

European Union Market Transformation to Support the Energy Transition

Technology Innovation Spotlight

A case study on European Union and Irish market developments in the wholesale and ancillary markets with the increase of variable renewable generation.

KEY TAKEAWAYS

- Importance of ancillary services and Long Duration Energy Storage (LDES) to the energy transition
- Cross border flows and pan EU interconnection needs to support market approaches
- Need for synchronous inertia response to support system inertia
- Critical role of demand side participation for flexibility
- Many new market tools are needed: PPAs, CfDs, market coupling, SDAC, SIDC

INTRODUCTION

The European Union (EU) has pledged to a renewable energy target of 42.5% [1] of the gross energy consumption by 2030. This increase in non-synchronous generation from solar and wind will create challenges to grid stability, in addition to increased demand on the grid from data centers and electrification of transportation and heat. As an example, the share of electricity produced by renewable energy sources in Ireland (predominantly from wind, hydroelectricity, bioenergy and solar) is expected to grow from 41% [2] in 2021 to between 70% and 80% by 2030, with an aim to operate up to 95% system non-synchronous penetration (SNSP) by 2030 [3].

Reliability and Flexibility

Reliability is crucial to the energy transition with electrification of critical energy systems and increasing levels of intermittent renewable generation and more variable loads. It is important to consistently provide electricity without interruption or failures, even with the presence of more variable renewables. Some key factors enabling reliability are interconnectors, demand response, energy storage, market coupling, and ancillary

services. Together, these services to support reliability with variable and intermittent generation are often referred to as flexibility services. Grid flexibility refers to the ability to adapt to fluctuations in supply and demand on various time scales (hourly, daily, etc.), by responding to real time changes.

Ireland is an excellent example where flexibility services are key to the energy transition. Ireland operates on a small, shared island power system and relies heavily on intermittent variable renewable electricity. With a goal of further increasing the renewable percentage in the mix to 80% by 2030, both reliability and flexibility are critically important in the context of the Irish energy system especially with the rapid load growth due to electrification demand.

Current European Energy Market Design

In the 1990s the EU introduced regulations requiring electricity network operations to be unbundled, (i.e., legally and operationally segregated) from generation and supply, and fully open to competition in energy retail and supply. More recently pan European Single Day Ahead Coupling (SDAC) processes coordinate electricity trading and price optimization across European member states, ensuring fair pricing and efficient cross-border use, while the Single Intraday Coupling (SIDC) enables continuous intra-day electricity trading as needed to manage supply/demand fluctuations.

The Clean Energy for all Europeans Package is a set of energy related regulations for generation, transmission, distribution, storage, and supply of electricity. The package focuses on increasing integration of electricity markets, cross-border capacity and greater energy efficiency.

The European Energy Crisis of 2021–2022 highlighted key issues with the current market design in Europe, and despite the absence of any major load-shedding event, EU policy makers rapidly investigated necessary changes to market design to ensure a well-diversified, secure, low-cost and low-carbon power system [4], with the development of a market reform legislation package during 2022/2023 [5]. Some of the main elements of the general approach proposed in the legislative package included:



- Establishing free choice of energy supplier for customers
- Making contracts for difference mandatory for public funded projects on both renewable and low-carbon nuclear energy
- Adding more flexibility for the distribution of revenues from contracts for difference to consumers
- Strengthening the role of the Council in declaring EU-wide electricity price crises

Irish Market Example

Ireland's energy mix is undergoing a significant transformation, driven by the EU goal to become carbon neutral by 2050. The Single Electricity market (SEM) is a cross-jurisdictional, all-island power market between the Republic of Ireland (ROI) and Northern Ireland (NI). The Northern Ireland Protocol ensured the continuation of the integrated-SEM in NI after Brexit (the withdrawal of the United Kingdom from the EU). The SEM requires the ROI's transmission system operator (TSO), EirGrid, and NI's TSO, SONI, to jointly operate the grid to enable the all-island wholesale market. Ireland and Northern Ireland have been the first power system in the world to reach system non-synchronous penetration (SNSP) of 75%, overcoming numerous technical challenges. Central to this was the DS3 (Delivering a Secure and Sustainable Electricity System) System Services programme which focused on innovation across multiple areas and saw the introduction of new system support (ancillary) services, new control centre tools and new operating policies. DS3 successfully achieved its targets by 2022 and is set to conclude in early 2024. The DS3 program will be followed by the 'Shaping our Energy Future Program' [6], which focuses on reforming system operation through four key areas: policy, standards and services, tools, and technology enablement.

Demand Response [7]

Demand response is a tool for managing electricity networks during strain on the grid, providing flexibility, stability and resilience. Demand response seeks to adjust the demand side instead of the supply side, which is important for liberalized electricity markets with ever increasing penetration of renewable energy sources, when the peak generation of renewables does not match peak demand. Demand response was included in the Energy Efficiency Directive (EED) 2012/27/EU (updated 2023/1791) stating that member states should ensure the removal of barriers to participation and enable tariffs that improve consumer participation in demand response [8]. In 2024, the EU Agency for the Cooperation of Energy Regulators (ACER) was mandated to write a framework guideline on Demand Response, which is currently in development by ENTSO-E and EU DSO entity, [9] and sets out the main principles of EU rules on demand response [10]. The areas covered in the framework include principles for coordinating market-based procurement

of congestion management, voltage control and balancing services with other wholesale markets, as well as products used for electricity congestion management.

Cross Border Flow [11] [12]

Cross-border electricity interconnectors are key for Europe to lower energy costs, boost energy security and independence, and meet climate goals. The EU has set an interconnection target of at least 15% for each country by 2030. Market coupling unites European electricity markets through interconnectors, setting a shared price for efficiency. Interconnected regions facilitate energy flow from low-price to high-price areas, supporting the EU's reforms and maintaining stability in EU market prices. Complexity arises for regions with different market designs, like Ireland, trading with non-EU states. The SEM region plans to boost its current interconnection links (two to GB currently) with two new interconnectors: Greenlink to GB by 2024 and the Celtic link to France by 2026, reintegrating the SEM with EU markets.

Wholesale Price Dynamics [13]

EU energy market volatility, particularly in gas prices, has led to significant price fluctuations in the EU energy market. The EU's REPowerEU plan aims to stabilize this through measures like price caps and diversifying energy sources, reducing reliance on Russian fuels and enhancing energy security [14]. Negative pricing in EU wholesale markets (increasing in frequency) can signal that there is excess energy production compared to demand. While consumers may benefit if they are able to access wholesale prices it can have a destabilizing impact on investment in the energy sector.

In 2023, the European Commission (EC) proposed reforms to the EU electricity market, aiming to reduce price volatility for consumers and create favorable conditions for low-carbon investors. Key wholesale market aspects include greater opportunities for forward contracting, Power Purchase Agreements (PPAs) and Contracts for Difference (CfDs). CfDs with state support offer fixed floor payments to energy generators, irrespective of market price fluctuations (with an equal requirement to refund excessive revenues) and PPAs can enable longer term routes to market that do not require state subsidies.

FUTURE MARKET AND SYSTEM REQUIREMENTS—AN IRISH PERSPECTIVE

Ancillary Services

Ancillary services enhance grid stability by providing operational support beyond primary generation and transmission, essential for energy transition resilience through ensuring frequency and voltage stability and enabling system restoration in

the event of a partial or complete blackout. In Ireland, the DS3 system services are evolving (through Future arrangements of System Services) to enable new quarterly and ultimately Day ahead reserve service auctions to ensure efficiency and appropriate procurement of required services.

Long Duration Energy Storage

Long Duration Energy Storage (LDES) technologies enable multi-hour to multi-day energy storage, essential for balancing renewable energy supply with demand. Scaling LDES is key to continuous energy supply and carbon emission reduction. There is currently no explicit framework for the implementation of LDES across the EU, however some EU markets are developing policies to enhance investment in LDES by ensuring revenue predictability and system flexibility, streamlining permits, and establishing fair network charges, supporting the EU's goals for energy security and climate neutrality.

Ireland's current battery capacity stands at over 700 MW [15], focusing on short-duration storage. A new Electricity Storage Policy Framework has been developed by the Irish Government. The Climate Action Plan 2023 [16] and ESB Networks initiatives [17] underscore the growing significance of LDES. EirGrid and SONI's "Call for Evidence" is a step towards incorporating LDES into the national energy strategy, reflecting a commitment to enhancing Ireland's energy infrastructure.

Low Carbon Synchronous Inertia Response [18] [3]

Ireland is integrating renewable energy into its grid, which requires advanced solutions to manage the inherent frequency fluctuations. EirGrid and SONI have identified the need for synchronous inertia response and are advancing grid stability through a market-based approach for Low Carbon Inertia Services, in line with the SEM Committee approved procurement process. This includes competitive tendering for low carbon synchronous inertia response, essential for integrating more renewables into the grid by 2030. Upcoming changes involve a new Request for Proposal phase to finalize contracts, a regional inertia model by 2025, and adjustments to the All-Island inertia requirement. These steps, part of a broader strategy, aim to enhance energy management and support ESG goals in the energy sector.

References

For more information and references, visit <https://msites.epri.com/ms/sectors/OTIZ12/technology-innovation-spotlight-report#230548828-161089571>

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3002030301

April 2024

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