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Corporate Finance

Energy Storage: Unlocking Renewable Power's Full Potential

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Fergal McNamara has more than 30 years' experience in the electricity industry. He was Group Manager for Regulation and Policy at ESB, Ireland's leading utility, and has vast experience of the reforms of the energy industry in Ireland and the EU. Fergal was the Chairman on the Distribution Committee at Eurelectric, the trade body representing the industry to the EU institutions; Senior Energy Advisor in the Irish Government Dept. of Environment, Climate and Communications; and Head of Capacity Market Design in the UK Government Dept. of Energy and Climate Change. He also worked in the transmission sectors in Canada and the USA.

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Key Takeaways

Storage will **play an important role** in the energy transition by facilitating and enabling the harvesting of renewable wind and solar. Specifically, storage can assist with stabilising the power grid and accommodating the matching of weather dependent renewable production with the variable patterns of demand.

The **total addressable market** for Storage in Ireland by 2030 is 2,500-3,000 MW of various durations; there is presently 670 MW of short duration installed and accordingly the approximate investment requirement is €4.4-5.6 billion. This requirement is set to increase as the transition involving electrification progresses to **net-zero** emissions by 2050.

Storage facilities can come to market by way of **stacking revenues** from the organised energy, capacity, and system services markets. There is a **supportive policy framework** in the EU (notably in the recent market design adopted by the European Commission) and the Government of Ireland is working on a dedicated policy framework.

The market most suitable to short duration 'power battery' storage plants is now largely **saturated**: most of the facilities now in service have come to market on foot of contracts or tariffs awarded by the Transmission System Operator's DS3 procurement programme.

Opportunity next exists for **longer duration storage facilities** which can contribute to management of grid constraints, curtailment, oversupply, and security-of-supply applications and recently contracts have been awarded in rounds of the forward capacity market. Nonetheless, there is uncertainty over whether a viable route-to-market exists for such facilities, although notable initiatives are underway by both the Transmission and Distribution System Operators.

While there are well known challenges with global supply chains, US re-shoring of manufacturing and domestic issues on planning and grid access, Storage facilities can also co-locate with other facilities and make better utilisation of infrastructure.

Introduction

The transition to net-zero emissions by 2050 is underway and much of the policy and regulatory framework has been or is being constructed.

The EU has given a legal strength net-zero pledge by 2050 in the **European Green Deal** and has set out ambitious plans for renewable energy deployment. The first legislative phase of the Green Deal is a policy compendium known as **Fit-for-55**, referring to 55% emissions reduction by 2030 compared to 1990. At present, a Union wide target for renewable energy of 40-45% of energy consumption by 2030 is being finalised by the co-legislators. It is expected this will ultimately be legislated by way of amendment to the **Renewable Energy Directive**.

The EU renewables target is continental wide and pursuant to the **Governance Regulation** each Member State has committed itself to individual targets, set out in their **National Climate and Energy Plans**. In the case of Ireland, it contains a target of 34.1% of energy to be met by renewable sources by 2030, addressing a Union wide target of 32%[1] . If/when a new EU target is agreed, Ireland's target will likely require revision. Accordingly, in the European Commission's Impact Assessment addressing a 40% target, an expectation is set that Ireland's target would also be (the numerically coincident) 40%.

In Ireland, there is a statutory net-zero emissions target and legally binding carbon budgets for the years 2021/5 and 2026/30, underpinned by sectoral emissions limits[2] and a **Climate Action Plan** which guides action to achieve a 51% emission reduction by 2030, compared to 2018.

Renewable energy sources (predominantly wind and solar) converted to electricity **("RES-E")** will play a major role in this transition. In this way, RES-E will inherently de-carbonise the electricity sector and importantly contribute to downstream decarbonisation. Downstream sectors, in particular **Heat** (e.g., by deployment of heat pumps) and **Transport** (e.g., by adoption of electric vehicles) are set to electrify and in that way also decarbonise. A target of 80% RES-E by 2030 has been set.

This is illustrated, for example, in a study by **MaREI** shown in Table 1 below. In this scenario the electricity generation sector grows by c. 3 times from 2019 to 2050 (i.e. electrification) and the combined production from wind and solar amounts to c. 96% (the decarbonisation). Moreover, the **Climate Action Plan** contemplates 2030 targets of up to 14 GW of wind (at least 5 GW offshore) and 8 GW solar.

1 The first targets were set in 2009 requiring 20% renewable energy by 2020 which was sub-divided into binding targets for each Member State by which Ireland received a target of 16%. The target structure was changed to Union wide by the **Clean Energy for all Europeans** legislative package and in 2018 reset at 32% and toward which Ireland was expected to pledge at least 31%. As part of the **Green Deal/Fit-for-55/REPowerEU** initiatives the target is being renegotiated and has variously been increased to 40% and 45%.

2 The sectoral emission celling for the **Land Use Land Use Change and Forestry** sector will be determined before the end of 2023.

Table 1 –Scenario of Solar/Wind in Ireland's 2050 Net Zero Energy Power System:
The total primary energy requirement grows from c 30 TWh in 2019 to 122 TWh in 2050 (*Our Climate Neutral Future.*) This study contemplates Storage of approximately 3 GW in 2050.

	TWh	GW	2019
Wind	77	21	≈ 10 TWh
Solar	4	4	≈ N/A
Total (Wind/Solar)	**81**	**25**	
Electricity	84	37	30 TWh
Wind/Solar Share of Electricity	**96%**	**66%**	
Primary Energy	122		157 TWh
Electricity Share of Primary Energy	**69%**		**19%**

Source: MaREI; Wind Energy Ireland; Davy Research.

Nevertheless, harvesting of these quantities of wind and solar by means of electricity - which are variable being weather dependent, have diverse yields and the conversion devices have different characteristics to those historically connected to the grid - is not straightforward. Broadly, there are three principal aspects to this:

- Maintaining the stability of the grid, the domain of system services;
- Enabling the grid to intake the variable production, the domain of management of constraints, curtailment, and dispatch down or back-up during resource availability lulls; and
- Shifting renewable production from one season (say Winter to Summer) given the different yields of wind and solar or the variable patterns of demand.

These challenges can be enabled by Storage i.e., methods or devices that take electricity from the power grid, convert it to another form of energy and later reconvert it to electricity and return it to the grid. In this sense, electricity can be thought of as being stored.

This White Paper concerns the role and contribution of Storage in the transition. It is focused on **industrial scale facilities** i.e., front-of-meter which are grid connected, discusses the policy framework, use cases, technologies, route-to-market and the investment requirements.

Policy Framework

Overall, EU policy recognises that the energy systems must become more flexible by which is meant a capability to adapt and absorb the variable renewable resources. Storage is well recognised in the policy corpus, although unlike the topics of **Hydrogen** (see below) or **Solar** (as set out in previous Davy White Paper *'Irish Solar's Time to Shine'*) there is no recent dedicated publication.

Specifically, it is worth highlighting at the outset that the **EU Electricity Directive** (2019/944) creates a default presumption that Storage will be developed and owned by the private/non-regulated sector (Article 36), although derogations can be given in certain circumstances. This obviated early concerns that understandably grid operators seeking solutions may have sought to self-develop storage facilities and thereby would become less inclined to develop and incubate regimes for contracting for system services (below):

Moreover, this Directive goes further and encourages Member States to place such incentives on system operators (Article 32), extracted below:

> *"Member States shall provide the necessary regulatory framework to allow and provide incentives ... to procure flexibility services.... In particular, ... procure such services from providers ... **energy storage**"*

The **Climate Action Plan** contemplates a review the regulatory treatment of storage including licensing, charging and market incentives.

Furthermore, a **Network Code on Demand Response** is being prepared which the **Electricity Regulation** (2019/943) specifically contemplates will include:

> *"Rules on aggregation, **energy storage** and demand curtailment."*

In the context of the war in Ukraine and its effect on the energy markets, a fundamental reform of market design is underway, which was covered in a previous Davy White Paper Identifying the Opportunities in an Accelerated Energy Transition. The European Commission has now adopted proposals on market design, which at the time of writing has been sent to the co-legislators. Storage is well featured and notably contains the following passage:

> *"Member States should define a **national objective** for non-fossil flexibility such as demand side response and **storage** which should also be reflected in their integrated national energy and climate plans."*

More locally, Government is also currently working on **Energy Storage Policy Framework** which covers a wide range of issues including definitions, role, media, grid, planning and safety issues. The shape of the final policy framework is awaited and it may address targets, support schemes (especially for long-term Storage), coherence and reform of other market mechanisms and other forms of storage.

In conclusion, the EU policy framework is supportive of Storage and a domestic Policy Framework is awaited from Government.

Storage Use Cases

While energy can be stored in multiple forms, for example in chemical form in batteries, as part of familiar Uninterruptible Power Supplies or within an Electric Vehicle **(“EV”)**, as heat in domestic cylinders or central vats of hot water which can then be piped into premises say as part of a District Heating installations, such as that being promoted by **Codema** in Poolbeg and Tallaght, Co. Dublin or as Hydrogen. This White Paper is mainly concerned with Storage facilities operating in conjunction with the electricity system.

This is distinguished from **reserves** being for example stockpiles of coal (in the yards of **ESB’s** Moneypoint Power Station); or the oil holdings by the **National Oil Reserves Agency**; or the line pack by **GNI** in gas network; or the maintenance of secondary fuels at power stations.

Broadly, for our purposes there are the following use cases of Storage (which may overlap in some respects):

- **Immediate or Short-term** – This case concerns assisting with the stabilisation of the grid by providing near instantaneous fast acting (within 200 mili seconds) primary reserves sustained for short periods of 30 minutes hour to 1-hour or perhaps longer: ‘power batteries’ can for example address this use case.

- **Several Hours/Intraday** – The Storage duration of this would be longer than 4 hours[3] and ‘flow batteries’ or other chemistries such as Nickel Bromide battery are a relevant technological innovation. This provides solutions for:

  - Dealing with diurnal cycles e.g. shifting daylight generated solar to the night-time;

  - Catering for periods of lull or surplus of wind or solar energy (that might otherwise be constrained or curtailed) thus providing temporary grid support.

  - For ‘peak shaving’ or to deliver at times of ‘system scarcity’ (which would contribute to security-of-supply).

- **Long Duration/Multi-Day** – This case address time periods of several days (perhaps longer) where there is a lack of wind or solar i.e., weather conditions known as *Dunkelflaute* (i.e. an extended period when little or no generation is available from wind or solar), or perhaps other circumstances where repairs or failures may be being experienced elsewhere on plant and equipment. Suitable technologies include Compressed Air Energy Storage **(“CAES”)**, ‘flow batteries’, liquified air, thermal storage and green hydrogen.

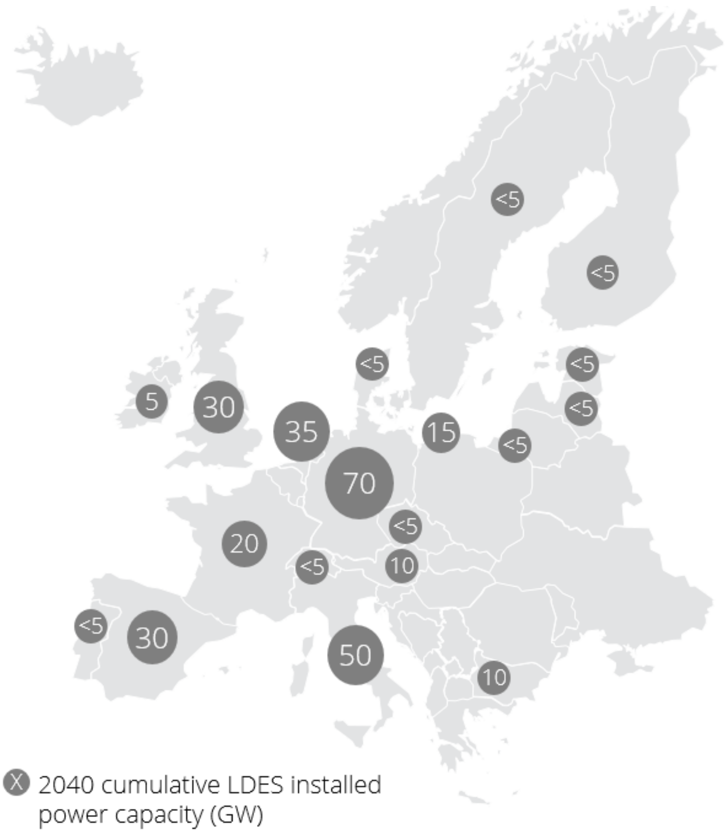
- **Seasonal** – This addresses shifting energy from season to season and in the future may be a good use case for Green Hydrogen but could also involve the use of reserves.

- **Annual Or Multi-Annual** – This concerns reserves as discussed above and is not subject of this White Paper.

3 For example, the UK Department of **Business and Industrial Strategy** refer to ‘long-duration’ as 4 hours of more.

Of the above, long-duration energy storage **("LDES")** is presently attracting much attention and the LDES Council estimates that 1.5-2.5 TW by 2040 and Fig. 1 is an extract for Europe.

Figure 1 – Projected installed Long Duration Energy Storage capacities (GW) in Europe by 2040:



Source: LDES Council

Storage Technologies

There are ostensibly **four Storage technologies** or configurations of interest for the purposes of this White Paper which operate or will operate in conjunction with the electricity system.

Pumped Hydro

This uses electricity to pump water from a lower to a higher reservoir converting electricity into potential energy. The most notable example of this is the Turlough Hill facility in Co. Wicklow a 292 MW/1,700 MWh (5.8 hours) facility which began operation in 1973.

A 360 MW/1,800 MWh (5 hours) project is underway in Silvermines, Co Tipperary, expected to be in service in 2028 and is included in the list of **EU Projects of Common Interest** which enables it to streamline an application of funding under the **Connecting Europe Facility** with €4.3 million of grant funding has already been received.

There were preliminary site survey works carried out in the 1980s in Co. Antrim. but otherwise no other development sites are in prospect.

Finally, there has been a recent new development in pumped hydro using a fluid which is 2.5 times denser than water. This allows pumped storage sites to be developed with a lower 'head' perhaps widening the availability of suitable sites. This could mean that they could be located proximate to wind/solar generation.

Compressed Air Storage

This uses electricity to compress air which is stored in natural caverns or other vessels for later re-conversion and reuse. The storage capacity depends on the cavern size. This is currently being developed by **Corre Energy** in The Netherlands and Denmark. This technology naturally depends on the location and availability of suitable geological sites of which the proposed facility at Islandmagee, Co. Antrim is the only known example (see below) on the island of Ireland.

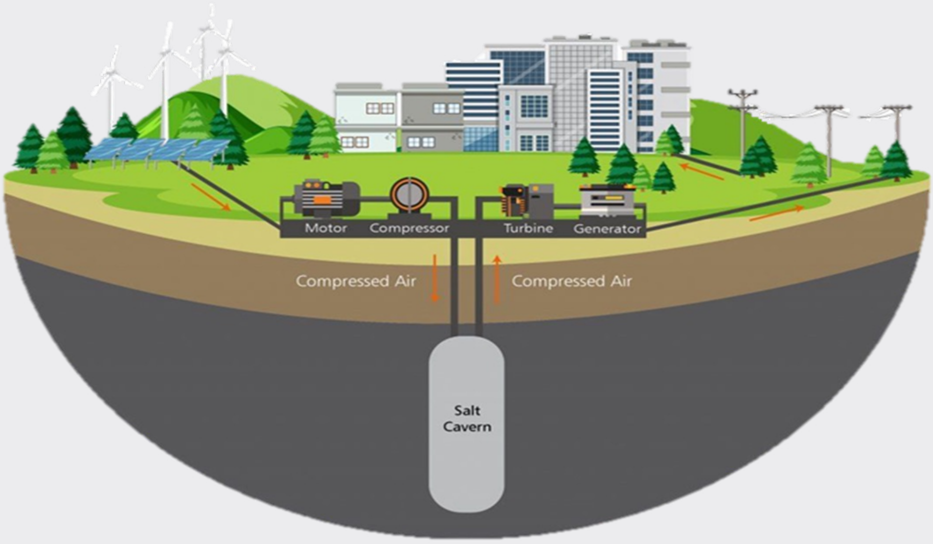
Compressed Air Energy Storage – Corre Energy

Corre Energy is focused on the development, construction, future operation, and commercialisation of long duration grid-scale renewable energy storage solutions, aimed at accelerating the transition to net zero and to enhance flexibility of energy systems. The company, which is currently in development phase, will use renewable electricity to store compressed air in underground salt caverns, which can subsequently be combined with green hydrogen stored in co-located caverns to fuel the generation of electricity.

When renewable electricity supply is high resulting in lower prices, Corre Energy will compress air into storage caverns and conversely when renewable electricity supplies are low and prices are high, Corre Energy will generate green electricity from compressed air energy storage. Corre Energy's configuration can yield up to 84hrs (3.5 days) of storage to enable balancing solutions to grid infrastructure.

The company has two 320MW projects under development Zuidwending in The Netherlands (an EU **Project of Common Interest**) and Green Hydrogen Hub in Jutland, Denmark, with a further six pipeline projects across Europe, all of which are designated included in the Ten-Year National Development Plan of **ENTSO-E** and **ENTSO-G**.

Davy advised Corre Energy on its successful listing on Euronext Growth Dublin in September 2021, as well as further capital raises aimed at accelerating the development of its project portfolio.



Liquid Air

Air can be compressed and cooled until it becomes a liquid and then stored until required whereupon it is expanded into a gas which can be used to generate electricity.

Hydrogen

Hydrogen is liberated from water by electrolysis and can be stored in various ways; as a gas (placed in a vessel or the gas grid), as cryogenic liquid or absorbed into other materials. This can then be reused as a fuel in for example in domestic appliances, gas turbines or industrial feedstocks.

There is a dedicated EU policy on the Hydrogen Economy which is not the subject of this White Paper although there is much activity underway in Europe and in Ireland. Government is presently working on a Hydrogen Strategy; **ESB** in partnership with **dCarbonX** is working on projects in Co. Clare, Co. Dublin and Co. Cork (for storage in unused Kinsale gas fields and in salt caverns); **EI-H2** on a project in Co. Cork; Valentia Island Co. Kerry was selected as the subject of feasibility study; and a Hydrogen Hub is in formation in Co. Galway. Hydrogen will also have a role in decarbonising the gas grid (in addition to biomethane) and work by **GNI** is underway. Finally, pilot projects are taking place in certain transport applications e.g. bus transportation (see below on Northern Ireland).

Battery Storage

This form of storage is an electrical to chemical conversation and the battery technology has enjoyed technological leaps over the past 20 years, driven by demands from mobile telephony and other consumer electronics. For this paper we are mainly concerned with front-of-meter or industrial or utility scale **stationary** batteries or **Battery Energy Storage Systems ("BESS")**.

There are other configurations of batteries which can be placed behind-the-meter and co-located with other asset classes offering the site occupier energy management services or specifically Storage as a service. Synergies and diversity with other asset classes can also be created e.g., solar, wind either co-located or assembled into Virtual Power Plants.

There were early prototypes of these installations, notably in the late 1980s a lead-acid battery was in service in the then-isolated West Berlin power grid (17 MW/14 MWh or 2 hours) to assist with grid stabilisation and in Chino, California (10 MW/40 MWh or 4 hours) where installation of new transmission lines into the San Bernardino valley was difficult at that time. At that time, there was a lot of interest in Storage in so-called 'island' power systems (e.g. Israel, Hawaii, Puerto Rico, Ireland and Northern Ireland) but the battery technology was not adequately advanced.

The battery technology currently most commonly used is Lithium iron **("Li-ion")** which is predicted to dominate over the coming decade, although innovation continues apace. The requirement for these batteries will largely be driven by the expected growth in EVs. This has already resulted in a rapid scaling of the battery manufacturing industry: approximately 10x in the last 6 years (there are now c. 350 'Gigafactories' in existence worldwide) and it is predicted to scale 8-10x over the coming decade. Currently, battery production is equivalent of c. 450 GWh/year (sufficient for approximately 10 million EVs) but estimates are that this needs to scale to 4,000+ GWh/year by 2030. Two issues arise:

- **Mining** – This is likely a limiting factor i.e. to supply the minerals the batteries require by expanding mining capacity in the context of the increasingly widespread adoption of Environmental Social and Governance practices. Artisanal mining of **Cobalt** is exclusively sourced from the Democratic Republic of Congo; **Nickel** is largely supplied from Indonesia (with high embedded carbon and experience of trading disruptions on the London Metals Exchange); **Graphite** is dominated by China; and **Lithium** is dominant by Australia, Chile, and Argentina.

- **Geopolitical Tensions** – The supply chain for mineral refining and the production of the cells and modules is dominated by China, which had an early start from c. 2015 and has scaled successfully. China attracts the imports of the majority of minerals (thereby indirectly dominates upstream), manufacturers the batteries (thereby dominates midstream) and sells to the rest-of-the-world. There is significant US activity to re-shore manufacturing and the EU has established the **European Battery Alliance**. Indeed, transport of Li-ion batteries is both hazardous and bulky and it makes sense therefore that batteries are produced proximate to EV factories in locations where energy costs are competitive.

Battery Energy Storage Systems - Lumcloon Energy

Lumcloon Energy is an Irish energy asset development company, which currently has a focus on short duration storage projects and previously had pioneered a 0.5MW flywheel project in Co. Offaly in 2014.

The company has in operations the largest battery energy storage facility in Ireland – 100MW (½ hour) at Shannonbridge and 100 MW in Ferbane in partnership with the South Korean conglomerate **Hanwha Energy Corporation**. A further development which included a Synchronous Condenser is in train in Shannonbridge.

These BESS projects are high-power batteries to provide System Services to suit the Irish power system needs, under the DS3 System Service programme.

In addition, Lumcloon Energy also has a strong development portfolio including solar and open cycle gas turbines to support the grids transition to renewables.

The Route-to-Market

Storage facilities can come to market by way of stacking revenues earned from the energy and capacity markets and system services arrangements:

- **Energy Markets** – margins are earned from trading around the temporal price differentials (arbitrage), the value of which is related to the underlying magnitude and/or volatility. For example, a study by **AFRY** *(The Missing Link)* estimates that an assumed 1.9 GW (on the all-island power system) of Storage could reduce net costs by €34 million annually. **Baringa** *(Protecting Consumers)* estimates that if the 471 MW of battery storage currently installed could participate in the day-ahead market, it would result in a saving of (also) €34 million over this winter 2022/23.

- **Capacity Markets** – storage facilities can compete in the periodic capacity auctions. These markets have the express purpose of complementing the energy markets and supporting investment. In recent auctions, Storage has been awarded contracts and are required by these contracts to deliver energy at times of system scarcity.

- **System Services Arrangements** – storage facilities can participate in the arrangements organised by the Transmission **("TSO")** or Distribution System Operator **("DSO")** for trading of system services. The value of all-island TSO services is budgeted at approximately **€280 million**, and this could increase, by some estimates, to approximately **€700 million** by 2030.

Energy Markets

Arbitrage within and between the organised energy markets (Forwards, Day-Ahead, Intra-Day and Balancing[4]) and/or the over-the-counter or bilateral markets are another source of value for Storage. In principle, this can be taken further by bargaining with end-use customers to remove volatility and fix prices, or complementing Corporate Power Purchase Agreements etc. This is known to be profitable in other countries (e.g., Australia) where prices can swing or vary more than they do in the Irish single electricity market (with its adjunct capacity market). In this area, companies such as **Grid Beyond** and **Viotas** have sophisticated offerings to optimise and trade assets on behalf of their owners in the various markets.

The structure of these markets is not static. Furthermore, the **Agency for Cooperation of Energy Regulators** is pursuing incremental reform in the organised forwards markets, addressing insufficient liquidity, accessibility, competition and transparency. The new Commission proposals on market design also place a large emphasis on long-term contracting.

To relieve **congestion** or **curtailment** on the grid, the TSO issues instructions which cause deviations from the market schedules. This invariably results in higher costs (recovered by imperfections charges[5]) and new compensatory arrangements are being put in place to comply with **Electricity Regulation** (2019/943). For example, the TSO has reported that the volume of 'dispatch down' of wind energy amounted to 7.3% of total wind energy in 2021[6].

Accommodating the intake of this power is the challenge and **Baringa** (in its study Game Changer) examines the costs and benefits in a range of scenarios which have portfolios of various durations of Storage modelling the constrained circumstances in Co Donegal.

4 At this moment due to technicalities, Storage cannot access the Balancing Market.
5 The approved charge for tariff year 2022/3 is €21.84 compared with €9.19 for 2021/2.
6 This is the point made by **Energy Cloud** which seeks to divert this surplus that would otherwise be wasted to homes in fuel poverty

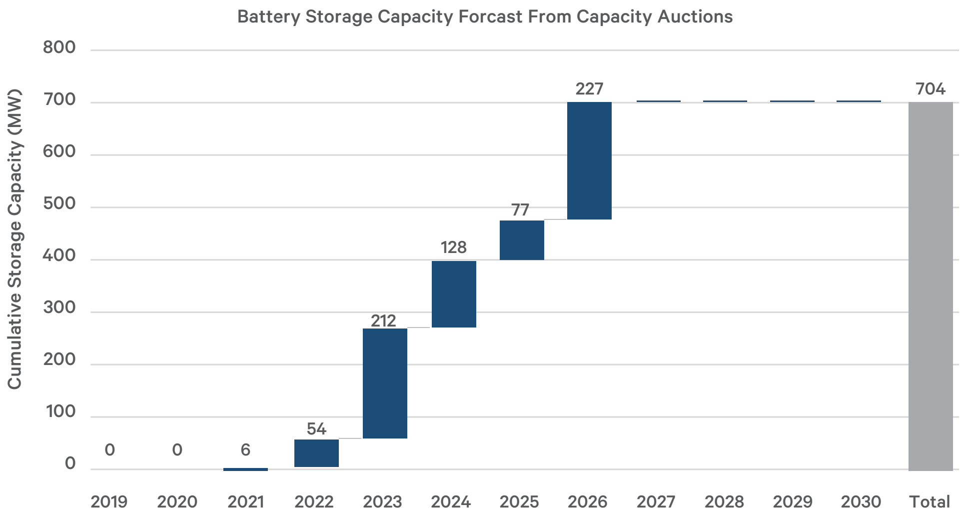
This is another area where Storage may contribute. Individual commercial arrangements can be negotiated with the TSO/DSO where the latter is unable or delayed or indeed wishes to delay investment or might otherwise be experiencing local issues on the grid.

Capacity Market

The Capacity Market primarily addresses security-of-supply and is an adjunct to energy markets with the aim of lessening price volatility in the latter. The Capacity Market has a 10-year State Aid approval to c. 2028 and is subject to reporting to the EU in Implementation Plans and Annual Monitoring Reports. Storage is eligible to participate in this market.

In recent capacity auctions, Storage has been awarded contracts. Davy has reviewed the published results of all the forward capacity auction rounds since the reforms of 2018[7] to date and a total of **704 MW** of storage projects have been awarded contracts, although no information is available on the storage durations of these plants. It is reasonable to assume they are of a longer duration given the performance requirements in that market. The results are set out in Fig. 2 below

Figure 2 – Storage facilities (all BESS) awarded contracts in the forward capacity auctions.



Source Single Electricity Market Operator and Davy analysis.

7 The capacity market opened in 2018 replacing a capacity tariff that had been in place from the SEM opening in November 2007.

System Services Arrangements

The management of power grids is a sophisticated and specialised undertaking, especially on an isolated 'island' grid such as the island of Ireland. Accommodating ever increasing quantities of RES-E has posed new challenges. These arise mainly from **variability** (weather affecting the output of wind and solar) and the **characteristics** of facilities (i.e., wind turbines, solar photovoltaics, inverters, and associated power electronics). This field of engineering science is known as **energy system integration** and the Irish TSOs/DSOs are creditability world leading. For example, **ESB** has recently installed the world's largest Synchronous Compensator in **Green Atlantic @ Moneypoint**. Synchronous condensers provide instantaneous response other grid stability services and Flywheels are well suited to frequency regulation.

The TSO manages this by the DS3 programme originally put in place to facilitate meeting the 2020 climate and energy targets. This is in essence a procurement programme by which the TSO acquires the system services it requires. These arrangements, which have been extended a number of times are now set to expire by April 2024. A new programme called **System Services Future Arrangements** is then expected to be in place. Moreover, there may be unfinished business to implement or comply with the EU **Guideline on Electricity Balancing** (2017/2195) which becomes more relevant post interconnection with France in 2026 i.e., when Ireland is re-connected with the wider European internal energy market.

The DS3 programme was originally based on a tariff framework operating within fixed revenue regulatory regime and occasionally tariffs have had to be reset so as to avoid a budget breach. Lately, it was divided into two streams known as **Volume Capped** and the traditional stream known as **Regulated Arrangement Volume Uncapped**. Furthermore, the TSOs have made recommendations for a specific procurement scheme known as **Low Carbon Inertia Services** which may well also provide a precedent or model for LDES.

The Volume Capped stream became a once off auction held in 2019 for a fixed volume of services (targeting products of Fast Frequency Response, Primary Operating Reserve, Secondary Operating Reserve, Tertiary Operating Reserve 1 and 2) and 110 MW of Storage cleared this auction and were awarded 6-year contracts at a total cost of €6 million per year. In parallel, the Volume Uncapped stream continued, and other BESS installations joined this framework and received tariff income. In any event this part of the DS3 market has now become largely saturated (see below on addressable market).

In addition, the **ESB Networks**, the DSO in common with DSOs throughout Europe (as contemplated by the Directive and by the **Climate Action Plan**) are mainstreaming the procurement of flexibility services by way of a multi-year programme known as **National Networks Local Connections**. ESB Networks have signalled their intention to introduce a competitive process for a significant quantum of flexibility services in the later part of 2023. Whereas this process will be technology neutral, it is believed that Storage will be well qualified to competitively meet the technical specifications and could even provide a route-to-market for long-term Storage.

Northern Ireland

Northern Ireland has a statutory net-zero emissions target by 2050 as set out in **The Climate Change (Northern Ireland) Act (2020)** and an associated strategy **NI Energy Strategy – Path to NZ**.

Updated advice on the first 3 carbon budgets has been rendered by the **Climate Change Committee** and the 1st budget (advised reductions of 33% over the period 2023-7 compared to 1990) must be finalised with a **Climate Action Plan** by the end of 2023.

There is currently an interesting hydrogen storage project (Ballylumford Power-to-X) involving a consortium of **B9 Energy, Mutual Energy** and **Islandmagee Energy** which has received UK Government funding under the Longer Duration Energy Storage demonstration innovation competition (meaning 4 hours or longer). Furthermore, **SONI** in its paper **Shaping our Electricity Future** identify a need for 300 MW of storage by 2030 in Northern Ireland.

Translink has piloted Hydrogen buses in Belfast.

Finally, **Northern Ireland Electricity** as the DSO mainstreaming flexibility services has a programme for procurement of flexibility services known as FLEX and projects on innovating on Storage.

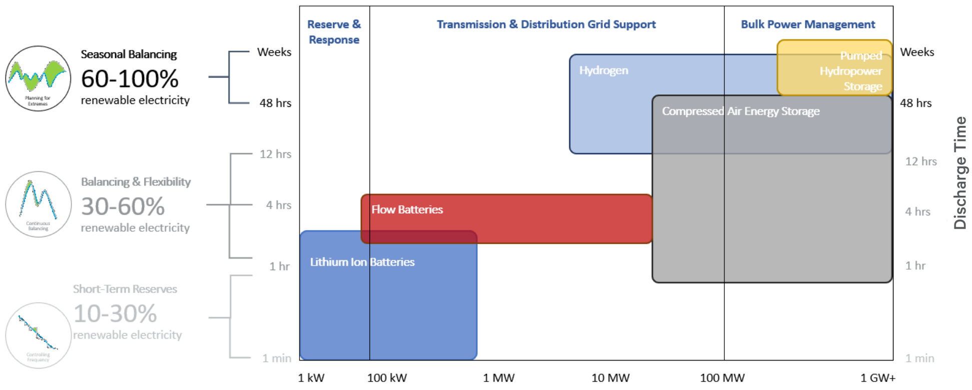
Constraints

There are well known challenges facing Storage developers including (a) planning and grid access; (b) grid tariffs (although a recent reform means there is only liability for demand tariffs); and (c) policy is being finalised on private wires and multi-use of grid connections. Storage is well suited to co-locate with other technologies especially wind and solar. In this regard it is worth noting the planning reforms that are underway as covered in the Davy White Paper *'Irish Solar's Time to Shine'* and recently the **Planning and Development Bill (2022)** has been published.

In summary, Storage has a route-to-market by revenue stacking from capacity and energy markets and system service arrangements i.e., organised by both the TSO's (DS3 arrangements) and the DSO (National Networks Local Connections) programme. The BESS installed in Ireland to date have been mainly a 'DS3 play' and this market is now largely saturated. The next 'play' is therefore LDES and indeed in recent years some BESS have been awarded contracts in the Capacity Auctions. The DSO's programmes under development may also offer promise. Nonetheless, there remains uncertainty over whether all of these mechanisms will be adequate to provide a route to market for LDES.

This is illustrated in Figure. 3 below. We believe however that other storage solutions including CAES, pumped hydro and Green Hydrogen will all play a role in meeting the growing demand for storage solutions in Ireland and beyond.

Figure 3 – Storage Applications and Technologies: Storage technologies by application, capacity, and discharge time.



Source: Graph adapted based on information contained in "Hydrogen – a sustainable energy carrier", Progress in Natural Science, 2017 (Vol 27, Issue 1) and "Electricity Storage And Renewables: Costs and Markets to 2030", IRENA (October 2017)

Addressable Market

There is presently **670 MW** of storage (BESS) installed as set out in Table 2 and intelligence from the trade association suggests that **114 MW** is under construction, **1,747MW** has grid offers and **3,604 MW** is in planning.

Table 2 – Battery Energy Storage Installations in Ireland:

Name	Location	Developer	Capacity (MW)	Operation Date
Kilthamoy	Co. Kerry	Statkraft	11	2020
Porterstown	Co. Kildare	Gore Street	30	2021
Kelwin-2	Co. Kerry	Statkraft	26	2021
Stephenstown	Co. Dublin	RWE	8.5	2021
Shannonbridge	Co. Offaly	Lumcloon Energy	100	2021
Lumcloon	Co. Offaly	Lumcloon Energy	100	2021
Gorey	Co. Wexford	NTR/ RES	9	2022
Avonbeg	Co. Wexford	NTR/ RES	16	2022
Lisdrumdoagh	Co. Monaghan	RWE	60	2022
Aghada	Co. Cork	ESB	19	2022
Gorman	Co. Meath	Iberdrola	50	2022

Source: Trade Associations, EirGrid and Davy Research

Distributed Storage

An interesting question is the interaction between stationary BESS and the decentralised storage that could be made available from EVs. A typical EV, for the sake of argument may have a 50-100 kWh battery and be connected via a 7-22 kW charge point (or perhaps by fast or high-powered chargers). Presently, there are approximately 50,000 EVs registered in Ireland; the **Climate Action Plan** contemplates 940,000 vehicles in the fleet by 2030. Typically, vehicles are not in use for 95% of the time. This is a considerable upper bound on the amount of storage and by this reckoning is up to 45-89 GWh of latent storage which could be 'crowd sourced' by the TSO/DSO.

This is known as **Vehicle-to-Grid** or **bi-directional charging** and is an involved issue. There are social science and behavioural economic considerations i.e., whereas such micro commerce engages citizens in the energy transition proud owners of new EVs may not wish them to be used in this way, particularly in light of their own mobility priorities and associated battery warranty constraints. There are unsolved issues with data standards for interoperability between a wide range of actors including vehicle manufacturers, charge point operators and the EU has lately proposed European **energy data space**[8]. There are **data privacy, portability**, and **cybersecurity issues**.

Grid connected stationary BESS and EV storage are not perfect substitutes and even vehicles at rest may not be fully charged or connected. This is illustrated in a GB study by **BloombergNEF** which estimated that there is a net benefit of less than US$430 per vehicle in 2040 if 12.5% of the fleet could be simultaneously capable of bi-directional charging and this falls to US$152 per vehicle if 50% of the fleet participated saturating value.

EirGrid's paper Shaping our Electricity Future (Tables 21 and 22), contemplates that **1,700 MW** (various durations 0.5h, 1.9 h and 6h) of storage will be installed by 2030. Furthermore, EirGrid provided additional detail in CAP23 Emissions Analysis Key Scenarios which was published alongside the **Climate Action Plan**. Two scenarios 'Central' and 'Further Accelerated' are extracted in Table 3 below.

Table 3 – Storage Capacity 2030:

	Central		Further Accelerated	
Hours	**MW**	**MWh**	**MW**	**MWh**
0.5	800	400	800	400
4	**375**	**1500**	**375**	**1500**
6	**550**	3300	800	4800
8	**750**	**1000**	**1000**	**8000**
Total	**2475 MW**	6.2 GWh	**2975 MW**	14.7 GWh

Source: CAP23 Emissions Analysis (EirGrid); Davy Research ('short duration' assumed at ½ hour duration). This table does not include any requirement that ESB Networks/DSO may have for Storage.

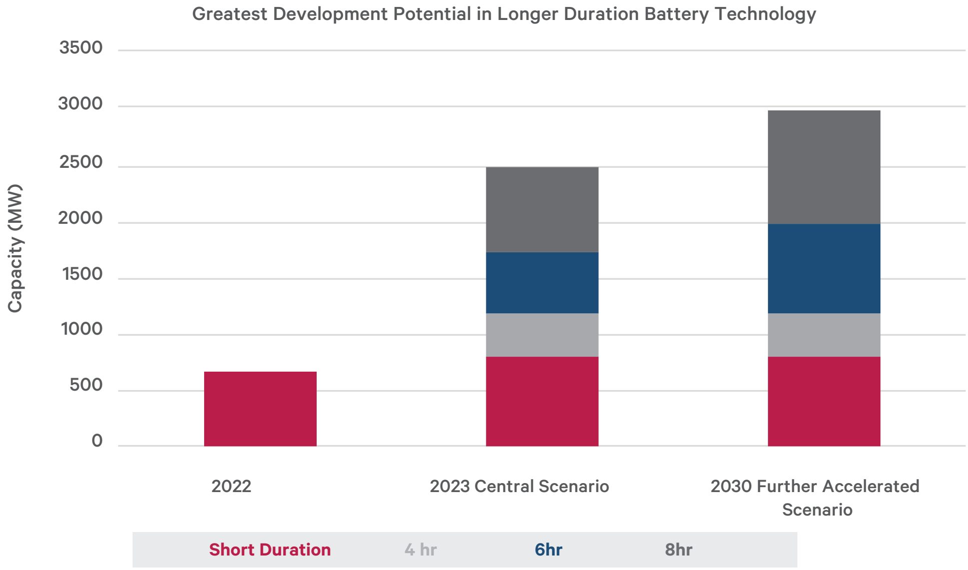
8 A key emerging policy choice related to **interoperability** and **standardisation** is whether (or not) to mandate Application Programming Interfaces and indeed the UK Competition and Markets Authority citing the **Open Banking** experience recommend open data and software standards.

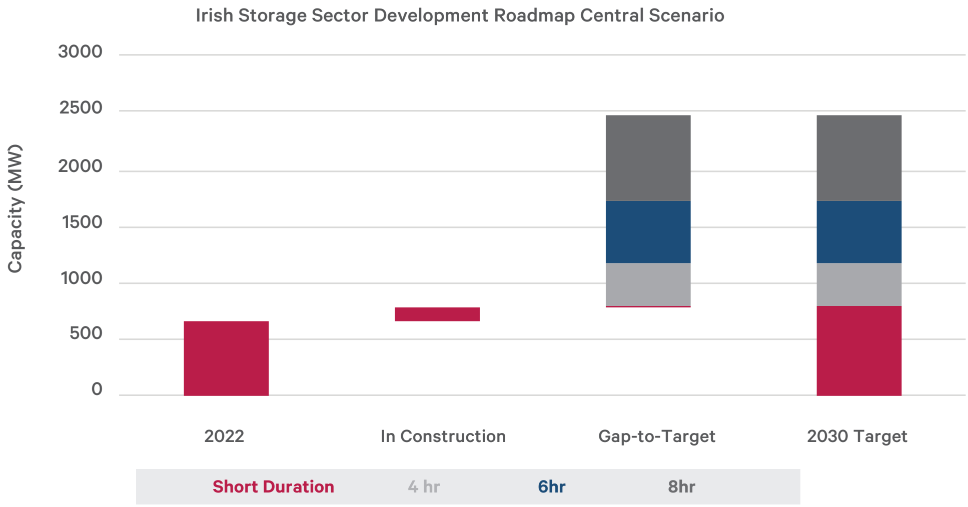
The installations on-the-ground **(670 MW)** already exceed the short duration Storage plant additions assumed by EirGrid (to be **571** MW by 2025). This points to the fact that (this particular niche of) the DS3 market has now become saturated, or the first of the use cases defined above (i.e., immediate, or short term) has largely been addressed.

The next aspect is to enable the intake of all the available variable RES-E i.e., addressing 'dispatch down' which requires longer duration Storage and/or contributing to security-of-supply. Consistently, the EirGrid analysis assumes that progressively longer duration plants will be installed as the decade progresses. This is the second and third use case as defined above. In the longer term, perhaps post 2030 longer duration seasonal storage will be increasingly needed.

The Total Addressable Market to 2030 is in the range 2,500-3,000 MW (of various durations). This is depicted in Figures 4a and 4b below.

Figures 4a and 4b – The Total Addressable Market for Storage in Ireland: The requirement for storage of various durations.





Source: EirGrid.

Given that there are currently 670 MW (of short duration) BESS installed, the mid-range gap-to-target is c. 2,000 MW.

The unit cost range of various duration of Li-Ion based installations is shown in Fig. 5 (for comparison the Corre Energy's CAES storage projects (3.5 days) are approximately €1 million per MW. which totals to an investment requirement of €4.4-5.6 billion.

In conclusion, short duration BESS plants which are both commercially available and installed in Ireland address the system services (or DS3) market, which has the purpose of maintaining grid stability. That market has now become saturated. Longer duration storage solutions are now needed and are beginning to materialise on foot of recent capacity auction. Overall, the total addressable market is of the order of 2,500-3000 MW which approximates to an investment requirement of €4.4-5.6 billion.

Figure 5 – Investment Requirement for BESS (of various durations). The investment requirement is of the order of €4.5-5.6 billion:

Duration		2030 Targets (Central Scenario)		Cost Estimates		Site Estimates			Total Cost	
				Variable Plant Costs (€m)	Other Costs (€m/ site)	Average Size		# Sites	€ m	
hrs	MW	MWh	Low	High	Low	High	MW/ site		Low	High
4	375	1,500	600	750	6	9	75	5	630	795
6	550	3,300	1,320	1,650	6	9	75	7.3	1,364	1,716
8	750	6,000	2,400	3,000	6	9	75	10	2,460	3,090
Total	1,675	10,800							4,454	5,601

Source: Irish Energy Storage Association

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Davy recognises the importance of decarbonization in the fight to protect our environment. We also know that it will take a lot of innovation and investment to achieve the ambitious targets set by Governments across Europe and the world. That is why we have set up our Decarbonization Team to help existing and new businesses develop and fund decarbonization strategies and solutions.

Our expertise includes:

- Fundraising for public and private companies across the capital structure
- Mergers and acquisitions
- Strategic advice
- Sector expertise

The team's focus is on the decarbonization of five core sectors:

- Power Generation and associated supply chains
- Commercial & Industrial processes
- Transport
- Built Environment
- Agriculture

Contact Us

For further information, please contact the team at **decarbonization@davy.ie**

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