CAPACITY

CLIMATE ACTION PATHWAYS & ABSORPTIVE CAPACITY

Vision 35-A Net Zero Electricity system

The Climate Act and the Power Sector

This analysis presents the characteristic and attributes of a net-zero power system in Ireland that is compatible with the Climate Action and Low Carbon Development (Amendment) Act 2021 (known here as the Climate Act)

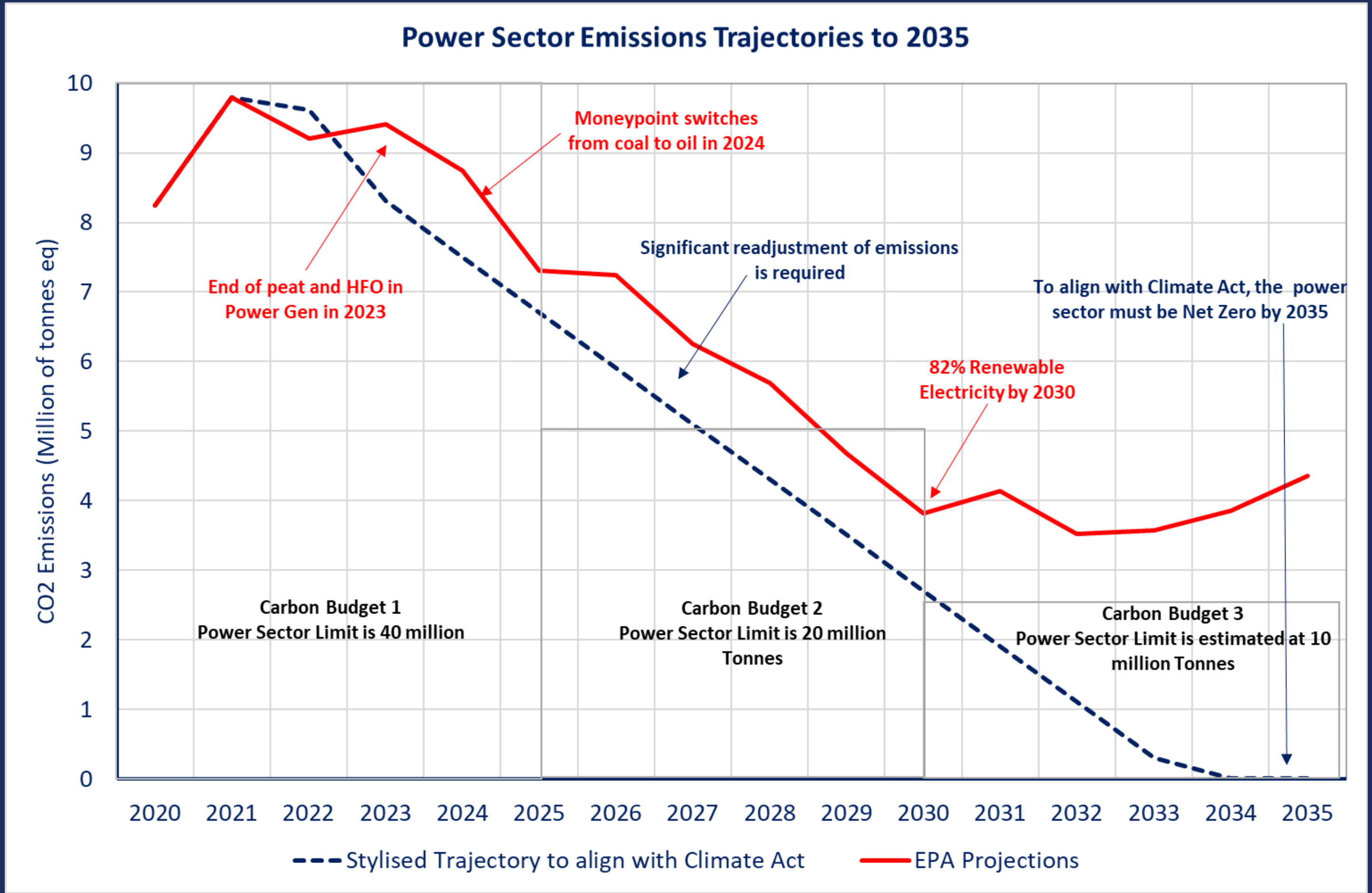
As part of the Act, sectoral Ceilings have been set by Government as a mechanism to assist with the achievement of Carbon Budgets and the ambition in the Climate Act 2021. These sectoral ceilings are legally binding and set out the maximum amount of greenhouse gas pollution permitted in different sectors that align with Governmental responsibility.

For the electricity sector the limit is 60 million tonnes of Carbon Dioxide in the period 2021 to 2030. Recent EPA projections (red line in graph) point to an overshoot of 13 Mt CO2eq of this target and a significant readjustment of power sector emissions is required (dashed blue line in graph) in the period to 2035 with the overall trajectory depending on the level of electricity demand and amount of negative emissions options.

UCC economy wide analysis points to the need for Ireland to achieve a net zero power system in the period between 2032 to 2037 to align with sectorial ceilings as defined by the Climate Act.

In this study, our approach is to start with a view of what a net zero power system should look line in 2035 and recommend that all market decisions, investments made today should be consistent with deliver of such a system.

This is a snapshot analysis of the year 2035 only



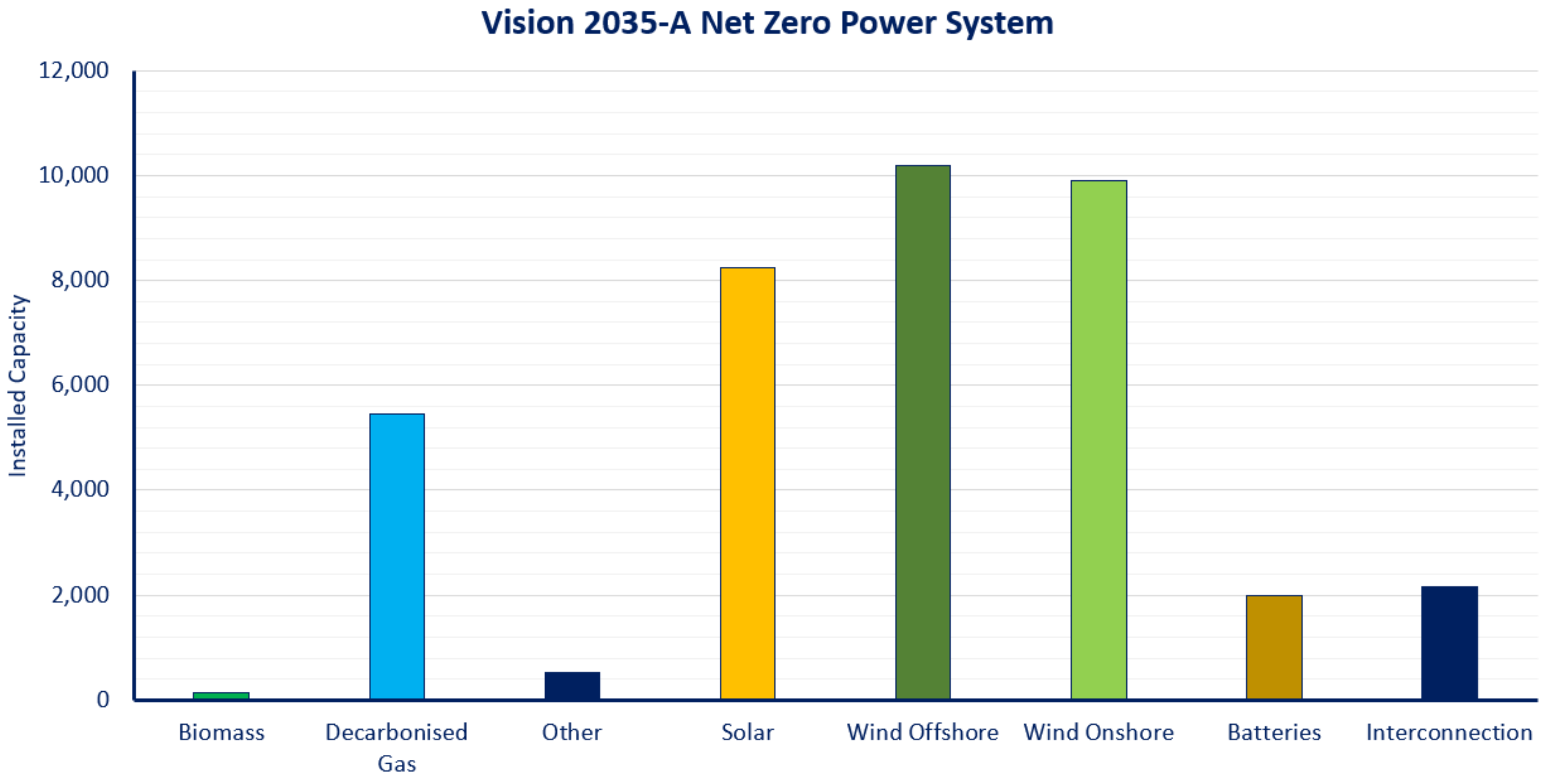
As we move to 2035 electricity demand will increase as it replaces the fossil fuels in the wider economy. The demand for electricity grows from 35 TWh in 2023 to 61 TWh in 2035 driven by electrification of heat, transport, and new loads. The size of the resulting power system increases from 9,300 MW today to one dominated by weather driven renewables in 2035 with a capacity of 33,800 MW.

While the climate act is based on average, the future power system must be resilient to extremes and extremes in weather will require new levels of flexibility and economy wide energy storage to manage extremes in weather.

Even though the system has a high level of renewable capacity, there are approximately 4,000 hours when there is insufficient sunshine and wind for renewables to meet electricity demand and therefore needs battery storage and imports from interconnection. This helps meets a further 2,000 hours of demand but there is still a shortfall of another 2,000 hours.

Renewables reduce the use of conventional plant but do not replace the need and the 2035 the Power system will require similar levels of conventional generation to today but will be used significantly less (approx. capacity factors of 15%) and it must be fired with fuel that does emit climate pollution. In this scenario we assume some form of decarbonised gas, but the exact type needs further consideration.

From a Natural Gas to a Weather Driven System



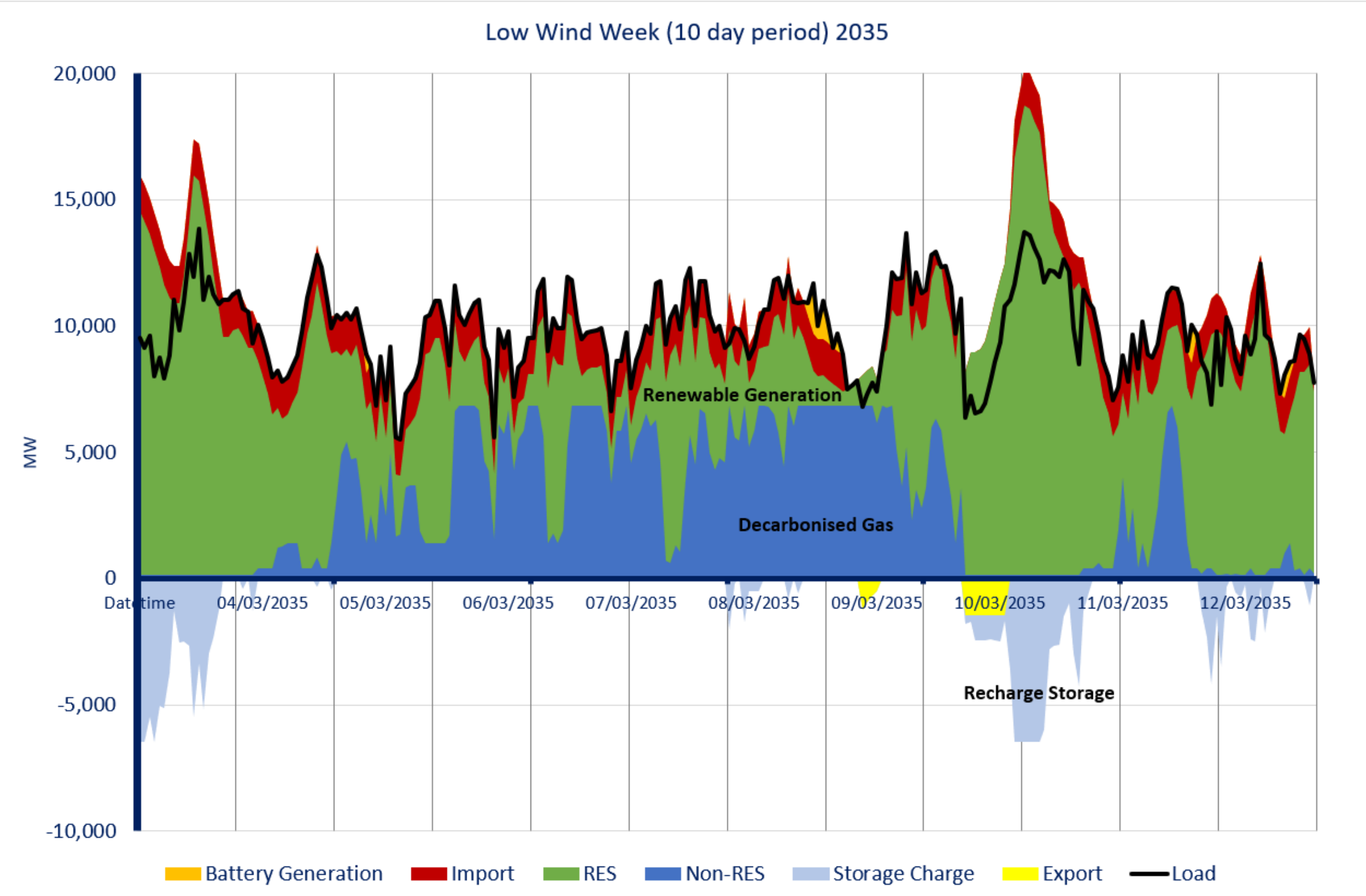
Keeping the Lights on the when the wind is Low

Over the next decade, being able to operate the Irish power system during times with 100% renewable generation is key to reducing emissions, beyond that being able to operate the system at times with close to 0% renewable generation is essential for reliability. This is particularly relevant at times of low wind speeds that may endure for 1 to 2 weeks.

Extended periods of low-wind conditions already occur today. Europe experienced a long period of dry conditions and low wind speeds, through summer and early autumn 2021. The system in Ireland was resilient to these conditions because of conventional generation primarily fired with natural gas with the supply of gas coming from importing pipelines.

This image captures how the system can operate over a 10-day sample period with low levels of renewable generation (Green) complimented by decarbonized gas electricity production (Blue). Because it is unlikely that this decarbonized gas is imported, we assume that it is produced (light blue) at times of excess renewable generation through electrolysis and stored in Ireland for use in modified conventional power plant at times of low renewable generation. Generating electricity in this way is expensive, possibly ranging from 25c€/kWh to 40c€/kWh and reflect a lack or viable alternatives (at time of low generation, low import availability) rather than value for money. Prices are moderated to a degree by the low running hours of the plant.

This points to the need for approximately 4 TWh of decarbonized gas storage to operate as a seasonal storage to balance the power system, however this is not considering a strategic storage which would likely need to be larger to cover extreme events. For comparison a Floating Storage Regasification Unit (FSRU) would typically hold 1 TWh of natural gas storage in one shipment while Ireland has a strategic oil reserve of 20 TWh to cover 90 days of oil interruption.



Insights

- This analysis is based on public domain data and the PLEXOS database and all associated data are freely available.

- The power system is simulated with 3 sequential weather years of historic data from ENTSO-E Pan-European Climatic Database with the years 2009,2010 and 2011 run in sequence to allow storages to rebalance. An average climate year assumed of 2008 for demand and no sensitivity is undertaken for cold years. Power system portfolios for the UK and France are from ENTSO-E.

- This system achieves negative emission of just over 1 Million tonnes of CO_2 as we assume 150MW of Biomass with Carbon Capture and Storage. This assumption requires significant investigation.

- Interconnection capacities are set at an All Island basic at 2.1 GW with a further sensitivity of 3.3 GW. Interconnection modelling outcomes are sensitivity to power plant portfolios in neighbouring countries and no adjust of portfolios in the UK or France were made. The level of interconnection did not change the overall need for large scale storage with net imports ranging from 8TWh to 6 TWh in low wind years.

- Battery capacity is underestimated in this model analysis because only commercial opportunities for arbitrage are considered. Batteries are added to the system until the annual capacity factor drops below 10%. Batteries offer systems services and capacity market opportunity that increase the system and economic viability of the asset therefore the values in this study should be considered in this light. However, in the analysis, battery's do have to compete with the large-scale storage and it is likely that there will be duplication of roles which will erode some of the future market value of batteries.

- Flexibility. Demand flexibility is key to a functioning net zero power system. In this analysis we assume that 15% of daily loads, EV and electric heat profiles are flexible across the day but are subject to load ramp restriction of 15MW/minute. This gives rise to two types of peak demand. A static peak demand (load that are not movable) of 7.6GW is assumed while a further 2.7GW of dynamic load (load that are movable) giving a peak demand of electricity of 10.3GW. The system wide load for electricity can increase further as electrolysers and batteries charge giving a full system peak of 16.9GW across the year.

- Seasonal Energy Storage. No judgement is made as to the type or chemistry of what storage is needed but what is clear is that some form of economy wide energy storage is required. The storage is optimized for the low wind year and is assumed to start the first year half full. A round trip efficiency of 30% is assumed. Approximately 18 TWh of electricity is needed to produce and store 12 TWh of decarbonized gas which then produces 5.4 TWh of electricity at a later stage. Today Ireland uses 27 TWh of natural gas to produce 15 TWh of electricity.

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