'22 PORTUGAL RENEWABLE ENERGY SUMMIT

Iberian Flexible Energy Market

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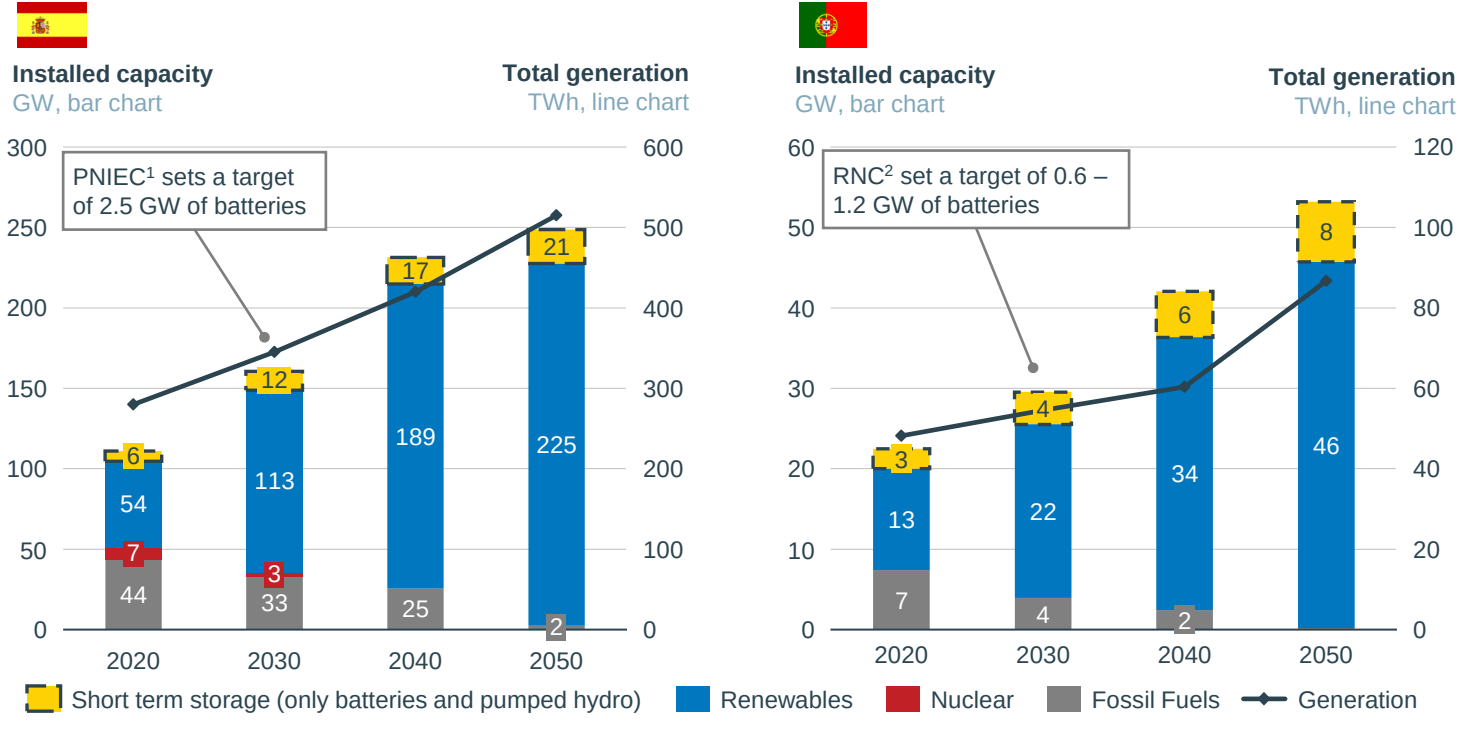
The Spanish and Portuguese decarbonisation roadmaps suggest a significant role for storage to support renewables integration

Evolution of the system composition in Iberia according to the national 2050 roadmaps



1) Plan nacional integrado de energía y clima (Integrated national climate and energy plan). National plans to be updated in 2023. 2) Roadmap for Carbon Neutrality. 3) For Portugal, targets regarding storage can be found in the roadmap to 2050; there is not a specific storage roadmap.

Sources: Aurora Energy Research, Estrategia de Descarbonización a Largo Plazo 2050, RNC 2050

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The Spanish Energy Storage Strategy aims to reach 20 GW of installed capacity in 2030 and 30 GW by 2050

On 9th February 2021, the Spanish Government approved the Energy Storage Strategy. The approved measures aim to increase the role of storage in the power sector (including, but not limited to batteries) by increasing system flexibility and ensuring security of supply.

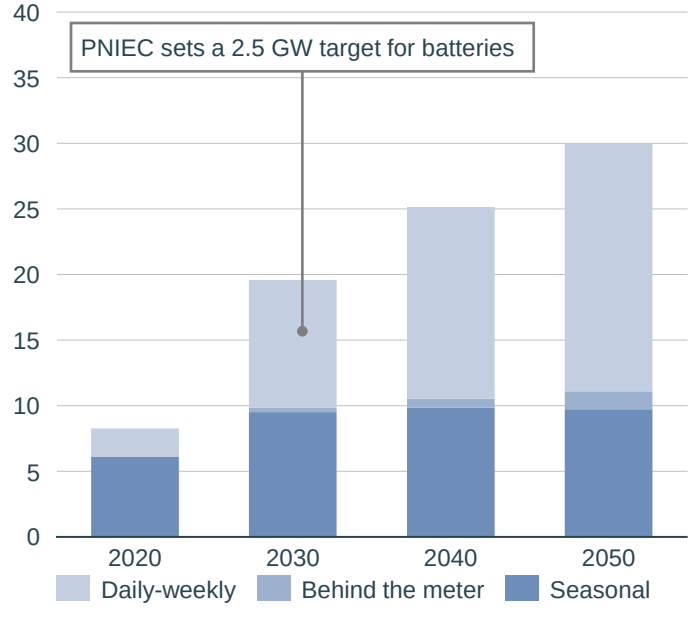
1 The plan aims to increase storage capacity to 20 GW by 2030

- A total of 20 GW are expected to be installed by 2030, and an additional 10 GW by 2050
- While seasonal storage (e.g. large hydro reservoirs) is envisioned to increase in the next decade, most of the increase will come from shorter duration (e.g. batteries, vehicle-to-grid, etc.)

2 Storage will benefit from additional revenue streams

- **Ancillary services** – the draft highlights the increasing role that storage can play in providing ancillary services
- **Capacity market** – storage capacity will be able to provide firm capacity in a potential Capacity Remuneration Mechanism (CRM)
- **Local flexibility markets** – storage can also help alleviate grid congestion. The government intends to analyse the potential role of distributed storage capacity in local markets

Installed storage capacity by type[1] GW, bar chart



1) Includes all types of energy storage technologies e.g. electric vehicles, heating, pumped hydro, batteries, etc. The document does not differentiate by technology.

Sources: Aurora Energy Research, Energy Storage Strategy Draft

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The regulatory framework for storage has been amended over the past 2 years, but there are still policy and regulation barriers to be addressed

Regulatory and policy updates for storage

2020	23 June	Royal Decree-Law 23/2020	Includes storage within the sector’s regulatory framework, and allows for co-location and independent aggregators
	3 November	Royal Decree 960/2020	New renewable scheme approved, allowing for hibridisation for new and existing plants and storage co-location
	29 December	Royal Decree 1183/2020	Regulates storage, sets exemptions for self-consumption and simplifies procedures to support co-location
2021	9 February	Energy Storage Strategy	Strategy contemplates total storage capacity of 20 GW in 2030 and 30 GW in 2050
	20 April	Capacity Market public consultation	Mechanism is technology neutral and works as a centralised system in which the TSO contracts the required capacity
	15 October	P.O. 12.2: rules for grid connection	Sets the grid connection technical requirements for storage under different modalities (stand-alone, co-located)
	14 December	PERTE for RES, 3H storage	Announcement of funds to support development of stand-alone and hybrid storage installations[1] which must be operational by 2026
2022	10 June	Consultation on grid capacity auction	Awards 5.8 GW of grid access for RES and storage. Criteria prioritises self-consumption, storage, hybridisation and repowering projects
	28 July & 27 Sept	Voltage control sandbox	Regulatory sandbox for voltage control (pay-as-bid mechanism) announced in July. Followed by regulatory changes allowing storage participation in system’s essential services

Regulatory barriers and clarifications to be addressed

1 Requirements allowing storage to charge from the grid

- Subject to interpretation if a DC co-located asset can charge from the grid, since regulation does not explicitly specify the types of connections allowed to charge from the grid

2 Technical requirements to participate in ancillary services

- Even though is clear that storage can participate in 2R, 3R and RR, the technical requirements for batteries to provide these services have not been defined

3 Unclear licensing and permitting process

- Ambiguous environmental impact assessment requirements
- For hybridisations i) if adding storage is considered a substantial change, some administrative processes must be restarted, ii) if >50 MW, project must be processed at central level, requiring additional permits

4 Participation in additional markets suitable for batteries (e.g., primary reserve)

- Primary reserve[2] is currently mandatory and not remunerated
- No process has been started to change this

5 Possibility to operate hybrid installations (e.g., RES and battery project) separately

- Unclear if in the case of a RES imbalance i) the battery could participate separately in ancillary services or ii) assume the imbalance cost at the expense of more lucrative opportunities

1) PERTE ERHA first call for R&D storage projects happened in 2022 and it is waiting for resolution (50 MEUR). Other two storage calls (co-located – 150 MEUR – and stand-alone – 139 MEUR) were expected in Q3/Q4 2022, but might be delayed to 2023. 2) Fast frequency response.

Sources: Aurora Energy Research, MITECO, Boletín Oficial del Estado, CNMC

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Since the regulatory figure of storage was first introduced in Portugal there have been clarifications on regulations and procedures

Regulatory and policy updates for storage

2019	03 June	Decree-Law 76/2019	Includes storage within the sector's regulatory framework, and introduces key co-location and permitting concepts
2020	29 May	Dispatch 5921/2020	Announces solar auctions that include a flexibility option
2021	23 August	Regulation 785/2021	Provides clarification on pumped hydro tariff exemption and network access tariffs for batteries (only CIEG exemption)
2022	14 January	Decree-Law 15/2022	▪ Sets regulatory framework, licensing deadlines and permitting process for stand-alone and co-located storage. ▪ Includes regulatory framework for hybridisation with RES
2022	14 April	Decree-Law 30-A/2022	For storage projects with installed capacity <50MW not located in sensitive areas, the EIA[1] is no longer required
2022	21 Sept	Directive 20/2022	Introduces the first battery in a Balancing Zone[3], and states that its network tariffs should be the ones applicable to pumped hydro (which is exempt)
2022	19 October	Decree-Law 72/2022	▪ Creates incentive for local authorities to approve RES and storage permits[4] ▪ Updates auction tariffs by inflation at project COD (applicable to flexibility option of solar plus storage)[5]

Regulatory barriers and further clarifications to be addressed

1 Tight permitting deadlines

- Deadlines for renewable projects seeking permits have already been extended twice this year due large administrative backlogs
- DGEG[6] stopped accepting new applications for grid access in '20

2 Environmental permitting process

- No specific EIA requirements exist for storage assets, creating uncertainty around environmental requirements for batteries

3 Participation in additional markets suitable for batteries (e.g., primary reserve and constraint management services)

- Primary reserve[7] is currently mandatory and not remunerated
- Storage is not explicitly included in the technical restrictions regulation
- No process has been started to change these market rules

4 No exemption from grid access fees for batteries

- Unclear if batteries will be exempt from grid access fees

5 No permitting benefits for co-location of new assets

- When hybridising an existing asset with a battery, it is not necessary to request a new grid connection. However, co-located projects with no existing grid connection must follow the standard permitting procedures without any additional benefits for hybridisation[8]
- Projects with an ongoing permitting procedures are not eligible to request additional capacity for hybridisation

1) Environmental Impact Assessment. 2) Also applies to renewable, self consumption and green H2 assets. 3) To participate in tertiary and replacement reserves, assets must be in a balancing zone. 4) Incentive of 13.5kEUR per MVA of allocated grid connection. 5) Also extends experimental period (remuneration at market price) by up to 12 months. 6) Direção-Geral de Energia e Geologia. 7) Fast frequency response. 8) In Spain, installations with no grid connection benefit from a 50% savings for financial guarantees when initiating request for hybridisation. Ongoing grid requests can be updated, and the original permit request date is maintained.

Sources: Aurora Energy Research, Diário da República, APA

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Wholesale and ancillary markets will be the key sources of revenues for batteries, although other revenue streams could open up

Time prior to delivery

Currently available markets

Years → Days → Hours → Minutes → Seconds → Delivery

CM Capacity Market

- Ensures sufficient reliable capacity and security of supply in the long term
- For Spain, MITECO has published a draft proposal for a capacity market, but implementation timeline is uncertain
- Storage will be allowed to participate, but the de-rating factor (reflecting its contribution to security of supply) is still to be defined
- Longer-duration storage can typically benefit from higher de-rating factors

WM Wholesale Market

- Market to buy and sell power to **meet demand** on an hourly basis
- Contracted **from years ahead to up to one hour ahead**
- Market participants can trade in day-ahead and intraday markets
- Two intra-day market modalities in Iberia: explicit auction sessions every six hours and a continuous intraday market up to 1 hour ahead

AS Ancillary services

- Maintains operational grid requirements and balances demand and generation in real time
- Contract tenors can vary widely by country, but moving to shorter term contracts
- Key ancillary markets in Iberia:
  - Primary Reserve (non-remunerated)
  - Secondary Reserve
  - Tertiary Reserve
  - Replacement Reserves
  - **Constraints (day-ahead and intraday)**

LFM Local Flexibility Markets

- Storage can also help **alleviate grid congestion,** which needs to be analysed locally and procured through local markets

Source: Aurora Energy Research

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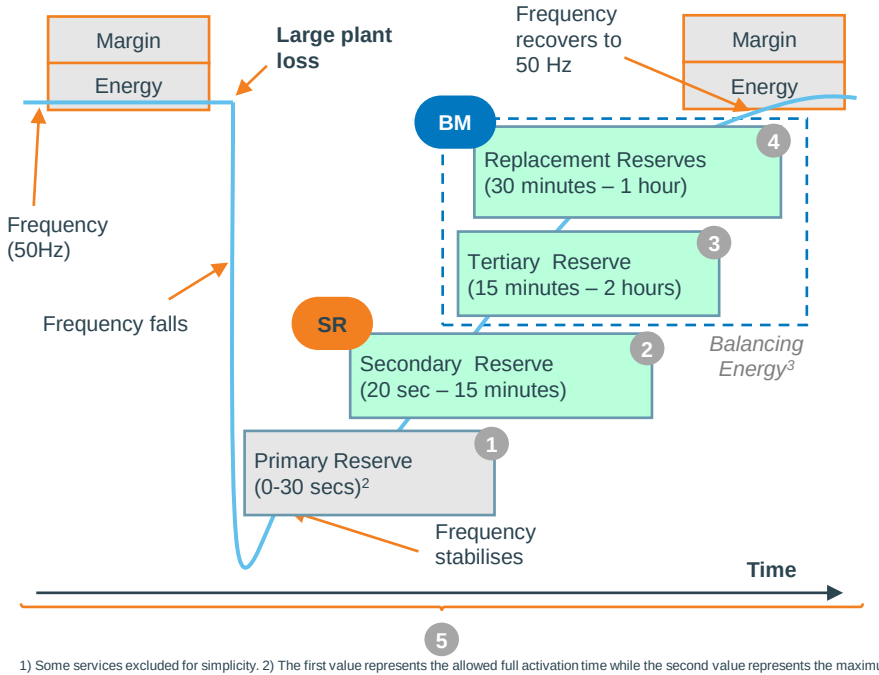
System security is managed through ancillary services; from those, the Secondary and Balancing Markets are the main sources of potential revenues

REN and REE Ancillary Services

Illustrative case study example of response to a major outage[1]



1 **Primary Reserve**
- Obligatory/ non-remunerated
- Automatic response of up to 30 seconds

2 **Secondary Reserve (aFRR)**
- **Automatic** Frequency Restoration Reserve
- Voluntary service
- Remuneration based on two components: available capacity and dispatched energy

3 **Tertiary Reserve (mFRR)**
- **Manual** Frequency Restoration Reserve
- Mandatory offers for generators who opted in
- Remuneration based on dispatched energy

4 **Replacement Reserve (RR)**
- Previously called deviation management
- Remuneration based on dispatched energy

5 **Constraint Management**
- Service to solve technical constraints in the grid
- Managed through the re-dispatching of market units

1) Some services excluded for simplicity. 2) The first value represents the allowed full activation time while the second value represents the maximum duration of the delivery period. 3) The Balancing Energy combines Tertiary Reserve and Replacement Reserve which represent over 70% of the energy traded in all markets, without considering grid constraint management services. In Portugal, due to a lack of historical data, the analysis is focused on the Tertiary Reserve exclusively.

Sources: Aurora Energy Research

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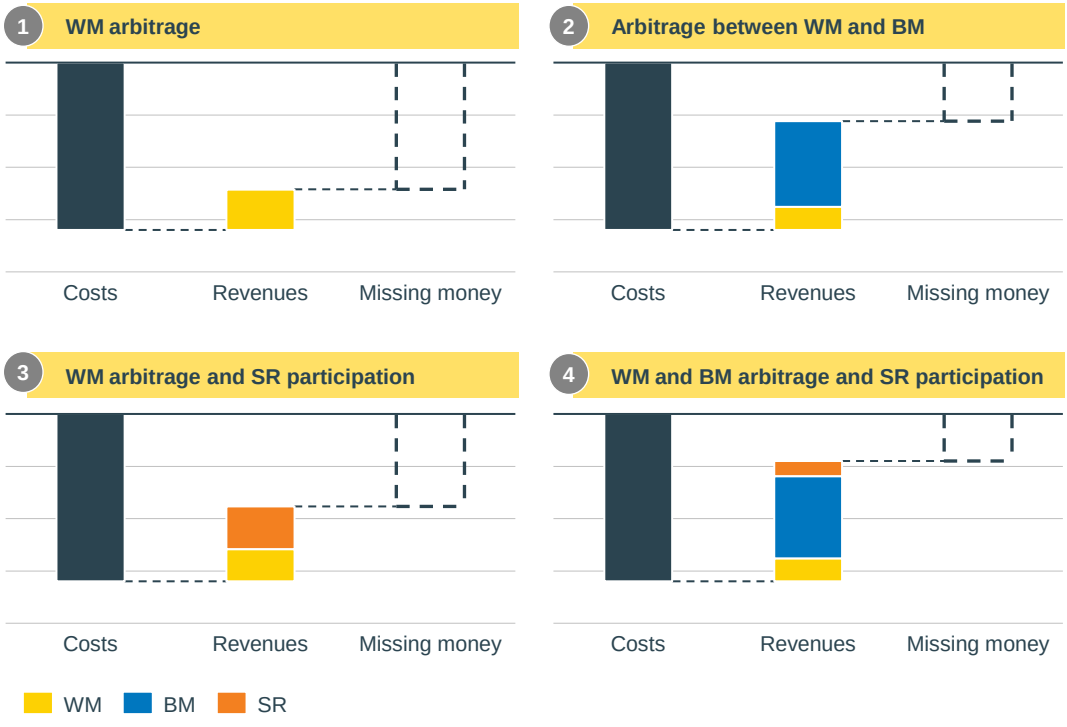
Revenue stacking improves the profitability of batteries, however there is still a missing money problem

Illustrative example of present value of cashflows[1] for a 2-hour duration[2] stand-alone battery EUR/KW



Revenue stacking strategies

1. The battery only participates in the WM and only recovers a small portion of the costs
2. Considering a pure arbitrage strategy between WM and BM, the battery recovers approximately 65% of its costs
3. By participating in the SR market and the wholesale market, less costs are recovered compared to scenario 2
4. It is possible to stack revenues from the 3 markets, ensuring that approximately 75% of the costs are recovered. The missing money can come from a CM payment

1) Cashflows discounted at 12%. 2) 90% round-trip efficiency entering in 2025, 2 target cycles per day with a 0.0037% degradation per cycle.

Source: Aurora Energy Research

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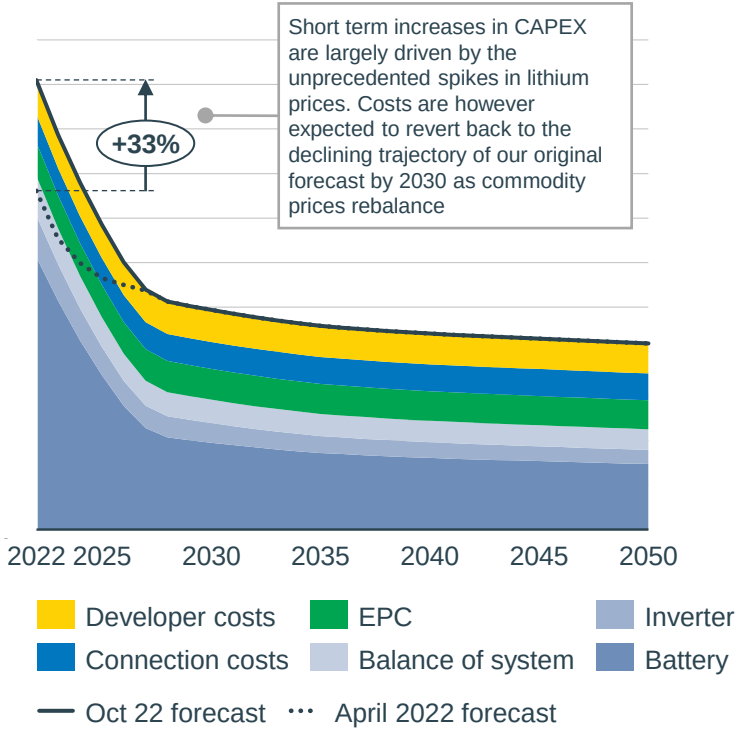
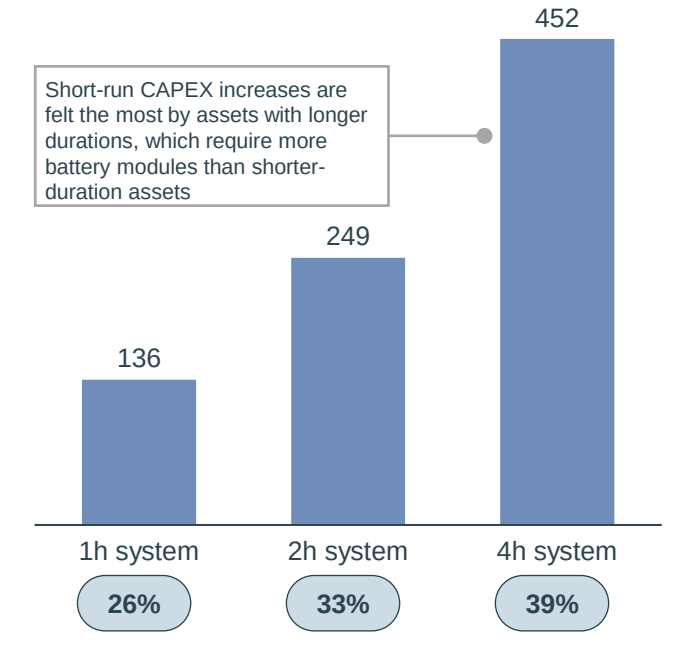
Persistent high commodity prices have increased battery system CAPEX for a 2h asset by 33% in the last six months

Li-ion battery total system costs – 2h asset
EUR/kW real 2021



Implied increases in 2022 CAPEX
EUR/kW, real 2021



Source: Aurora Energy Research

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