| **WACC** | Weighted Average Cost of Capital |