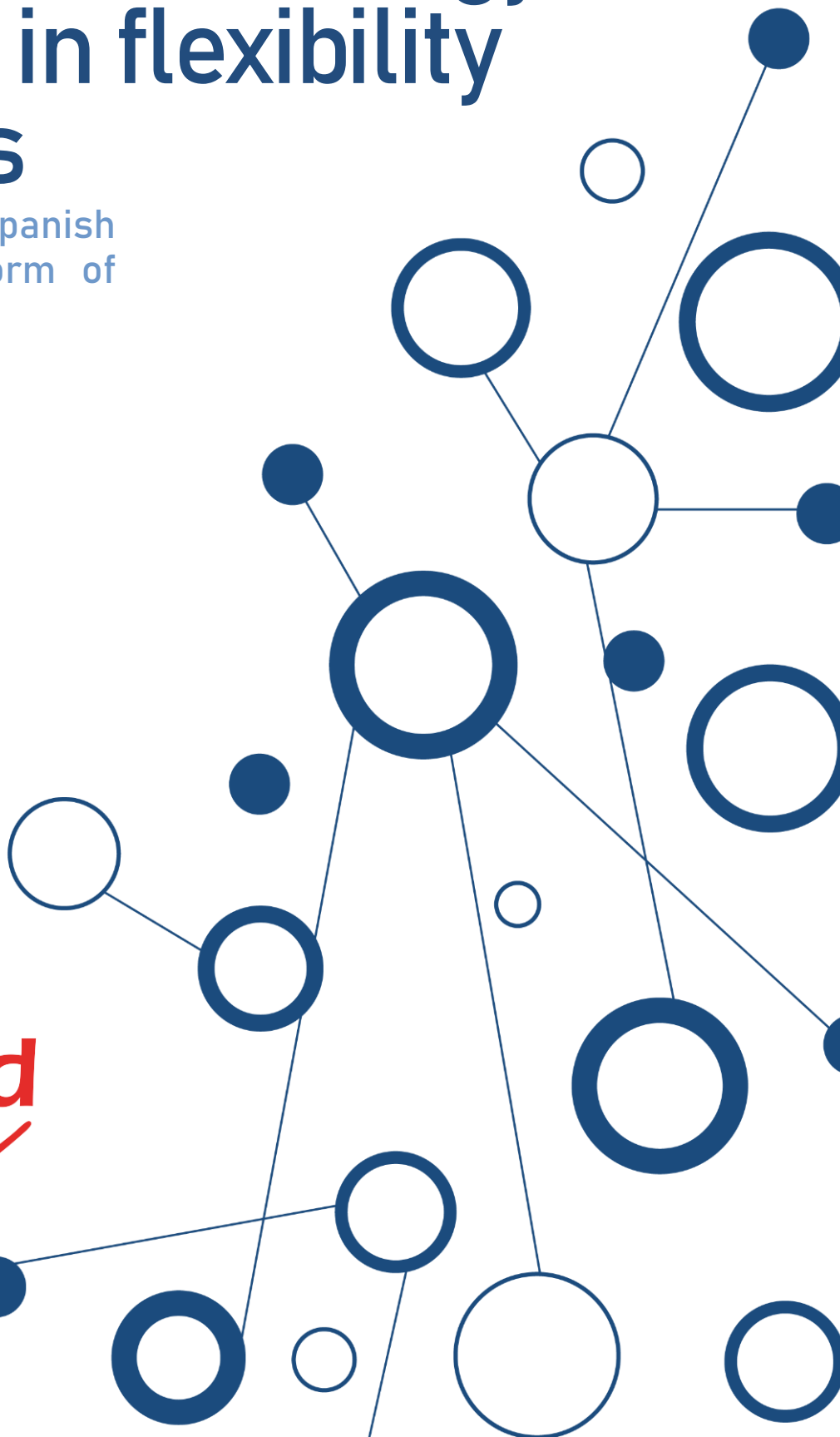
2025

Integration of energy storage in flexibility markets

FUTURED - Spanish technology platform of electrical grids



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Introduction

In 2021, the Futured Flexibility Working Group published its report 'Flexibility in electricity distribution networks', which included batteries among the technical solutions for flexibility.

This report already pointed out that batteries could be an element to support the operation of the distribution grid in certain cases to provide services such as voltage control or island operation, among others. Regardless of their value in the deregulated business due to the management they allow for the purchase and sale of energy, their value as a grid asset could be a guarantee of efficient, reliable and safe operation at certain points in the distribution grid, under the supervision of the regulator.

In addition, the batteries can provide 'last resort' flexibility services (improve voltages, reduce losses, reduce peak demand, provide support for island operation, among others) at those points in the grid where there is no alternative flexibility provider.

Subsequently, in 2023 the Futured Storage Working Group published its 'Storage Use Cases' report which showcased innovative projects that developed some of these possibilities for flexibility in grids.

Several countries are recognizing the importance of energy storage and are implementing regulations to promote its adoption. In the United States, the Federal Energy Regulatory Commission (FERC) has introduced policies that allow storage technologies to participate in energy markets. Similarly, in the European Union, the Renewable Energy Directive includes specific provisions to encourage the development and implementation of energy storage solutions. These policies are designed to eliminate barriers and create incentives that drive investment in storage technologies.

Therefore, having identified both the need and the demonstration projects that address it, the Storage Working Group decided to benchmark the state of regulatory progress in different countries to see how storage technologies are allowed to provide reliability services.

This document is the result, as of early 2025, of that enquiry.

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Abbreviations

Acronym	Description
aFRR	Automatic Frequency Restoration Reserve
AEMO	Australian Energy Market Operator
ASM	Ancillary Service Market
BESS	Battery Energy Storage Systems
CAISO	California Independent System Operator
CfDs	Contracts for Differences
DSO	Distribution System Operator
DUID	Dispatchable Unit Identifier
EOH SOC	End of Hour State of Charge
ESPS	Energy Storage Power Stations
ESS	Energy storage systems
FCA	Flexible Connection Agreements
FCR	Frequency Containment Reserve
FERC	Federal Energy Regulatory Commission
FSPs	Flexibility Service Providers
LGCs	Large-scale Generation Certificates
mFRR	Manual Frequency Restoration Reserve
MLF	Marginal Loss Factor
MPGGS	Manual de Procedimientos da Gestão Global do Sistema
NEM	National Electricity Market
NGR	Non-Generator Resources Model
PPM	Power Park Modules
RR	Replacement Reserve
SEN	Sistema Nacional de Portugal (Sistema Elétrico Nacional)
SIPS	System Integrity Protection Schemes
SOC	State of Charge
SoH	State of Health
TSOs	Transmission System Operators
UPACs	Unidade de Produção para Auto-Consumo
V2G	Vehicle to grid
WEM	Wholesale Electricity Market

Executive summary

Based on a prospective exercise, the members of the working group selected a set of geographical areas (countries and states in the US) that have shown the most regulatory activity in the area of flexibility. They then defined a set of questions to compare the regulatory situation which they transferred to a form to collect information from the working group members. After a comparative analysis of how energy storage is addressed in the flexibility regulation of seven different geographical areas (France, Italy, Ireland, UK, Portugal, Australia and California), the following findings have been made:

1. In the seven geographical areas analysed, storage units can individually provide flexibility services without the need to participate jointly with a generation or a consumption unit.
2. In the seven geographical areas analysed, storage is included among the resources that flexibility service providers can operate.
3. In some geographical areas like Italy and Portugal, there are not specific Flexible Connection Agreements solutions for storage, but this possibility does exist in other geographical areas.
4. The management for the procurement of services is carried out differently in each geographical area. In Ireland and Portugal, the processes are managed by the TSO.
5. Italy, Ireland, Portugal and Australia do specifically include real-time monitoring of storage equipment in their regulations.
6. Italy, Portugal and California set a minimum threshold of 1 MW to be able to bid and in the United Kingdom there are different minimum thresholds for some services. In all other countries there is no minimum threshold.
7. Italy, Ireland, Portugal and Australia don’t have specific administrative records for storage facilities.
8. France and Portugal have already paved the way by including situations where network operators can own and operate storage equipment.
9. In Italy, Ireland, Portugal and Australia storage systems are included by network operators in their planning.
10. Including storage in contracts for differences (CfDs) and State of Charge (SoH) Management are specific aspects covered by some regulations.

1 Objective and working method

The aim of this report is to find out how the regulation of the flexibility of power systems in certain countries which have shown clear signs of progress in this field, contemplates the participation of energy storage technologies.

To this end, the members of the working group previously established a series of conditions that delimit the scope of the study:

1. What storage technologies do we consider in this area?
    a. Batteries
    b. Pumping
    c. Thermal storage
2. Grid levels: both transmission and distribution
3. We exclude behind-the-meter storage and the electric vehicle (V2G).
4. We focus our analysis on consolidated regulation and not on R&D projects.
5. Flexibility services
    a. Balancing services (excluding wholesale market)
    b. Congestion management (active energy)
    c. Voltage control (active and reactive energy)
    d. Inertia
    e. Service restoration
    f. Other (phase balancing)

With this as a starting point, the working method consisted of drawing up a form that was distributed to members of the working group who, due to the activity of the companies or research entities they represent, have access to information on the state of regulation in the countries under study.

The form consisted of the following questions for each country:

1. ¿Are storage units entitled to provide flexibility services individually or they shall participate jointly with a consumption or generation asset?

2. Is storage included among the flexibility service provider's resources?

3. Are there specific Flexible Connection Agreements ''FCA'' between network operators and storage equipment operators)? Which ones exist?

4. How is the procurement of services performed?

5. Are the storage facilities subject to real-time monitoring by the network operator?

6. Is there a minimum bid size to provide flexibility services? If so, are they different by service?

7. Is there a registry of storage facilities? Are there several registries in each country per network zone?

8. Are there any exemptions from Directive (EU) 2019/944 on the network operator's own storage?
9. Are there any additional aspects that are covered by the national regulation that you consider relevant, which have not been addressed in previous questions?

10. Are network operators taking storage into account in their planning?

Entities involved

Country	Entity type	RoI within the entity
Australia	Utility	Smart Grids, Technology & Innovation
California	Technological research center	Area Manager
France	Utility	New Network Business Opportunities
Ireland	Technological research center	Researcher
Italy	Technological research center	Researcher
UK	Technological research center	Researcher
Portugal	Utility	Stakeholders & Public Affairs Iberia

2 Findings

The findings have been structured into 10 topics according to the questions asked to the contributors to this study.

2.1 Entitlement of storage units to provide flexibility services

In the seven countries analyzed, storage units can individually provide flexibility services without the need to participate jointly with a generation or consumption unit.

Australia

Storage units can operate individually to provide flexibility services to the electrical network as well as jointly with a consumption or generation asset. Both cases are classified by the Australian Energy Market Operator (AEMO) as Integrated Resource Providers.

From a global perspective, Storage units can participate in four service categories:

- Network services: Fast frequency response and System Integrity Protection Schemes (SIPS).
- Competitive market services: Energy, Regulation Frequency Control Ancillary Services and Contingency Frequency Control Ancillary Services.
- Generator support: Curtailment reduction and Marginal Loss Factor (MLF) improvement.
- Non Market ancillary services: Reserve Capacity.

California

Storage can operate individually. The Non-Generator Resources Model (NGR) [21] has been implemented by the CAISO, ISO of California. This system allows the integration of non-conventional resources, such as energy storage systems and variable demand, into electricity markets.

This model allows these resources to efficiently participate in energy services, acting as both load (when they store energy) and generation (when they release energy), something that was not possible in traditional models intended only for conventional generators.

The main flexibility services where these batteries that have been incorporated into the grid participate are:

1) Frequency regulation
2) Spinning reserve
3) Non-spinning reserve
4) Flexible ramp
5) Voltage support
6) Blackstart
7) Load shifting/demand respond

France

Storage has 2 connection agreements, one for injection and one for demand. Regarding national markets, they're considered like generation, mainly for financial compensation and BRP provisions.

Ireland

Energy storage systems (ESS) can provide flexibility services individually. The Irish grid code recognizes "Energy Storage Power Stations" (ESPS) as separate entities capable of participating in grid services. The “Battery ESPS Grid Code Implementation Note” explicitly details that ESS, particularly batteries, are considered as flexible assets under grid connection and operational procedures. This highlights that ESS are entitled to provide flexibility services independently.

In Ireland, storage units are used in several areas of the power system, especially in providing flexibility services such as frequency response, operating reserves, and balancing services. According to the “Battery ESPS Grid Code Implementation Note”, battery energy storage systems (BESS) are integrated into the grid as Power Park Modules (PPM) and are subject to the same technical requirements as other generation and flexible resources. They are specifically deployed to support grid stability, particularly in managing the variability of renewable energy sources like wind and solar.

The FlexTech initiative plays a key role in promoting the use of ESS to provide flexibility services. This initiative focuses on enhancing the integration of energy storage and other flexible technologies into Ireland’s power system, addressing technical barriers, and ensuring that storage

contributes to frequency control and reserve services. Therefore, battery storage is being used both for grid management and for enhancing the overall flexibility of the transmission system to accommodate increasing amounts of renewable energy.

Italy

Battery storage units are currently entitled to provide flexibility services only via an exention of the local DSO as in pilot projects, both individually and jointly with consumption or generation assets, and at all connection voltage levels. Hydro pumped storage is among the traditional resources for the provision of ancillary services on the Ancillary Service Market (ASM). Other storage devices like synchronous condensers are employed "directly" by the TSO to increase system flexibility, so they do not participate in the ASM.

Portugal

The flexibility service provider is an agent duly authorised to provide flexibility services, on an individual or aggregated basis, through flexible resources connected to the Public Utility Grid, directly, through an internal network or through a Closed Distribution Network, including consumption, production and storage.

United Kingdom

In July 2017, the Government and Ofgem published "Upgrading our energy system: smart systems and flexibility plan".[1] In this plan, the Government committed to define electricity storage as a distinct subset of generation in the Electricity Act 1989. At a later stage, the Energy Act 2023 inserts in section 4 of the Electricity Act 1989 a subsection (3ZA) (1)(a), where the reference to a person who generates electricity includes a reference to a person who generates electricity from stored energy. Can therefore be interpreted as considering storage as a subgroup of generation.[2]

[1] Available at https://www.ofgem.gov.uk/decision/upgrading-our-energy-system-smart-systems-and-flexibility-plan
[2] Available at: Energy Act 2023

2.2 Inclusion of storage among flexibility service provider's resources

In the seven countries analyzed, storage is included among the resources that flexibility service providers can operate.

Australia

Storage Unit is included among the flexibility service provider's resources, as indicated in the Rule Determination "INTEGRATING ENERGY STORAGE SYSTEMS INTO THE NEM" (December 2021) where Australian Energy Market Operator (AEMO) introduced a new specific Dispatchable Unit Identifier (DUID) for Storage Units defined as "Scheduled bidirectional unit", legally capable to provide market ancillary services from generation and load.

Ireland

Storage is explicitly included as a resource for flexibility services in Ireland. The Irish grid code identifies ESPS as key components of the ancillary services framework. These include frequency response, reserve services, and balancing mechanisms. This is further confirmed in the "Battery ESPS Grid Code Implementation Note", where it is mentioned that storage units are integral to flexibility services and will continue to be central to future grid code revisions.

2.3 Specific Flexible Connection Agreements between network operators and storage operators

In some geographical areas like Italy and Portugal there are not specific Flexible Connection Agreements for storage, but this possibility does exist other geographical areas.

Australia

Flexible Connection Agreements can be negotiated between network operators and storage equipment operators in order to specify which of the services described in question 3 will be covered.

California

Flexible Connection Assets are possible not only for storage but also for EV charging points.

Ireland

In Ireland, there are bilateral agreements established between Transmission System Operators (TSOs) and storage operators. While the reviewed documents do not specifically reference "Flexible Connection Agreements" (FCAs) by name, the existing connection agreements for energy storage systems (ESS) are designed to be adaptable to meet grid technical requirements and facilitate participation in providing operational flexibility. These connection agreements allow for the procurement of storage assets through auctions, where TSOs have the option to operate these assets under specific conditions. It is important to note that this option must be exercised before the day-ahead auction takes place. If the TSO does not exercise this option, storage units are free to participate in other market opportunities, thereby mitigating the risk of asset underutilization. Overall, the flexibility embedded in the connection agreements ensures that storage operators can effectively engage in multiple market opportunities, maximizing their operational efficiency and contribution to grid stability.

United Kingdom

The regulator has carried out a series of reforms, as part of the Significant Code Review, with the aim of ensuring that networks are used efficiently and flexibly. The implementation of access reforms aims to reduce connection charges and to define and standardise different access rights options, allowing for more flexible access rights and reducing barriers to entry. From 1st April 2023, Curtailable (non-firm) access arrangements are available for new application connections where the DNO identifies a requirement for network reinforcement, and a specific network need for curtailment to manage local network constraints until that reinforcement is completed or on a permanent basis. A curtailable connection will enable a customer to connect quicker by agreeing that the use of some or all of that connection may be restricted by the DNO at certain times when the network is congested.

2.4 Procurement of services

The management for the procurement of services is carried out differently in each country. In Ireland and Portugal, the processes are managed by the TSO.

Australia

There are two different electricity markets in Australia: Australia National Electricity Market (NEM) and Wholesale Electricity Market (WEM).

By submitting commercial offers, storage units can participate in12 markets in the NEM market where bids are issued for 5-minute time intervals:

- Two markets of energy (generation and load).
- Two frequency regulation markets (AGC: up and down frequency setpoints every 4 seconds) for continuous frequency regulation.
- Eight contingency regulation markets (1 second, 6 seconds, 60 seconds and 5 minutes) for frequency regulation in power plant trip events.

In the case of the WEM market, Energy arbitration, LGCs (large-scale generation certificates) and Capacity Credits are the issues to role in.

California

All these services are offered through the Ancillary Services Market and are remunerated accordingly.

Ireland

Procurement of services from ESS is done through structured processes managed by the TSO. ESS, as part of ESPS, participate in scheduling, dispatch, and balancing markets by submitting commercial offers, physical notifications, and technical data. The procurement of ancillary services such as frequency control, operating reserves, and voltage control is well-defined, with storage units being able to offer these services based on their technical capacity.

Italy

Pilot projects enable battery storage, also in aggregated virtual units, to participate in the ASM for the provision of aFRR, mFRR, RR; battery storage can also supply the so-called fast reserve service, which is faster than FCR and has a capacity remuneration awarded via a tender procedure; battery storage integrated in thermal power plants can supply FCR, with optional remuneration according to a scheme based on regulated prices.

Portugal

Energy storage physical units are duly authorised to participate in the system services markets managed by the TSO, and those which are included in this MPGGS (Manual de Procedimientos da Gestão Global do Sistema) may be incorporated into an Offer Area.

2.5 Real time monitoring by network operators

Italy, Ireland, Portugal and Australia do specifically provide for real-time monitoring of storage equipment in their regulations.

Australia

Storage units are in continuous communication with AEMO to send bids and receive dispatch instructions about all the services supply, through a real-time monitoring that let real-time tracking and compliance.

Ireland

Storage facilities are subject to real-time monitoring by the TSO. The TSO requires continuous data submissions, which enable real-time performance tracking. Monitoring ensures compliance with dispatch instructions and provides necessary data on ancillary services like frequency regulation and reserve provision.

Portugal

The Global Manager of the SEN (National Electricity System) has access, through its computer systems, to a set of real-time measurements, and sends commands for the control of electrical variables to production facilities and production facilities and autonomous storage systems with installed capacity greater than 1 MW and production units for self-consumption (UPACs) with surplus energy injection greater than 1 MVA, and to the other SEN facilities that are significant users of the grid, under the terms defined in the Global System Management.

2.6 Bid sizes to provide flexibility services

Italy, Portugal and California set a minimum of 1 MW to be able to bid and in the United Kingdom there are different minimum thresholds for some services. In all other countries there is no minimum.

United Kingdom

For Capacity market, the minimum threshold is 500 kW (recently reduced, previously 2 MW). In the local markets, in general, there is not any specific size requirement to participate. This size

requirement only depends on the specifications set by the system operator launching each market. For example, in Piclo[3] the requirements are defined for each "competition".

For the participation in the ancillary services, the minimum bid size is, in general, 1 MW. However, some services, like Fast Reserve, require a minimum size of 25 MW.

2.7 Administrative records of storage facilities

Italy, Ireland, Portugal and Australia don't have administrative records for storage facilities. In this context, the administrative records are information collected by governmental organisations as part of their ongoing operations.

France

There is not a specific registration for storage facilities but for flexibility assets in general.

United Kingdom

As in France, there is not a specific registration for storage facilities but for flexibility assets in general. The Flexibility Market Asset Registration digital infrastructure will allow asset installers, owners, and contracted flexibility service providers (FSPs) to register assets just once through data collection interfaces; this can be at any time but primarily upon first entering an ESO or DSO flexibility market. The data will then be stored as a common single source of truth.

2.8 Directive (EU) 2019/944 on ownership of storage assets by network operators

France and Portugal have already paved the way by including situations where network operators can own and operate storage equipment.

France

Storage devices are considered fully integrated network components.

[3] Piclo Flex is a marketplace that supports SOs in the end-to-end process of procuring and operating flexibility (https://www.piclo.energy/flex)

Portugal

By means of a Directive adopted by ERSE, and at the request of the grid system operator, the prohibition laid down by Directive 2019/944 may be derogated from, where energy storage facilities are fully integrated grid components.

2.9 Storage in network planning

In Italy, Ireland, Portugal and Australia storage systems are included by network operators in their planning.

Australia

Regulations are being progressively adapted to properly integrate storage systems in the planning network (example of this is the Rule Determination "INTEGRATING ENERGY STORAGE SYSTEMS INTO THE NEM" (December 2021), that was already commented previously).

Ireland

Network operators are explicitly required to consider storage in their planning processes. The Irish grid code highlights the importance of storage for future grid stability and flexibility, and the “Battery ESPS Grid Code Implementation Note” also points to ongoing efforts to integrate storage as a key component of grid planning, particularly as part of the FlexTech initiative.

Italy

Terna’s (Italian TSO) development plan for the Italian power system includes different generation technologies, and also storage technologies.

Portugal

Connected or committed storage is included in network planning.

2.10 Other topics covered by national regulations

Including storage in contracts for differences (CfDs) and State of Charge (SoC) Management are specific aspects covered by some regulations.

California

The Non-Generator Resources (NGR) Model in California is a framework developed by the California Independent System Operator (CAISO) to enable energy storage and other non-generating resources to participate in the electricity market and provide flexibility services and Regulation Energy Management.

Among of the features of the NGR Model, the following one stands out for its refinement: State of Charge Management. One of the challenges of managing batteries in electric markets is the need to monitor the State of Charge (SOC) to ensure that sufficient power is available when needed. The NGR model offers advanced parameters, such as End of Hour State of Charge (EOH SOC), which allows operators to ensure that batteries remain within certain charge ranges at the end of each interval.

United Kingdom

Contracts for differences (CfDs) were implemented through the Energy Act 2013/Chapter 2, and they represent a key mechanism to incentivize investment in new renewable technologies. These CfDs are available to renewable generators located in the UK who meet the eligibility requirements.

According to the Transitioning to a net zero energy system Plan (2021), future activities related to storage would focus on ensuring a level playing field between storage co-located with generation, and stand-alone storage. Currently there are barriers to deploying storage alongside generation projects supported under the Contracts for Difference (CfD) scheme. In principle, storage should be able to provide grid services and store power from CfD generators, provided that the metering arrangements can distinguish between the two.

In response to this Plan, a public consultation on considerations for future CfD rounds, which also comprised the requirements for including facility-linked storage under CfD, was issued in 2023. Moreover, in October 2024, after public consultation, the Government has issued the Government response to the consultation on policy considerations for future rounds of the Contracts for Difference scheme. One of the proposals, Co-located generation and hybrid metering, would allow CfD generators to be more easily co-located with storage.

Conclusions

The conclusions of the report on the regulation of the flexibility of electricity grids and the participation of energy storage technologies in the analyzed countries can be summarized as follows:

1. **Flexibility Services Provision**: In all seven countries analyzed, energy storage units are allowed to provide flexibility services independently, without the need to be associated with generation or consumption units. This indicates a recognition of the value of storage as a standalone resource in enhancing grid flexibility.

2. **Inclusion in Flexibility Resources**: Energy storage is explicitly included among the resources that flexibility service providers can operate in all seven countries. This highlights the growing importance of storage technologies in supporting grid stability and integrating renewable energy sources.

3. **Regional Variations in Flexible Connection Agreements**: There is a notable difference in the availability of specific Flexible Connection Agreements for storage. While such agreements exist in Anglo-Saxon countries, they are absent in southern European countries like France, Italy, and Portugal. This suggests differing regulatory approaches and market structures across regions.

4. **Service Procurement Management**: The management of service procurement processes varies by country. In Ireland and Portugal, these processes are managed by the Transmission System Operator (TSO), reflecting different administrative frameworks and responsibilities.

5. **Real-Time Monitoring Requirements**: Countries such as Italy, Ireland, Portugal, and Australia have specific regulations that mandate real-time monitoring of storage equipment. This ensures better oversight and management of storage systems in real-time operations.

6. **Minimum Bidding Thresholds**: Italy, Portugal, and California have set a minimum threshold of 1 MW for bidding in flexibility services, while the United Kingdom has different minimum thresholds for specific services. In other countries, no minimum thresholds are specified, indicating varying entry requirements for storage participation.

7. **Lack of Registries for Storage Facilities**: Italy, Ireland, Portugal, and Australia do not have registries for storage facilities, which could impact the tracking and regulation of storage assets within these countries.

8. **Ownership and Operation by Network Operators**: France and Portugal have regulations that allow network operators to own and operate storage equipment. This paves the way for network operators to directly engage in storage activities and enhance grid resilience.

9. **Inclusion in Network Planning**: Storage systems are included in the planning processes of network operators in Italy, Ireland, Portugal, and Australia. This indicates a forward-looking approach to incorporating storage into future grid development.

10. **Regulatory Aspects**: Some countries have specific regulations that address the inclusion of storage in Contracts for Differences (CfDs) and the management of State of Charge (SoC)[21]. This highlights the evolving regulatory landscape to support storage integration.

Overall, the report underscores the crucial role of energy storage technologies in providing grid flexibility, while also highlighting the diversity in regulatory approaches and frameworks across different countries

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