

WHITE PAPER

The Need For Speed

Supporting Rapid Decarbonization with the World's Fastest Grid-Scale Battery

How much better can the grid function if you take a leading-edge resource like battery-based energy storage and make it 60 times more responsive than the current standard and 2,000 times more responsive than traditional “flexible” power generation? That is what the Republic of Ireland is working to understand as it manages a grid increasingly dominated by renewable wind energy.

Summary

To help manage volatility as the island nation ramps up deployments of solar and wind projects, the Republic of Ireland recently became host to the first battery in the world specifically engineered to guarantee a lightning-fast 150-millisecond (ms) response time. The Fluence solution is over 66 times faster than a typical resource in the UK's FFR market (which requires a response in 10 seconds), and over 2,000 times faster than a fast-starting Open Cycle Gas Turbine (i.e. if the turbine is not already serving as spinning reserve).

The Republic of Ireland's first grid-scale battery-based energy storage project, the 11-megawatt (MW) Fluence-supplied system is part of a 34 MW hybrid wind-battery

project in Kilathmoy, developed and owned by Statkraft, Europe's largest producer of renewable energy. Other markets quickly moving to adopt high percentages of renewables – notably the UK and Australia – are already experiencing curtailment of solar and/or wind generation in part because of a lack of system stability. Those markets are considering similar super-fast services to either remedy existing grid stability issues or procure them proactively to ensure smooth integration of future renewables. New energy storage upgrades like those developed for Kilathmoy will ensure that the public maximizes the value of Ireland's investment in renewable energy.

This white paper will explain why Ireland has such a need for speed on its network, the value of fast response for enabling rapid decarbonization, and what this success in Ireland could mean for other international markets incorporating large amounts of low-inertia, high-output, variable wind and solar renewable generation.



Those projects coming online [in Ireland] will be the fastest-acting projects in the world.”

FELICITY JONES, EVEROZE



PROJECT SNAPSHOT

Kilathmoy

System Overview

- 34MW wind-storage hybrid plant
- 11MW/5.5MWh Advancion platform
- Customer: Statkraft Ireland
- Commissioned: January 2020

Application

- Fast Frequency Response, Primary Operating Reserve, Secondary Operating Reserve, Tertiary Operating Reserve (1) and Tertiary Operating Reserve (2)
- Steady State Reactive Power (SSPR)
- Reactive Power support for the 34 MW hybrid

The Challenge: Ensuring Stability in an Electricity System with 50% or More Renewables Capacity

The island of Ireland is already at the forefront of grappling with high levels of renewables penetration in Europe – with the Single Electricity Market (SEM) boasting the highest level of wind energy in Europe with 36 percent of supplied electricity in Ireland and 44 percent in Northern Ireland¹.

However, Ireland has already set its sights higher, with a legally binding commitment to meet 70 percent of needs with renewables resources by 2030 (“70 by 30”). Meeting this new goal will require doubling the amount of wind installed to date and building that generation in half the time it took to build out all of Ireland’s existing wind capacity.

With a new 12 GW renewables procurement program kicking off in June 2020² – including 333 MW of mandated solar capacity and plans announced to fast-track planning of offshore wind – Ireland is already moving quickly to deliver on this target.

Currently, the Transmission System Operators (TSOs) in Ireland, EirGrid

and SONI, apply limits, known as “constraints”, to the operation of the grid. These constraints ensure there are always sufficient system services available to maintain the safe and secure flow of electricity.

Traditionally, system services have been largely provided by fossil-fueled power stations, which often must be turned on (“positioned”) by the TSOs during times when they otherwise would not be running, so that they are available to provide these services. These power stations receive compensation to cover the additional fuel and carbon costs they need to operate in order to provide grid stability. This dispatch pattern – the equivalent of leaving a diesel generator running on standby – results in increased CO₂ emissions from the power stations and increased curtailment of zero-carbon renewable energy that would otherwise be supplied to the market.

The grid is therefore limited in how much renewable generation it can accommodate in real time. Currently, the Irish electricity grid is operating successfully with renewable energy levels of up to 65 percent at any given moment. According to EirGrid, Ireland set a new record of 4,000 MW of wind generation in 2019, covering

72 percent of demand across the island on the 19th of December.

In order for Ireland to meet the 70 by 30 target, the Irish government’s Climate Action Plan sets the goal that the grid will be able to accommodate over 90 percent intermittent wind and solar at any given time³. At the same time, Ireland also needs to find a way to reduce its reliance on an aging fleet of fossil fuel generation to meet its decarbonization goals and ensure stability. This combination of factors makes energy storage essential for system decarbonization.

The Solution: Fast(er) Frequency Response Services through the DS3 Market

Since Ireland has relatively limited access to other grid networks, it is particularly sensitive to the volatility of supply from wind and solar resources. To ensure reliability, the Transmission System Operators (TSOs) created a suite of 14 grid stability products under a program known as **Delivering a Secure Sustainable Electricity System**, or **DS3**. That package includes five frequency response products, which compensate actions taken to keep the grid’s frequency in

balance moment-to-moment. These products can be obtained either via competitively procured 6-year contracts (the “Volume Capped” regime) or via a regulated tariff (the “Volume Uncapped” regime).

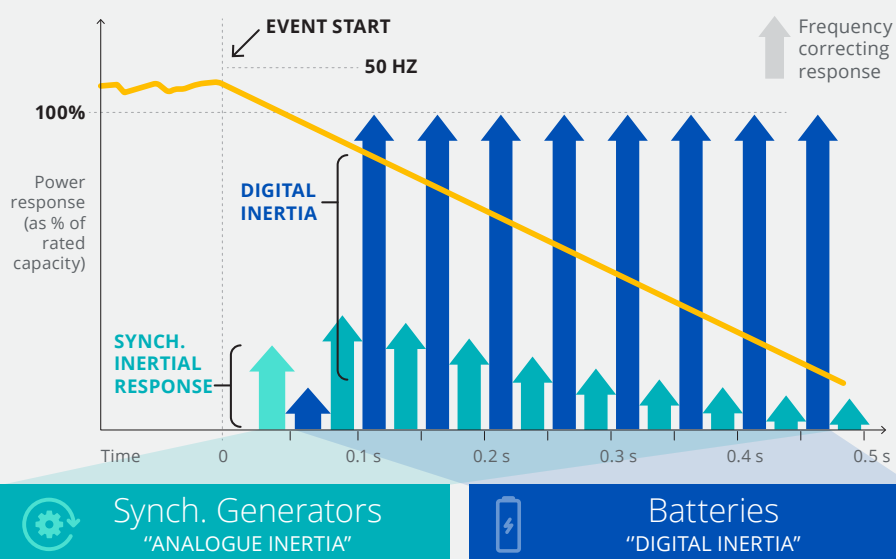
The fastest of the DS3 services, “Fast Frequency Response” (“FFR”) requires

a response in less than two seconds but provides a significant pay-for-performance incentive – a payment as much as 3 times higher – for responding in 150 ms.

Independent research on the island of Ireland has identified that there is significant value in rewarding super-

fast batteries, which can support the grid operator in stabilizing the grid with one-tenth the capacity than would be needed from thermal generation to provide the same services⁴, due to batteries’ speed, precision and “digital inertia”-like qualities.

Poles Apart: Differing Response Characteristics in The First Half-Second



When frequency drops suddenly, synchronous generators respond automatically and immediately by slowing down, releasing energy stored by the large rotating masses contained in these plants. This is inertial response, with each unit providing a power increase of 7-14% of their rated total capacity within 0.05 seconds for a typical large event. The inertial response tails off after a few seconds and then might be replaced by a governor response that tries to push the frequency back up.

To respond, synchronous generators must be running. Each unit can only increase output by a small proportion. This means a large number of units have to be running on the system, in case there is a fault, displacing variable renewables.

(Source: Everoze “Batteries: Beyond the Spin” report)

Batteries have no moving parts. They begin to respond as quickly as the fault can be measured, with reaction times approaching 0.1 seconds being seen. This provides a slightly slower initial response than that of synch. generators. But once the fault is detected, batteries can respond dynamically with high ramp rates. This means that with the right control procedures, batteries can deliver full output in less than 0.2 seconds. This output can be sustained for minutes to hours depending on the size of the battery.

Batteries are ‘turned up’ when needed. By responding more aggressively to faults, and at full power output, batteries reduce curtailment – allowing renewable generation to replace more conventional generation.



I have been in some form of project or contracting role for over 35-years and the Kilathmoy battery is one of the most challenging projects in time and technical scope I have encountered. Not only is this the first ever industrial-scale battery storage system in the Republic of Ireland, it’s also breaking new ground with MW size, technology (incredibly fast response time), and special signal requirements.

It was an outstanding effort to deliver against all odds and - due to grid delays - with 11 days less commissioning time to pass the difficult EirGrid testing. However, with the strong commitment from Fluence and Suir, I never once thought we weren’t going to make it.”

JIMMY BLACKBURN,
STATKRAFT
CONTRACTS MANAGER



Delivering in the Blink of an Eye

The human eye takes around 300-400 ms to blink, meaning a DS3 response is unusually fast, even for batteries – quite literally addressing a drop in frequency faster than the blink of an eye.

With the Kilathmoy project, Statkraft chose to lead the market with a first of its kind project in Ireland: a storage system to provide FFR for the DS3 market with as-yet unmatched responsiveness. Statkraft chose Fluence as a technology provider and as a partner to work toward delivering the high-performance system. Fluence, a joint venture between Siemens and The AES Corporation, is a market leader⁵ with more than a decade of experience in energy storage technology and a history of introducing many groundbreaking applications for energy storage.

To deliver the project, there were also many first-of-its-kind obstacles to overcome. The demanding performance requirements, hybridization with the wind farm and a narrow timeframe to get the project completed in time for the April 2020 tariff window all contributed to Kilathmoy being a very technically demanding project to deliver. Despite these headwinds, the project was completed on time by Fluence's experienced delivery team.

Delivering Innovation, from Europe's First Commercial Grid-Scale Battery to Today

To successfully complete the project, Fluence needed to take its proven controls and supercharge them to achieve nearly an order of magnitude



With Ireland's natural abundance of wind, they clearly see the value of a responsive power system to lower cost, reduce emissions, and avoid throwing away clean energy due to constraints caused by old thermal power plants. Energy storage is a natural fit with high value to all. Working with innovative companies like Statkraft and EirGrid, we can bring the whole value of energy storage to benefit people in Ireland."

FLUENCE CHIEF OPERATING OFFICER JOHN ZAHURANCIK

improvement in response time. The work was informed by learnings from a previous 10 MW project the Fluence team delivered in Northern Ireland at Kilroot Power Station in 2015.

The Kilroot array, now in its fifth year of operations, was the first fully commercial, megawatt-scale battery project in Europe and a forerunner to demonstrating the significant benefits of fast, flexible energy storage. Developed by Fluence engineers, the Kilroot project represented a collaboration with Queens University Belfast and a steering group including EirGrid/SONI, the Utility Regulator for Northern Ireland and Northern Ireland Electricity Networks. These response capabilities also achieved another first: peer-reviewed third-party validation in a key IEEE journal⁶.

"While the demonstration of sub-150 ms response at Kilroot provided a base of technical learnings, the difference to Kilathmoy is significant," explains Brett Galura, Fluence's Chief Technology Officer. "Just measuring

the frequency change takes up valuable time. For Kilroot, we solved this by programming response curves directly onto the inverter firmware. That cuts out communications delay, but has long-term performance tradeoffs which limit the ability to most optimally dispatch portions of the battery array based on state of health, and limits the ability to stack additional valuable grid services."

"In the case of Kilathmoy, the system's response time is fully controls-based and uses alternative techniques to boost the response speed. A combination of highly efficient system coding and proprietary techniques helped make this the fastest-responding battery-based energy storage project in the world."

The innovative new control suite developed for the DS3 market continues Fluence's track record of over 13 years as a pioneer in the energy storage sector: bringing the myriad benefits of storage to new markets and proving out new

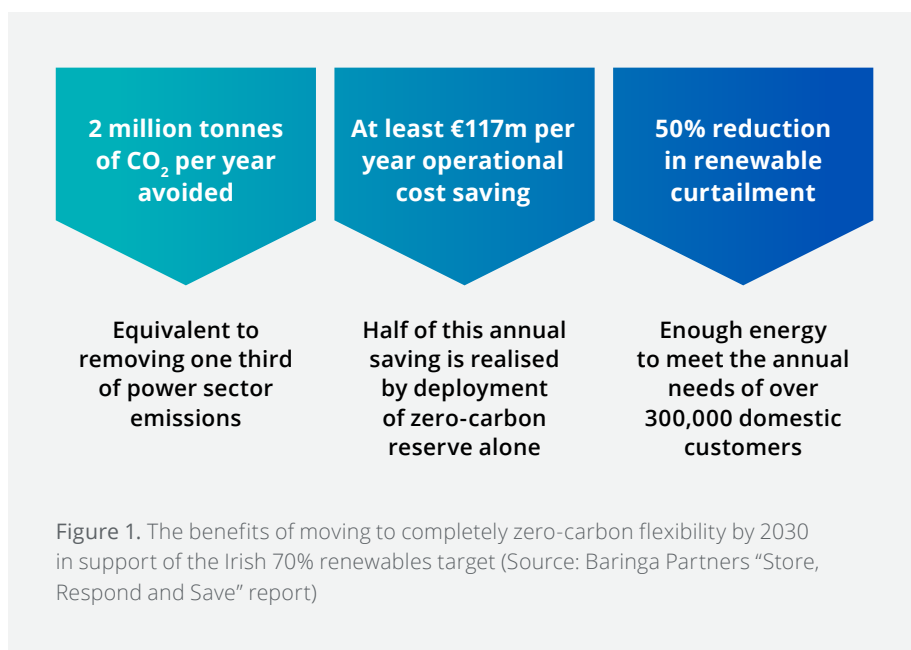
use cases with forward-thinking customers like Statkraft. Some examples include:

- The very first commercially operated grid connected lithium-ion battery-based energy storage system in the world, in Chile in 2009;
- The first battery storage project contracted as a peaking power plant replacement, a 100 MW/ 400 MWh system for The AES Corporation under a 20-year PPA with Southern California Edison (online date targeted for early 2021); and
- The first “virtual dam,” where a 10 MW/50MWh energy storage project is capturing the output of a run-of-river hydropower plant in Chile.

To date, systems deployed by Fluence have provided a combined 7,000 GW-hr of delivered grid services – more than most gas fleets – and are currently providing over 40 unique and stacked applications in 29 markets globally.

Implications for Ireland

As Ireland works to meet its ambitious 70 by 30 target, the need for energy storage and the super-fast grid stability services projects like



Kilathmoy can provide will only grow. A recent report by energy markets consultancy Baringa Partners found that Ireland will need as much as 1,700 MW of battery energy storage by 2030⁷. Baringa’s analysts estimate that by providing flexibility with zero-carbon resources like energy storage – removing the need for flexibility from thermal generation – will deliver three key benefits for the SEM, reduced cost for the electricity consumer, lower CO₂ emissions, and full utilization of the renewable power that has been constructed by avoiding the need to impose curtailments (illustrated in Figure 1).

Conclusion: Applicability Outside of Ireland Already Picking Up Speed

The need for FFR services is not limited to Ireland’s SEM. Many economies working to decarbonize will also need stability services that can balance frequency within 100s of milliseconds as they retire thermal plants and attain higher renewable energy penetrations, in addition to using storage as a firm, predictable mechanism to take full advantage of renewable energy. As a result, demand will only grow for resources like fast-responding energy storage resources.



PROJECT SNAPSHOT

Kilroot

System Overview

- Europe’s first commercial battery, co-located with a thermal plant
- 10 MW / 5 MWh Advancion platform
- Customer: EP Investments UK (formerly AES UK & Ireland)
- Commissioned: December 2015

Application

- Frequency Regulation (Fast Frequency Response, Primary Operating Reserve, Secondary Operating Reserve, Tertiary Operating Reserve (1), Tertiary Operating Reserve (2))

For example, National Grid in the United Kingdom has confirmed that they plan to introduce a new, faster-response frequency regulation product⁸ – building on the success of their Enhanced Frequency Response (EFR) program – which will likely reward super-fast performance similar to the Irish DS3 program.

On the other side of the world, Australia is in the midst of a similar shift – with South Australia having already received 55% of its supplied electricity from solar and wind, and other states following suit soon. Australian regulators have been deliberating on the appropriate mechanism to provision FFR and

inertia services to ensure grid stability.

For those and other markets, Statkraft's hybrid wind-storage project provides a model for replication, showing how to expand adoption of wind power while ensuring network stability.

Endnotes

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ABOUT FLUENCE

Fluence, a Siemens and AES company, is the global market leader in energy storage technology solutions and services, combining the agility of a technology company with the expertise, vision and financial backing of two well-established and respected industry giants. Building on the pioneering work of AES Energy Storage and Siemens energy storage, the company's goal is to create a more sustainable future by transforming the way we power our world. Providing design, delivery and integration, Fluence offers proven energy storage technology solutions that address the diverse needs and challenges of customers in a rapidly transforming energy landscape.

The company currently has more than 2.1 gigawatts of projects in operation or awarded across 22 countries and territories worldwide. Fluence topped the Navigant Research utility-scale energy storage leaderboard in 2018 and was named one of Fast Company's Most Innovative Companies in 2019.

To learn more about Fluence, please visit fluenceenergy.com.

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